A WORKING MODEL B.&O. R.R. LOCOMOTIVE "PRESIDENT WASHINGTON"

BY MR. H. J. COVENTRY, M.E.

Edited from the original articles from THE MODELMAKER, 1928-1932

by
John McKnight and Andrew Romer

Including additional articles by Mr. Coventry about springs, drilling holes at an angle, reaming holes accurately, piston rings, etc.

Contents:

EDITOR'S NOTE

Limited editing has been done, principally to increase reading comprehension. The Modelmaker's editor apparently did not like to include the word "the" and omitted helpful commas. Run-on sentences abounded in the original, and some have been edited for clarity. The quality of most figures when originally printed reflect halftone practices at that time and cannot be improved. Mr. Coventry's notes, written approximately 100 years ago, reflect some construction practices that in the meantime have fallen into disfavor. Among those are many of his methods used to build the copper boiler (of the 2.5-inch gauge *President Washington*), including use of soft soldered joints, and use of brass and cast pieces in the boiler. Caution should be exercised by the amateur, and if necessary, consultation with more skilled builders may be appropriate.

A ¾" SCALE B.&O. R.R. LOCOMOTIVE[1]

"PRESIDENT WASHINGTON"

BY MR. H. J. COVENTRY

During the past two years that the writer's 1/2 in. scale B. & O. *President Washington* castings and drawings have been on sale, some requests have been received for the same engine built to 3/4 in. scale. Now, a 3/4 in. scale model is by no means a small undertaking, even if the amateur constructed just one to his own ideas and fancy. When such models are to be built by a number of individuals, several points become almost imperative.

The first is, of course, that it should be a powerful steam working model.

Secondly, it should be as close as possible to the full-size locomotive, without detracting from working qualities.

Third, the actual construction should be made as easy and straightforward as practical by designing all details suitable to the probable facilities of the average amateur.

Fourth, the material should be selected with care, in order to meet the work demanded of the various parts.

Fifth, all castings must be designed so that not only will patterns mold cleanly, but castings will be free from shrinkage cracks.

All these points affect the product from the point of view of the amateur.

There are still a number of points to be considered from the manufacturing side.

In order to produce a satisfactory design, a complete set of drawings and tracings takes a considerable amount of time, in fact, the vast amount of work involved is not so much in the finished design as in the layout, change, alteration and steady evolution prior to the finished drawings. Secondly, the American locomotive model has to contain a large number of castings, which means the outlay of several hundred dollars in patterns.

The number of amateurs who are in a position to undertake the construction of a 3/4 in. model would be relatively small, on the grounds of shop facilities, skill, expense, or the mere size of such a model, so that a very real risk is taken of expenditures exceeding the probable returns.

Then, too, the producer of any new model naturally likes to incorporate original features of detail that may improve the design.

[1] From Vol. 8 of THE MODELMAKER, 1931, pg. 129.

These few preliminary remarks are made so that the prospective builder of this model may better understand the practical and economic considerations of making a complete design and castings available.

As previously stated, having received a few requests for the ¾ in. B. & O.; not being blessed with a weighty pocketbook, and realizing that the production would be an expensive undertaking, the writer offered to a selected few to supply castings and detail prints as they were produced, under conditions agreed upon.

A full set of official detail drawings of the actual “President” class the writer already had, and the preliminary outline drawing was started in October, 1929. Then the valve diagram and gear layout, and, having developed all essential features, established clearance and fit, then the detail drawings were started.

Cylinders came first, and while patterns and core boxes were being made, other detail drawings were prepared. By this means, which, by the way, is the usual method of procedure in any mechanical engineering, considerable time is saved. Finally, all detail drawings were taken and a thorough general arrangement, sections, elevation and plan was made from them. This procedure forms a very efficient double check on the accuracy of the details. One small error was revealed and put right without difficulty.

At the time of writing (May)[2], there are sixty-five sheets of drawings, 17" x 11", and thirteen large sheets, ninety-eight patterns and nineteen core boxes. Two or three more of each will complete the job.

All patterns except wheels were made by Mr. Arthur Strausbaugh, 1400 Old Harford Rd., Baltimore. The wheel patterns were made by the writer.

In the course of these notes it is proposed to illustrate by photograph and reproduction of certain drawings, some of the special features of this model but general detail of methods of construction will not be gone into as previous notes on the half inch scale President Washington will apply and for these the reader is referred to Modelmaker issues of Oct. 1928 to Feb.1930 [Appendix 2 herein].

The plate Fig. 1 [reduced size copy of drawing 700-120] shows the general arrangement. The cylinders are 1-3/8" bore by 1-3/4" stroke, with piston valves 9/16" in dia. driven by Walschearts valve gear. Maximum valve travel is 7/16", lap of valve 3/32". The boiler is 5" diameter in barrel, containing nine 5/8" tubes and three ½” tubes. The grate is 7 inches long by 5 inches wide. Total heating surface: 454 square inches. Working pressure: 90 lbs. per sq. in. Coal is proposed for fuel. Track gauge is 3-1/2". Before passing on to the construction it will be as well to note some of the special features incorporated in the design.

Boiler. It was found to be a difficult matter to provide an adequate throttle within the scale outline, and because a valve of approximately 3/8 in. dia. was needed, the question of operating it against 90 or 100 lbs. pressure had to be considered. The load on a 3/8 in. valve at 100 lbs. is 11 lbs., so after quite a few tentative designs, it was finally decided to use a double beat valve in the

[2] 1931

smokebox, and because a superheater is also used, to combine the throttle valve in the superheater header, and to operate it with a push and pull movement by a rod passing through the 1/2 in. dia. steam pipe.

The steam is admitted to the dry pipe by thirty, 3/32 in. diameter holes arranged in one row on the top side of the dry pipe starting from the fire box end. The throttle valve seats are provided in the header; one 3/8 in. at the bottom of a counter bore, and one 7/16 in. in a bush pressed in the counterbore. The total load on the valve is now the difference between the respective areas; this difference being 0.04 sq. in., which, with 100 lbs. pressure, gives a load of 4 lbs. The throttle lever has a ratio of 2 to 1, so that only a 2 lb. pull on the lever is required. In order to admit steam to the outer part of the valve, a balancing port is drilled in the header casting connecting the front of the bush to the dry pipe. When the throttle is opened, steam is admitted to the saturated steam header, passes through the superheater elements, and is delivered to the front header passage and thus to the cylinders. The dry pipe is brazed into the back head, the front end of the pipe being a free fit in a flanged gland which is bored, coned and ground seated to receive the superheater header, which is secured by two stout bronze screws.

There is only one slight disadvantage in this arrangement, namely, the throttle rod is put in compression, but this rod is purposely made large enough in diameter, 3/16 in., and by using Tobin, or phosphor bronze, no trouble should be experienced with the valve load of 4 lbs. As a matter of fact, the out of balance effect can be still further reduced by making the difference of diameters of seals as small as consistent with assembly of the valve in the chamber.

The feed water is admitted by a top connection, which sprays the water into the steam space.

A steam turret with six outlets is provided in the cab, one to each of two injectors, one each to the power reverse gear, brake, lubricators and blower. The end view will show the arrangement of the fittings. A blow-off valve of new design is provided at the bottom right-hand corner of the firebox.

The blower is of the ring type combined with the exhaust pipe casting. The smokestack arrangement is similar to the 1/2 in. scale model, and the smoke box front, door, and ring are arranged in the same manner as on the full size engine.

The boiler is secured in the orthodox manner, namely, bolted to the cylinder saddle and to bearer plates at the rear end.

Reviewing the **running gear and framework:** The cylinders are of gray cast iron with exhaust passages wholly cored in and steam passages cored down to about half an inch of the cylinder bore. It was found in earlier experiments that to core the steam ports right through was uncertain and difficult, because the cores being relatively slender, would either shift or break when the metal flowed around them. By coring the steam passages part of the way, a good stiff core is obtained, and no bad casting has as yet turned up. Several have already been sold and are spoken of highly by the recipients. It is an easy matter then, to drill a row of short holes into the cored pocket to form the steam passage [Appendix 6 herein].

The valve chamber, or steam chest, is bored to receive bronze or iron bushes having the ports drilled in by a jig to be described later. These methods ensure accurate location of ports and free big areas for steam. The steam port area through the bushes is 0.098 sq. in. steam passage, 0.164 sq. in. exhaust passages, 3/8 in. by ½ in. or 0.1875 sq. in. or 1/16, 1/9, and 1/8 the area of piston, respectively.

Valve Gear Principles

Some readers have requested information on valve gear principles, the terms used being to them somewhat mystifying, so opportunity is taken here to supply the desired information.

If steam is admitted to a closed cylinder behind a movable piston, and is shut off at some portion of the total stroke, the piston will continue to move due to the "expansion" of the steam. Expansion and movement of the piston will go on until the steam is allowed to escape to some pressure lower than its own, either to the atmosphere as in a locomotive, or to a condenser, as in marine and power plant service. Here then, is established three distinct elements of the one stroke, or cycle, of the piston, namely, Admission, Expansion and Exhaust. There is usually one other, namely, compression, in which a small amount of the exhausting steam on one side of the piston is trapped to provide a cushioning effect and thus bring the reciprocating parts to rest gently prior to reversal. It is the function of the valve to control the Admission, Expansion, Exhaust and Compression, which are referred to as Valve Events.

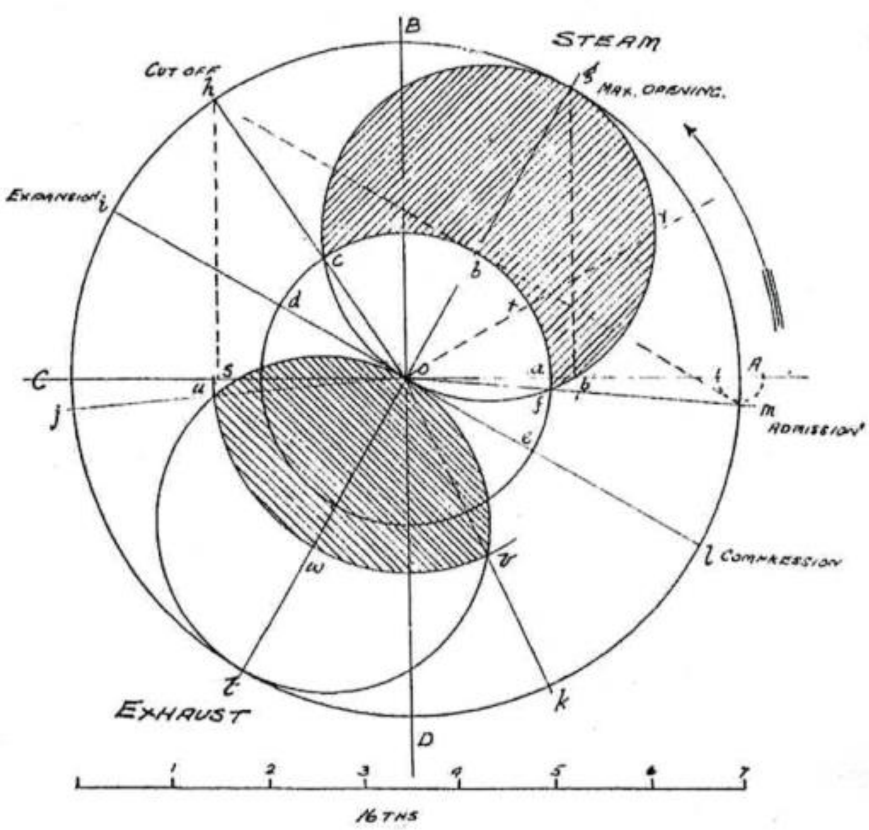


FIG 2 ¾" B&O P7

Now, if an advantage is to be taken of the expansion of the steam, it is evident that the inlet must be entirely closed after a definite amount of steam has been admitted, and kept closed for the period of expansion before opening for exhaust.

That point at which complete closure of the steam inlet or port occurs is known as “point of cut-off" and is measured by the ratio of piston displacement at which this event occurs to the total stroke, hence a 75 per cent cut-off means that the piston has traveled 75 per cent of total stroke before the steam port is closed. 95 per cent exhaust means that the valve starts to open at 95 percent of piston stroke.

Now, considering any form of continuously moving slide valve, it is obvious that in order to produce closure of the port during expansion, the valve face covering the port must be wider than the width of the port so that while the valve is moving a distance equal to this extra amount the steam is trapped in the cylinder. The amount that the valve overlaps the edge of the port when in mid position is called “Lap” and may be provided either on the steam inlet side or exhaust side of valve. For locomotive work exhaust lap is hardly ever provided but is common for marine or other condensing engines.

From what has been said it must be seen that there can be no expansion unless lap is provided. One more element of the valve must be explained before a clear understanding is obtained. Supposing the piston is at the extreme end of its stroke, the valve should either be just commencing to open or already opened a small amount, so that the piston has full steam pressure upon it at the earliest possible moment in its stroke. The amount by which the valve uncovers the port when the piston is at end of the stroke or - which is the same thing - the crank on dead center, is called Lead - pronounced like "seed” - or in other words, Lead is port opening on dead centers.

With these definitions clearly in mind, the functioning of any valve may be observed by laying out a diagram. Fig. 2. There are a number of diagrams used such as Bilgrams, Sweet, Releaux, Zenner, Rectangular and Elliptical. The Zenner will be used here, and we will decide to make the maximum movement of the valve or valve travel 7/16 in., Cut-off at 79 per cent of stroke, and Lead 1/64 in.

Describe the valve travel circle **ABCD** with radius of 7/32 in. to some convenient scale. Sixteen times will be a good scale, one inch on the diagram [as originally drawn; not as reproduced herein] will equal 1/16 in. on the actual valve. Lay in the diameters **AC**, **BD**, at right angles, and from **A** as center and with radius equal to the lead, describe a circle shown dotted. On line **AC,** set off a distance **AS** equal to the ratio of cut-off, that is, **AS** will be 79/100 of **AC**. Erect a perpendicular **Sb**, and from **h** draw a line to **hm,** to touch the lead circle and cut the travel circle at **m**. The perpendicular distance from this line to the center **bo** is the required Lap. With **bo** as radius describe Lap circle **bafedc,** join **om**, continue line **ob** to cut travel circle at **g**, bisect **og** and describe circle **fpgc**. Draw a line through intersection **c** to **o**. If the working is correct, **co** will continue straight to **h**. Continue line **gbo** to **t** and place line **idoel** at right angles. Describe a circle on **ot** and a circle **uwv** of radius **ow** equal to the port width. Join **ouj** and **ovk**. Shade in the crescent shaped area **fpgcba** and **ouwv** and the diagram will give all information regarding relative position of valve and piston.

Consider any radius such as **om**, **og**, **oh,** and so on, as crank positions, the crank turning in the direction of the arrow. Now, when the crank is at **om**, the piston obviously has not quite completed its stroke, but very close, and the valve is just on the point of opening to steam shown by point **f.** The crank revolves to **A**, dead center and end of stroke, the valve is open by the amount of lead indicated by **ap**. Now note how rapidly the valve opens for even small movements of the crank. When the crank is at **oxy**, port is open by the amount, **xy** and when at og the port is wide open, then commences to close till the crank reaches **h**, when entire closure occurs or cut-off. The valve remains closed while crank is going from **h** to **1**—Expansion—then the exhaust begins to open, and is wide open when crank reaches **j,** remains wide open to crank position **k,** then commences to close to crank position **1**. While the crank is going from **l** to **m**, a small amount of exhaust steam is trapped and compression occurs, till the port starts to open to steam once more at **m**. The position of the piston for the position of the crank can be found by erecting perpendiculars to line **CA**, such as **hs.** The length of the connecting rod will alter these positions slightly, but this is not taken into consideration in this explanatory diagram in order to avoid confusing the lay mind. If the reader will set out a few diagrams with different laps, leads and valve travels, he will readily see how Admission, Cutoff, Expansion, Compression and Exhaust are changed.

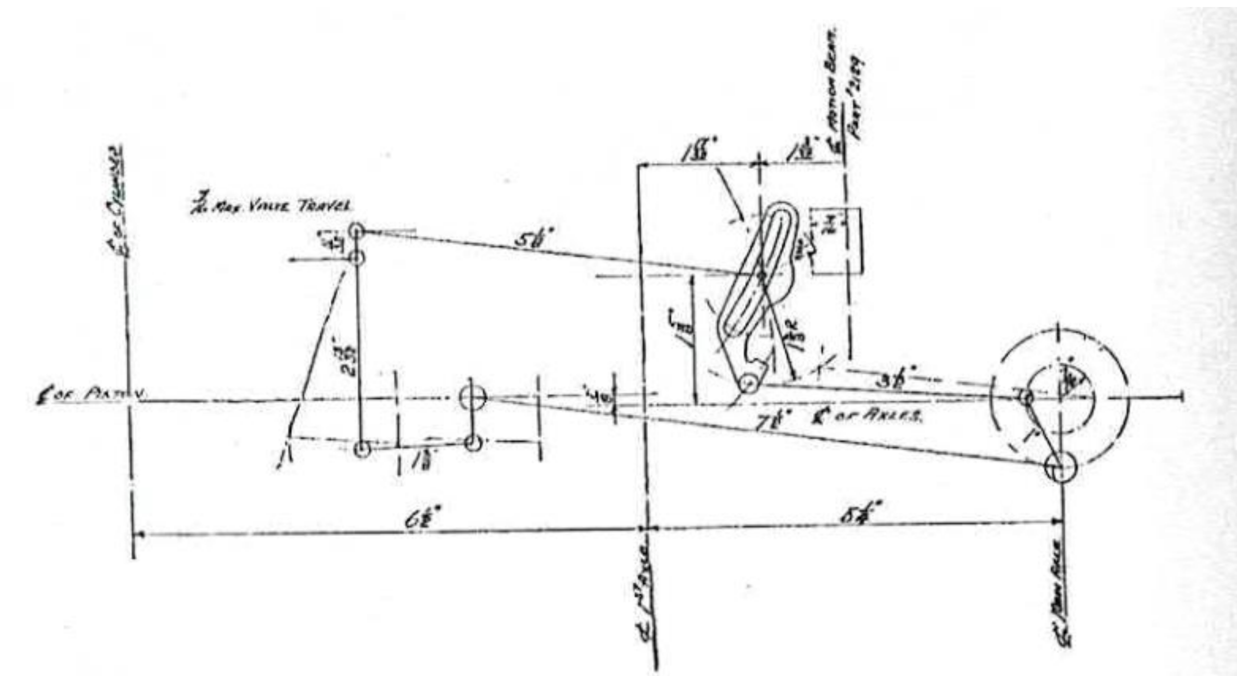


FIG 3

VALVE GEAR DIAGRAM. B&O P7 ¾ SCALE

Returning to our 3/4 in. model locomotive and tabulating our valve data, we will have:

Lap, 3/32 in.;
Lead, 1/64 in.;
Port width, 1/8 in.;
Travel, 7/16 in.,

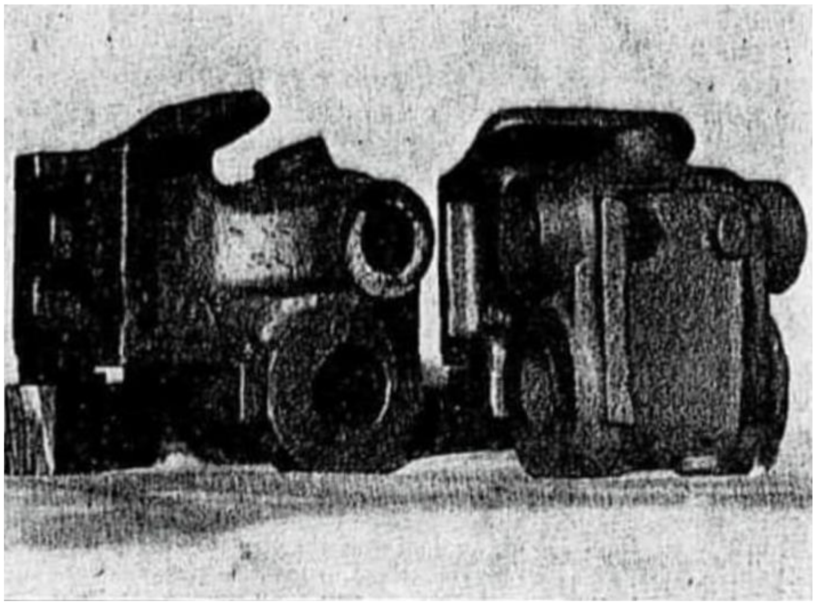
giving

Admission 5 degrees of angular crank movement before dead center,

Maximum opening at 22 per cent of stroke,
Cut-off at 75 per cent,
Exhaust at 93 per cent.

The modifying effect of the main rod has been taken into consideration. From these data, together with detail drawings of the full-size engine, the valve gear diagram Fig. 3, is laid out.

Machining the Cylinders



The photograph conveys some idea of the cylinders in the rough cast iron.

The **first operation** is to file up the outer vertical ribs, which have been purposely made parallel to the inner joint face, in order to facilitate marking out. Marking Out is exactly similar to the procedure[3] described for the 1/2 in. scale model. (See Modelmaker, November 1928.) [Appendix 2]

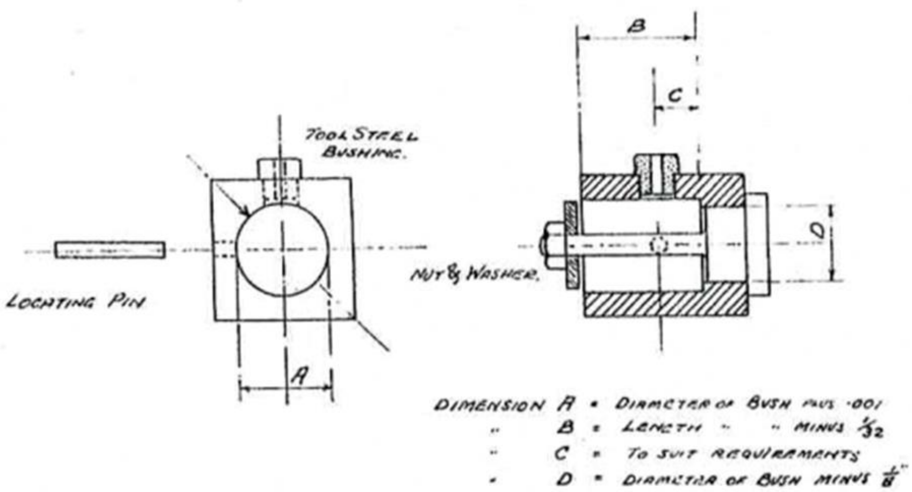
After marking out, bolt to the lathe face plate and locate so that the center lines of the valve chamber are on the lathe centers. Face off the joint and at same time bore into the exhaust passage to receive the 5/8 in. locating plug. This plug will serve two purposes; first, to locate the cylinders to each other, and second, to avoid the exhaust from one cylinder blowing over and building up back pressure on the other. Bolt the two cylinders together, with the plug fitted tight in one and easy in the other, and shape or mill the frame seat.

The **boring of the steam chest and cylinder** may be accomplished by bolting the casting to an angle on the face plate of the lathe. In facing off the ends, be careful that the dimensions are exact and equal from each side of the center line. The final operation is to drill a row of holes into the steam port core pockets. The connecting pieces between the holes may be chipped or milled out if desired, although there is ample area if left as shown on the drawing.

[3] (p.208)

The **piston valve bushes** are, it is believed, unique in model locomotive design in the U. S. and follow very closely full-size orthodox practice. Provision of peep holes as is common in full-size cylinders makes the valve setting easier because the edge of the valve can be spied through these holes.

It is, of course, essential that the eight, 1/8 in. steam port holes should be drilled exactly in line with each other and to do this a simple drilling jig is required, made like sketch Fig. 4.



JIG FOR DRILLING EIGHT HOLES IN P.V. BUSHES.

FIG 4

Take a piece of 1-1/4 in. square cold rolled steel, center it and bore out to 1.002 in., or an easy slide fit on the bush. Leave a shoulder at the bottom so that the bush can be held in tight by the bolt as shown. Locate the hole for the drill bush, also an 1/8 in. pin hole on one of the faces at right angles. Make the drill bush of drill rod or tool steel, harden, and press it into the jig body.

Having the bush already turned, slip it in the jig and bolt it up. Run the drill through, then loosen the holding bolt and turn the bush round until the hole already drilled will engage with an 1/8 in. pin inserted in the hole in the side of the jig. Lock it up and drill again. Repeat the operation until four holes are produced. Be careful not to drill into the bolt. Take out the bush and scribe a line through one of the 1/8 in. holes right along the bush. Now slip the bush in so that the line registers with the arrow scribed across the diagonal of the jig. Drill again and repeat the operation with the pin as above. All eight boles should now be nicely spaced and exactly in line around the bush.

The finish of the cylinder steam chest bore should be smooth, also the bushes. Dope the bush well with a paste or paint of white lead and lubricating oil and press in, taking care to have the exhaust port facing the center of the saddle joint and the steam ports leading. Heating the cylinder by boiling will facilitate the job.

Cylinder details. Most of these are simple, straight forward lathe jobs. A flanged cast iron bush is provided for turning the piston packing rings. In order that rings shall be effective in making a steam tight seal, it is necessary that they make contact with the surface all around and that this fit should be maintained by the spring effect of the ring. In other words, the ring should be a true circle after splitting. Chuck the bush and face off the flange, remove and clip to the lathe face plate by the flange. Bore and turn to the dimensions given and cut off the rings with a keen narrow cutting off tool. If the tool is ground with a slight bevel so that the point leads, the rings will drop off with hardly any fin. Four rings are required. Next cut out about 1/16", then turn up a mandrel to fit the bore of the ring when the gap is closed, then turn down the end and screw say 1/2" and fit a washer and nut. Slip on two rings, close in and lock tight with the nut. Turn the rings with light cuts and fine feed to fit the cylinder bore.

Valve chest back heads should first be marked out, and milled or fitted on the guide faces, then bolt on to an angle bracket to the lathe face plate so that its face is 3/16" out from the lathe centers, then attach the back heads to it and locate as centrally as possible. Turn and face the spigot to suit the valve chamber bush, and drill and ream for the valve spindle at the same time.

Crossheads are of malleable cast iron, a material that is tough and strong, and finishes the same as steel. These are castings having a cored pocket for reception of the stub end of the main rod. A lug is cast on to facilitate marking out and machining. The method of machining will depend upon available facilities. If a four-jaw chuck is used, first hold by the body and locate so that the collar and neck part is running true, take a cleaning cut over the lug and collar. If a four-jaw chuck is not used, it would be best to clean up the slipper face and bolt to an angle on the lathe face plate, then turn the lug as before. With the lug laid in a vee block on a surface plate, scribe off center for the wrist pin and also the groove of the slipper. Carefully file or better, mill the groove and slipper face. Set up on an angle with the lug level and drill for the wrist pin. This can be done either on the lathe or a drill press. Now turn the crosshead around so that the lug is again on lathe centers and running true, check this by putting a length of 5/16" drill rod through the wrist pin hole. The rod should be parallel to the face plate. If not make it so and disregard the lug. Bolt up tight and saw off the lug, face the boss and collar, center, drill and ream with a 1/8" standard pipe reamer. Go in a little at a time and test with the piston rod which is already made. The dimension from the collar on the piston rod to the face of the collar on the cross head should be 2-15/16". Ream carefully until this is obtained. The slipper should now be nicely parallel to the rod, and the wrist pin hole square with both. The final operation is to drill, tap, and shape the little boss on the bottom of the crosshead, for the union link.

Crosshead guides. These are to be milled out of mild steel. Take a length sufficient to make one pair and mill a groove, cut the bar in half and clamp over a piece of flat stock equal in width and thickness to the crosshead slipper, drill and tap for the row of holding bolts, and finish out according to the detail drawing.

Frames are best made of cold rolled steel, 3/8" thick. Cast brass frames are not recommended. Clean up the bars with emery cloth and copper plate for marking out. Cut out the various openings by drilling rows of holes close together and saw with the hacksaw. Most probably the bar will warp a little after the pedestal openings are cut. This should be corrected (methods have already been described in previous issues of Modelmaker)[4] before filing the jaws to size. The recesses for the rear frame cradle should be milled with a small end mill working close to the lines.

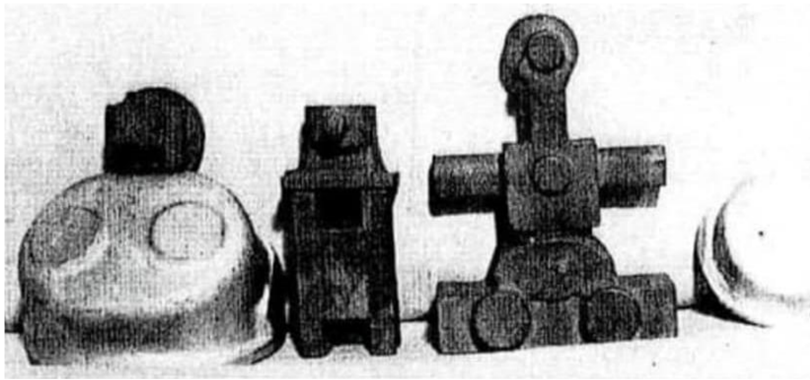
Guide Yoke, Motion Beam Brace and Crosstie can all be finished, either with a file or milling machine; if the latter, two cutters may be mounted on an arbor, at the correct distance apart for frame fit and each casting run through. They will then be alike and when the frames are fitted, they will be parallel and square.

The Front Bumper and Deck Plate can be treated similarly.

Rear Frame Cradle. This is a one-piece malleable iron casting. Owing to its irregular shape, special lugs have been cast on which will be found to greatly facilitate marking out. Clean those lugs up on the top edges and lay the casting down on a surface plate. It will be upside down from its normal position. Mark out the end that fits in the frames, also the end flanges which eventually carry the cab deck apron plate. File or mill the surfaces, to dimensions. Do not remove lugs yet, this can be done at final assembly, if everything is found correct.

The **Spring Rigging** should next be made up. Hangers may be made by cutting up strips of steel, sufficiently long. Finish one piece outright and case harden, then take each of the other pieces and drill one of the holes, lay the case-hardened one on with a drill rod pin through the hole and drill through the other end. Do this for all similar strips. The holes, of. course, are to be tapping size. String all the strips on a pin at each end and clamp together, the profile can now be finished with a file. Finish the hole by tapping or drilling to clear the link hanger pins. The making of springs was described in Modelmaker, both in notes on ½" B. & O. "President Washington" [Appendix 2] and an article by the writer on "Model Springs" [Appendix 3]. The detail drawing gives all necessary information.

[4] vol 6, p. 27-20 (1929) [Appendix 2[

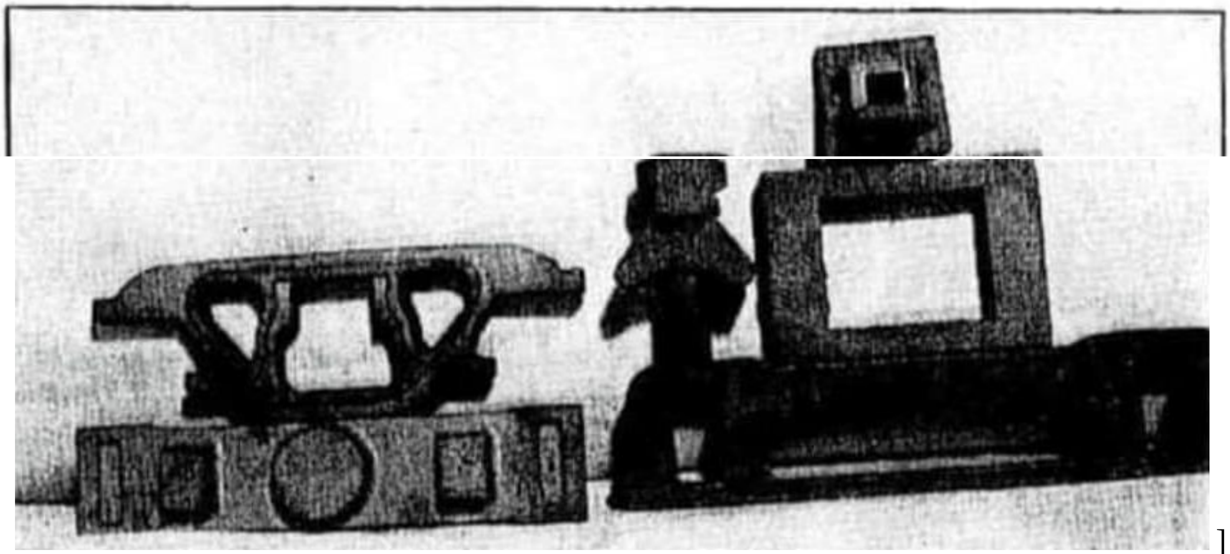


The **Equalizer Brackets** are malleable iron castings which also carry the top ends of the brake hangers. They form a simple milling or die and drilling job.

Wheels. The drivers being 5" diameter may be too large for the average model maker's chuck, so the lathe face plate must be used. Proceed as follows: Bolt the wheel to the face plate, back side out, by means of three bolts passed through spoke spaces, being careful not to use too much force or the spokes may be fractured. Estimate the amount of metal to be taken off the back and face off the rim and boss; do not bore the boss or turn the flange. Now remove and reverse the wheel, bolt on to the face plate with three pieces of parallel packing (square drill rod is ideal) between the face plate and the rim. Center the wheel as true as possible. The wheel may now be finished outright, turn the rim and flange, face the boss, then drill, bore and ream. In turning the rim, it is as well to set the top slide of the lathe over 2 ½ degrees. Feed up with the saddle until the wheel is 5" diam., and while the tool is at the throat of the flange, lock the saddle and back off with the top slide. This will put on the correct taper. The flange may be turned with a right and left radius tool, but a few careful strokes of a good file while the wheel is revolving will be just as good.

Axles. Cut off pieces of cold rolled steel 1/16" longer than the finished axle. Put in the lathe chuck, face off the end with a minimum cleaning cut, using a side tool and cutting lubricant; soda, water, lard oil or soluble oil solution. This will produce a high finish. Before removing from the chuck, center drill with a small "Slocomb"[5] not more than 1/16" and do not go too deep with the cone part, because large and uneven centers on the ends of axles look bad. All the axles of a set can be treated, then set the universal square to the exact overall length of the axle, and scribe a mark on the axle by resting the finished end against the head and length of axle against the blade. Place each axle in the chuck and face off the ends to line, and center drill. The rest of the axle is a plain "between center" turning job, gauging the shoulders from the finished ends. The measurement over the shoulders should be checked with the drawing and made correct, if not already so.

[5] A lathe center drill, also known as a combined drill and countersink.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Valve gear is to be cut from cold drawn steel of the following sizes or nearest equivalent:

Union link, ¼” x ¼”,
Combination lever, ¼” x 3/8”,
Radius rod, ¼” x 3/8”,
Eccentric rod, 3/8” x ½”,
Eccentric crank, and expansion link, 3/16” x 1”,
Expansion link trunnions, ¾” x 1”.

A milling machine will be useful and save much labor in cutting the various rods, otherwise the whole job is straight forward and needs only care and patience. The expansion link is carefully marked out on the 3/16" x 1" steel, taking particular care with the center line radius. With a freshly sharpened center punch, prick punch the intersection of the radius line and center line, and from this step off with a pair of small dividers or a spacing punch, the distance of 3/16", on the line. Carefully prick the points, exactly on the line. A watch makers eye glass will be found a very useful assistant in this operation. Now spot each point with a small drill, say No 44, or a Slocomb number 11 center drill, and then drill through with a 5/32” or No. 20 drill.

The ends of the slot are drilled No. 10. Next take a jewelers saw and saw out the connection pieces between the holes, so that thin files may be passed through. The convex side of the slot can be finished up with the flat side of a half round file and the concave side with the round edge or with a crochet file, which has both faces curved, one much shallower than the other. Work close to the line. It will be found that if the drilling has been done carefully the file will follow the curved path very easily. A piece of 3/16” drill rod makes a good gauge. It should slide up and down the slot without shake or sticking. The outline of the link can now be filed up, taking care to make the distance from center line to the back of the lug where the trunnions will presently be rivetted, exact to dimension, and square.

The **Trunnions** are made from small blocks of steel in one piece. Mark out and turn the trunnions between lathe centers. Perhaps a little trouble will be experienced in mounting between lathe centers. If the tail stock barrel does not permit of allowing the lathe saddle sufficient room, remove the center and insert the drill chuck holding a piece of drill rod having a cone center. This will act as an extended center. After the trunnions are turned, mill the material out between the trunnions to a depth equal to the distance between the center line of the link and the back of the lug on the link, making a neat fit to the link. Mill out the clearance for the radius rod, clamp on the link, drill right through and countersink both sides of the holes; then rivet up with soft steel wire or Bessemer rod. Finally cut away the back of the lug and finish to the profile given on the drawing. If no milling machine is available, drill, hacksaw and file must be used, taking care to make the opening for the link square with the trunnions.

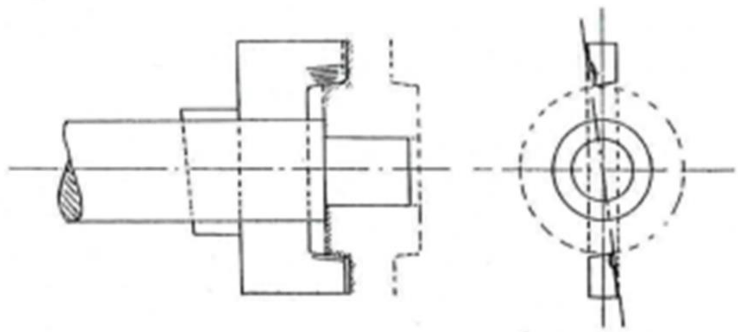
The other **rods and levers** can be cut out either by hacksaw and file or milling machine. In order to produce a nice finish with square edges, “draw file” with a No. 3 or 4 American Swiss hand file. This will be found superior to using emery cloth or buffing which has a tendency to round the edges and curve the surfaces which should be flat. The rounded ends or eyes where pins are used can readily be formed, as follows: Say an eye is to be formed to take a 2-56 screw pin, and the eye is 3/32" radius. Take a piece of 3/16 drill rod, chuck it, face off the end and drill No. 49 or tapping size for No. 2-56, cut off to say 1/4" long. Make two pieces and harden right out. Now drill the part or eye of the lever No. 49 and push a piece of No. 49 drill rod through so that about 3/16” stands through each side. On these ends slip the little steel bushes already made, put the whole set in the vise and file down to the bushes. A neat radius will result. The No. 49 hole can now be tapped and opened out for the pin as desired. A set of these little bushes and pins for various screws will be found useful. The outside diameter of the bush is usually twice the diameter of the body of the screw or pin.

The **eccentric rod**, that is the rod connecting the link to the return crank, should be left un-drilled until the valves are set.

Link brackets are of malleable iron and are cast together. They should be finished and bushed with brass, then fitted, the holes tapped and bolted to the motion beam, and finally taken off and sawed in two. If everything has been done correctly, when the link is put in and the bracket bolted up tight, the link should swing freely without shake. If it binds it is probably due to the inner faces of the brackets being a little full and nipping the trunnions end-wise. Ease down the bracket with a file.

The **reverse shaft and brackets** can now be made and fitted up to the motion beam, and all the special screws and pins made. Case harden any lever end that swings on a pin such as the combination lever and harden any pin that swings like those in the union link.

Side Rods and Main Rods are of malleable iron casting and their treatment is exactly similar to those already described for 1/2” scale model. These parts may be made either from solid steel, cast in nickel silver or malleable iron castings. The cast form has the advantage of eliminating a lot of hard work in cutting from solid and when finished up nicely leave little to be desired. The main rod may be first filed up to the dimensions and then the centers of the crank pin and wrist pin laid off. Drill and ream both holes and press in a brass bush at the crank pin end or "back end.” The main rod is more than likely too long to be swung in the average amateur's lathe, but if the following method is used, no great difficulty will be found.



Take out the lathe tool post and bolt on an angle. Having the rod marked out, clamp to the angle so that center of the big end is on lathe centers. Put a Slocomb drill in the chuck and feed up the saddle thus bringing the rod in towards the drill. Drill through and finish with a boring bar between centers. Face the boss with a pin drill or counter bore and face the diameter of the boss with a tool like the sketch, held in the chuck. Run this tool slowly and use cutting solution. Turn the rod over and treat the other side. If the amateur has a milling machine, a simple method of holding the rods on the table for the first cuts is to make a shallow tray of sheet metal or wood will do and pour lead or babbitt metal in around the rod. When cool. clamp the metal slab to the machine table and finish one side. Melt the lead, take out the rod, and this time the lead can be dispensed with, and steel packing placed between the machined surface and the machine table, and the rod held down by pinch plates and bolts. The molten lead method can, of course, be used for both sides and is quite effective if care is taken to level up the rod by its machined face before pouring.

Brake Rigging is a very similar job to the valve gear and is mainly cut from cold rolled steel. The brake hangers and main cylinder levers are, however, malleable iron castings. If the detail drawings are followed carefully there should be no difficulty in bringing all parts together. One note of warning, be careful to make the main brake hangers right and left hand. This is brought about by the fact that the brake shoe is set 1/16" behind the vertical center line. This offset is not very apparent in the rough casting, so it is best to pair up the rough castings before doing any drilling. The brake shoes are made by turning up a cast iron ring, boring to 5" dia. and grooving the edge. The shoes are then cut out to profile. If a hardened template or dummy shoe is made and bolted to the segment it will facilitate filing and all shoes will be the same. Be careful in tapping the hanger pin hole that the shoes are made right and left hand. Three shoes must be tapped one side and three the other.

Having reached this stage, **assembly of the engine** may be undertaken, and the first requirement is that the frames should be in-line with each other horizontally and vertically. There is more than one way of doing this; the method adopted depending upon the amateur's facilities. The frames have already been finished together, and while still riveted or bolted temporarily, scribe lines across the top rail at say the center line of the motion beam and the centerline of each equalizer fulcrum bracket and the drivers. Score these lines plainly. Now separate the frames and cut off say three pieces of 3/8" or ½" diameter steel exactly 2 1/8" long, tap one 10-32 and two for No. 2-56.

Lay the frames on a level surface with the top rail face downwards. Place the No. 10-32 tapped distance piece at the cylinder end and the other two at any convenient hole near the middle and the end. Screw up tight. If the drilling has been done squarely and a square is placed along the outside of the frame at one of the scribed lines, the line on the other frame will check and when the frame is placed upside down on a level surface it will rest firmly without rocking. A straight edge placed across the cylinder seat will show parallel to another placed across the top of the frame and the rear frame cradle will slide nicely into place. Check up the frames in this manner before proceeding to fit the details. If the tests show that the drilling is off, due to "wandering" of a drill or other causes, then take off one frame and open the hole slightly and screw up gently, tap the frame with the hammer till the scribed lines show square and other tests register correctly, then tighten up.

Place the cylinders in, they should fit snug. See that they go right down to the seat and fit closely between the ends of the seat in the frame. Clamp the cylinders in position but do not drill yet. Place the bumper beam and deck plate in position, clamp, drill, and tap for screws and screw up. The same may be done with the motion beam, guide yoke, rear frame cradle, brace and frame tie. The temporary ties must, of course, be removed one at a time as the various details are fitted in. The next job is to secure the cylinders, so take out all screws from one side of frame, thus freeing the frame entirely and leaving the other with all the braces, etc., standing; also take off the corresponding cylinder, thus leaving the other still clamped to the frame. The three No. 10-32 screw holes can now be tapped using the frame as a jig for the drilling by starting with a No.11 drill to make a pilot center for a No. 21 tapping size drill. Be very careful not to drill into the cylinder bore. This can be avoided by setting the collar or stop of the drill press or by slipping a piece of tubing of correct length over the drill, to act as a stop. Care must also be taken in tapping because a broken tap here is decidedly annoying. Go in a little way with the taper tap, back out, and use the plug tap, a little way, follow with the taper tap a little further, then the plug, and so on. Use white lead and lubricating oil paint, and clean the chips off the tap each time. This will produce good clean threads and avoid broken taps. When the cylinder is fitted to each frame the whole can be reassembled.

The next job is to **fit the bearings**. Full description of this operation has already been given in the notes on the 1/2 " scale model, and the same method may be adopted here. The **brake hanger brackets** follow next, then the **spring rigging** can be assembled. Take care to number each piece and its location so that they will always go back in the same place. Fit up the wheels and axles in the bearings and see that they revolve freely. Test for parallelism by calipering over each pair of axles on each side, and for squareness to the frames by means of a small square placed against the frame and axle on the inside of the frame. If correct, the side rods can be erected, and the wheels revolved. They should do so without decided binding, although they may be a little stiff throughout the revolution. If a decided stiffness is experienced, then take away the rear side rods which may give the main and front wheels freedom, thus indicating the trouble to be in either right or left rear crank pin. If not, then the binding must be sought in either the right or left front pin. To remedy, scrape out the rod brasses. Full size brasses are bored 1/32 inches larger diameter than the diameter of the pin when new, so side rods should not be fitted too closely.

The cylinders can now be assembled completely if not already done with glands packed, guide bars must be fitted between the back cylinder cover and guide yoke, and one main rod connected up. Turn over the wheels to see if the crosshead or main rod back end is binding, then do the same with the other rod. When this is satisfactory the valve gear can be assembled. Connect up the union link and combination lever. Find the front and back dead center and mark the crosshead and wheel at these points. Methods of doing this have already in the pages of The Modelmaker and an excellent book on the whole subject of valve setting “Locomotive Valve Gears and Setting" can be had through Spon & Chamberlain[6].

Place the engine on a level surface resting on two lengths of say ¼” square cold rolled steel and place the crank pin on front dead center. Set a surface gauge to the axle center or crank pin center (they should be identical). Push on the eccentric crank, raise the surface gauge needle 7/16” and set the eccentric crank pin to register with it. Now set the main crank in vertically under the axle, and the combination lever, vertical. The radius rod should now fit into place between the expansion link and combination lever. If it does not then, the expansion link brackets must be shimmed out or foot reduced, according to whether the distance shows long or short. If this is correct, then set the link so that when the radius rod is pushed up and down the slot, no movement is caused in the combination lever or the link. The combination lever may be temporarily clamped to the guide bar to facilitate this operation. When the proper position of the link is found, which will be its position in mid-valve travel, secure it by any suitable means (a little wooden wedge, between the link and bracket will do), and with the main crank on front dead center set a pair of dividers to the center of the eccentric crank pin and the hole in the bottom of the link. This will be the length of the eccentric rod, scribe off, prick punch and drill accordingly. Fit the eccentric rod in place and try over again with the main crank at top and then bottom. In either of these positions the radius rod should move up and down the slot without movement to the combination lever.

Next having the crank on front dead center and the steam chest front cover removed also the peep hole plug. Push the valve already mounted on its spindle into the chest, and screw into the valve spindle crosshead. This is easily accomplished by means of a socket wrench made to fit the valve spindle nut. The “lead” is 1/64 inch. A B&S or No. 6 music wire gauge is inserted in the front peep hole and the valve is gently screwed along until it just touches the wire on the inner edge of the valve, the lock nut on the valve spindle may then be tightened against the crosshead neck. Pull the wire out and turn over the wheels till the back dead center is reached. The port should now be open by 1/64 and the wire may be tried in. If it does not or is very sloppy, then a compromise must be had by making the “leads” as nearly alike as possible by adjusting the valve on the spindle. The peep holes will be found very valuable in checking the distance from port to port by pushing in two pieces of 1/8” drill rod and measuring over with the micrometer. The micrometer reading should be 1-7/16". If it is more or less, then the valve should be made the same overall, but the plugs (i.e., the pistons at each end of the valve) should be made to the width as given on the drawing in order to maintain the “lap."

[6] The publisher of THE MODELMAKER magazine.

The steam pipes and lubricator connections may now be fitted, and a temporary supply pipe connected to air service or a separate steam boiler, for test and running in[7].

[7] Here the articles in THE MODELMAKER specific to the 3.5-inch gauge version ended.

Appendix 1 – Sectional List - Castings and Prints

Section	Castings	No. Each	Currently Available	Shown on Prints
1	500 Cylinders	2	X	125C and 126B [710] Lists of Patterns, Drawing Materials. & Screws
	501 Cylinder Cover - Front	2	X	
	502 Cylinder Cover - Back	2	X	
	503 Gland	1	X	
	504 Packing Ring Bush	1		
2	505 Crosshead	2	X	127B, 128B, 129B, 130B, 151B and 182B [711, 712, 713, 719]
	506 Steam Chest Backhead	2		
	507 Guide Yoke	1	X	
	508 Motion Beam	1	X	
	509 Bumper	1	X	
	510 Bumper Deck Plate	1	X	
	516 Coupler Pocket	1	X	
3	511 Main Rod	2		131B, 132B, 133C, 139B [712, 713, 710, 715]
	512 Front Side Rod	2		
	513 Rear Side Rod	2		
	514 Main Driver	2	X	
	515 Front & Back Main Driver	4	X	
4	518 Coupler Crosstie	1	X	134B, 138C, 167C, 170B [713, 714, 703, 715]
	519 Brake Fulcrum	2	X	
	520 Frame Brace	1	X	
	521 Brake Hanger Bracket	4	X	
	528 Rear Frame Cradle	1	X	
5	531 Main Bearings	3	X	120C, 121c, 141B, 142B, 143B, 144B, 145B [700, 702, 720, 715]
	532 Main Bearings Slug	1	X	
	533 Brake Cylinder	1	X	
	534 Brake Lever	2	X	
	535 Brake Hanger	4	X	
	536 Brake Hanger at Trailer	2	X	
	537 Brake Shoe Ring	1	X	
	538 Transverse Equalizer	1	X	
6	522 Trailer Truck	1	X	136B, 137B, 146B [713, 715, 716]
	529 Trailer Wheel	2	X	
	530 Trailer Box	2	X	
7	523 Engine Truck Side Frame	2	X	136B, 137B, 146B [713, 715, 716]
	524 Engine Truck Bolster	1	X	
	525 Engine Truck Transom	1	X	
	526 Engine Truck Center Plate	1	X	
	527 Engine Truck & Tender Wheels	12	X	

Section	Castings	No. Each	Currently Available	Shown on Prints
8	550 Link Brackets	2	X	147B, 150B, 168B 718, 712, 717]
	551 Reverse Shaft Bracket	2	X	
	552L Lifting Arm	1	X	
	552R Lifting Arm	1	X	
	539 Smoke Box Front	1	X	
	540 Smoke Box Ring	1	X	
	541 Smoke Box Door	1	X	
9	542 Smokestack	1	X	148B, 149B [718, 717]
	543 Smokestack Base	1	X	
	544 Smokestack Washer	1	X	
	545 Draft Pipe	1	X	
	546 Exhaust Pipe Base	1	X	
	547 Exhaust Tip	1	X	
	548 Superheater Header	1	X	
10	549 Dry Pipe Gland	1	X	153C, 154B, 155B, 156B, 157B, 158B, 165B [705, 718, 719, 716, 719, 717]
	555 Top Feed Connection	1	X	
	556 Top Feed Pipe Flanges	1	X	
	557 Turret	1	X	
	558 Mud Ring	1	X	
	559 Firehole Ring	1	X	
	560 Fire Door	1	X	
	561 Fire Door Hinge	1	X	
	562 Fire Bar	13		
	563 Fire Bar Support	2	X	
	564 Steam Pipe Gland	1	X	
	583 Feed Connection Flanges	1	X	
	584 Safety Valve Flange	1	X	
	585 Safety Valve Body	1		
	586 Safety Valve Cap	1		
11	553 Sand Box	1	X	152B, 161C, 122C, 169B [716, 722, 719]
	554 Steam Dome Cover	1	X	
	576 Cab Front Plate	1	X	
	577 Cab Rear Plate	1		
	578 Cab Sash	4		
12	579 Power Reverse Cylinder	1	X	162B, 163B, 164B, 166B, 171B, 172B [709, 716, 718]
	580 Power Reverse Chest	1	X	
	581 Power Reverse Guide	1	X	
	582 Headlight	1	X	
	587 Cylinder Cock	4		
	588 Lubricator Valve	2		
13	589 Tender Underframe	1	X	123C, 124C [701, 721]
14	590 Tender Truck Frame	4	X	173B, 174B 176B [709]
	591 Tender Truck Box	8	X	

Section	**Castings**	**No. Each**	**Currently Available**	**Shown on Prints**
	592 Tender Truck Bolster	2	X	
	593 Tender Body Bolster	2		
15	594 Hand Pump Body	1	X	175B, 177B, 178B, 179B, 180B, 181B [722]
	595 Hand Pump Delivery Connection	3	X	
	596 Check Valve	3		
	597 Blow Off Valve	1	X	
	598 Tender Tank Filler	1	X	
	599 Bell Yoke	1	X	
	602 Bell Bracket	1	X	
	603 Bell Frame	1	X	
	604 Air Pump	1	X	
	605 Coupler Top	2	X	
	606 Coupler Bottom	2	X	
	607 Coupler Knuckle	2	X	
	608 Steam Pipe Lagging	4		
	609 Brake Cylinder Auto Drain Cock	1		

Availability updated February 4, 2024

Appendix 2 – 2.5-inch Gauge "PRESIDENT WASHINGTON"

A WORKING MODEL B.&O. R.R. LOCOMOTIVE[8]

½ Inch Scale

BY MR. H. J. COVENTRY

No one will deny the fact that the latest class of passenger locomotives, built for the Baltimore and Ohio R. R. are among the finest and most handsome of modern locomotives. Twenty engines of this class known as P7 were built in 1927 by the Baldwin Locomotive Works and named after the first twenty Presidents of the U. S. They were constructed to the specifications and under the supervision of Col. Geo. H. Emerson, the company's Chief of Motive Power and Equipment, and have the following characteristics:

Cylinders 27 in. bore, by 28 in. stroke.
Piston valves 14 in. diameter.
Wheels, 80 in.
Boiler heating surface, 3,846 sq. ft.
Grate area, 70.3 sq. ft.
Steam pressure, 230 pounds per sq. in.
Stoker fired.
Total weight of engine, 326,000 lbs.
Total weight of engine and tender, 540,000 lbs.
Tractive effort, 50,000 lbs.

The engines are painted throughout, Palmetto Green, except the smokebox and stack which are black, and lined with one broad line in gold and a narrow line in maroon close inside.

The type has some distinct advantages for modeling apart from any aesthetic value. The firebox is large, the wagon top boiler is somewhat easier to form than the Belpaire, and the barrel is of straight or conical sections. Engine and trailer truck frames are one-piece castings of Commonwealth Steel Co. design, valve gear is light; use being made of high tensile alloy steel.

The box type compound cross head guides and main rods may present difficulties, but if these notes on construction of the model are followed any such trouble should vanish.

Before passing to the notes on actual building a few characteristics of the model are given:

Cylinders 13/16" bore by 1-1/8" stroke.
Drivers 3-5/16" diameter.
Steam pressure 80 to 90 pounds per sq. in.
Tractive effort 10-3/4 pounds.
Weight on drivers approximately 30 lbs.

[8] From Vol. 5 of THE MODELMAKER, 1928, pg. 185

Boiler feed water supply is by means of one injector of L. Lawrence (L.B.S.C.) and a hand pump in the tender, either one of which feeds to a “top feed” connection in the correct position.

Fuel used is hard coal—starting on charcoal.

Lubrication of the cylinders is effected by using the brake air reservoirs as displacement lubricators. The reverse is a simple push and pull rod locked with a pawl in the cab. The rod passes through the power reverse gear, which latter is a dummy. Fully equalized spring rigging is provided and regular leaf springs fitted. The brake rigging is fully compensated and applied to all drivers, but not to the trucks. They are operated by means of a steam cylinder in the orthodox position, the draining of condensed steam being effected by means of an automatic valve of the writer’s design.

The smoke box front is screwed in thus giving maximum space for getting at the superheater heads and steam pipe joints. The blower is of a special design and as far as the writer is aware is quite new.

The cylinders are correct to the prototype and cast with half saddles in accordance with locomotive practice. Packing rings are fitted to both pistons and piston valves.

The work of building will be divided into fifteen sections, and each section will be fully described as to methods of machining tools[9] to use, fitting, etc., the aim being to assist the interested but uninitiated would-be devotee of this fascinating hobby of modelmaking, but it should be remembered that modelmaking, like golf, chess or any other pleasurable pursuit has its rules and methods, and the more quickly the rules are mastered the easier does the hobby become.

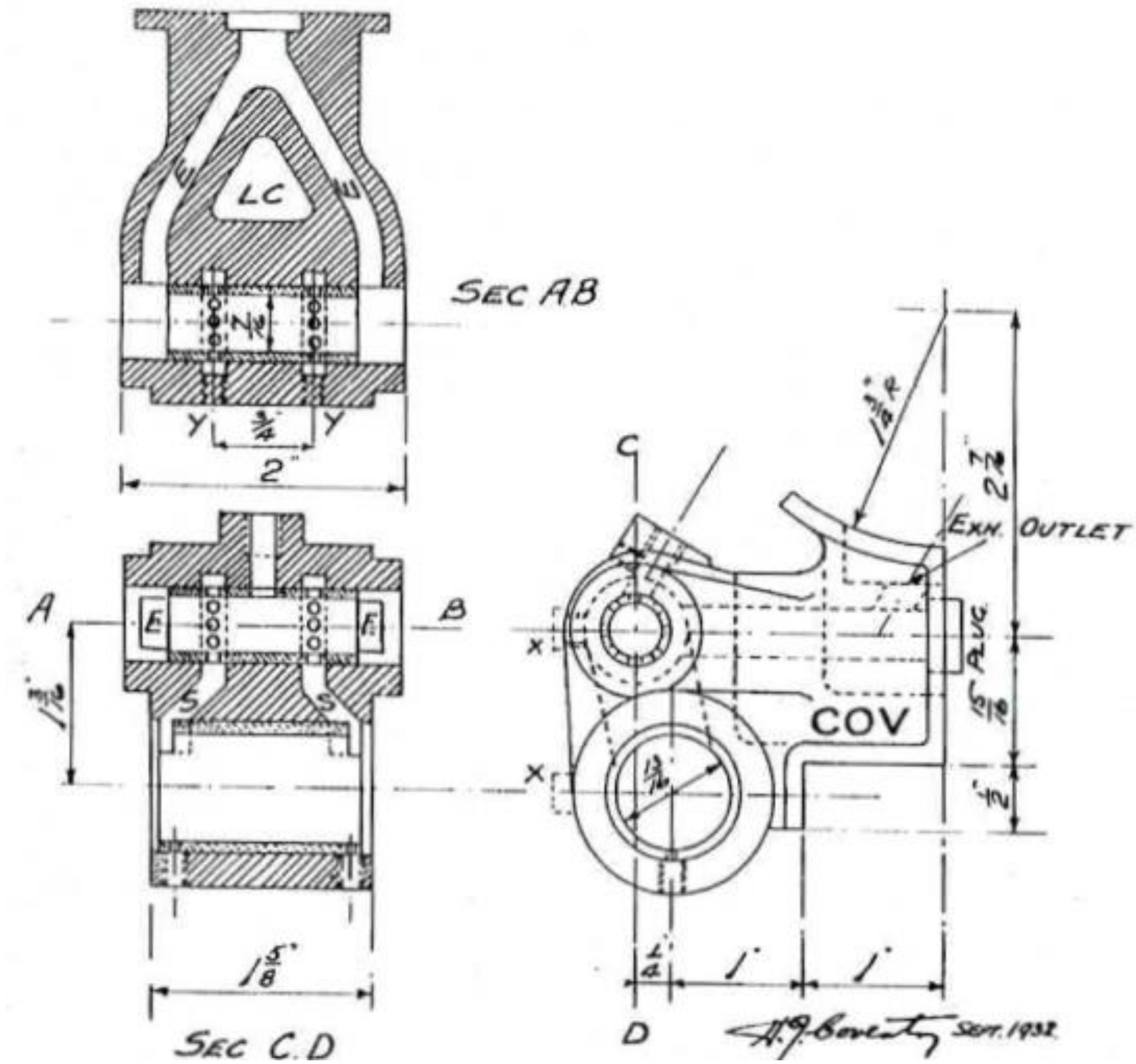
One of the first rules and guides is a good working drawing, and to be good each item should be fully and methodically dimensioned exactly as is done in full size engineering. Be suspicious of anyone offering so-called "simplified” drawings, as examination will show that the so-called simplification is mere crudity that invites all manner of trouble in machining and fitting. A good set of drawings to start with is a guarantee of a successful model. If the design is right, and a careful study of the drawing of any detail is the first prerequisite of actual operation on any casting or part. Next is to marshal shop facilities, consider the tools available, the various operations needed and the effect of sequence of operation. In other words, do not go at the job recklessly but, go step by step through the job in your mind before attempting to put the tool to the piece. In the notes to follow, general methods will be suggested as a basis on which the reader can make modifications to suit his particular equipment.

Cylinder Design

The need for a design of cylinder that should have its steam and exhaust passages all cored in, has long been felt by American modelmakers because although the alternative of drilling can be made fairly successful, port areas are necessarily limited and of course holes at right angles to each other are encountered, resulting in sharp angular turns decreasing efficiency.

The design illustrated is the result of many experiments and is found to be eminently successful.

[9] Mr. Coventry assumes a spartan shop equipped with lathe but not a milling machine.



Referring to the drawing, it will be noticed that full size practice is reproduced in principle, and in Sections **AB** and **CD**, the exhaust passage is clearly shown at **EJ**. The end of the passage at the central joint flange of the cylinder is to be plugged, which serves a dual purpose, (a) it locates each cylinder independently of the bolts and prevents the exhaust steam from one side blowing over to create back pressure on the other cylinder as it would tend to do without the plug. The final exhaust makes its escape to the blast pipe through a short, drilled hole into the cored exhaust passage. The steam passages are annular recesses in the chest and continued down into the cylinder barrel. These cores are made amply wide to ensure strength and prevent them being washed away when the molten metal is poured into the mold. These are marked **S** in the drawing. A lightening core **L.C.** is provided to insure sound metal between the saddle and steam chest.

Both the steam chest and cylinder barrel are bushed, as is done in full-size practice, and the casting is bored straight through for a press fit to both bushes. The bushes may be of steel or bronze. The valve bush is to be drilled with eight 3/32" holes by means of a jig described a few pages hence. It will be noticed that both bushes are made shorter than the cylinder. By this means, both bushes can be replaced if they become worn, without disturbing the fits of the cylinder and steam chest heads. In the case of the steam chest the bush covers the distance between the exhaust passages only because the valve does not travel beyond the end of the bush and a very free exhaust is obtained.

The castings are of gray iron, suitable for superheated steam. If steel bushes are used "Sumet" bronze is excellent material for pistons and valves, or if bronze bushes are used, stainless steel or cast iron may be used for these parts. Strips at **XX** are provided on the castings to facilitate marking out and machining, which may be done by methods already described by the writer and others in the pages of "The Modelmaker."

A valuable feature of this design is the possibility of using the regular orthodox "peep hole plugs" whereby the valve can be seen for setting purposes, these are shown at **YY**.

Machining of Cylinders

The **machining of cylinders** will, of course, depend largely upon available facilities. It will, however, be assumed that the average reader is not overburdened with equipment, but does possess a lathe of about 9" swing with slide rest and accessories such as face plate, self-centering chuck with inside and outside jaws, drill chuck and shank to fit the tailstock, and a set of drills from number 60 to 1. A light drill press is useful but not absolutely essential because much drilling can be done in the lathe if a plain face plate is fitted to the tailstock. A milling attachment to the lathe is also useful but these notes will be based on the absence of either a milling attachment or milling machine.

Having obtained the cylinder castings and detail drawing, study the latter carefully and observe where surfaces are to be machined. These are indicated by the letter "**f**" against them.

First file off any lumps or roughness and scratch off any traces of sand. Then file up the outer vertical ribs, which have been purposely made parallel to the inner joint face, in order to facilitate marking out. The ribs are to be removed when all is finished as is shown on the drawing. An allowance has been made shown dotted on the drawing, parallel to the inner bolting face. This facilitates marking out and holding to the face plate. Place the cylinder on a surface plate (a piece of thick plate glass makes a good substitute for a regular surface plate) with the joint bolting face upper most. With a surface gauge or scribing block, check over the face, if lower on one edge than the other, file the opposite outer rib; in other words, aim at getting the flanges as even thickness as possible, when they are subsequently machined. Now cut two small pieces of brass to fit tight in the cored hole of the cylinder. With the cylinder on the surface plate, scribe a center line on the steam chest, **A**. Reset the scriber the correct distance above this for the cylinder center line **B** and again for lines **C** & **D**. Now mount the casting on the lathe face plate, as at Fig. 2 and take a cleaning cut across the face **DD** but don't go right up to the line you have marked, leave a little metal on.

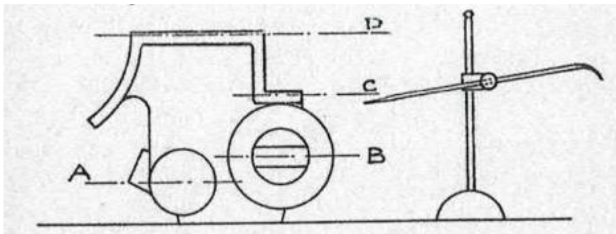


Fig 1

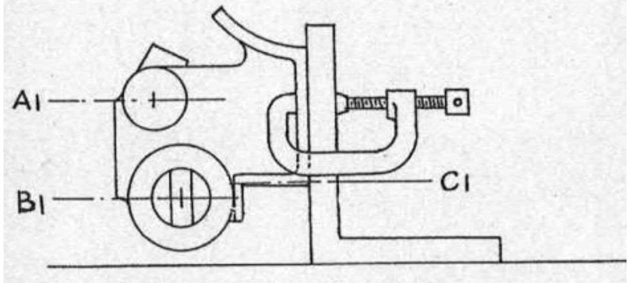
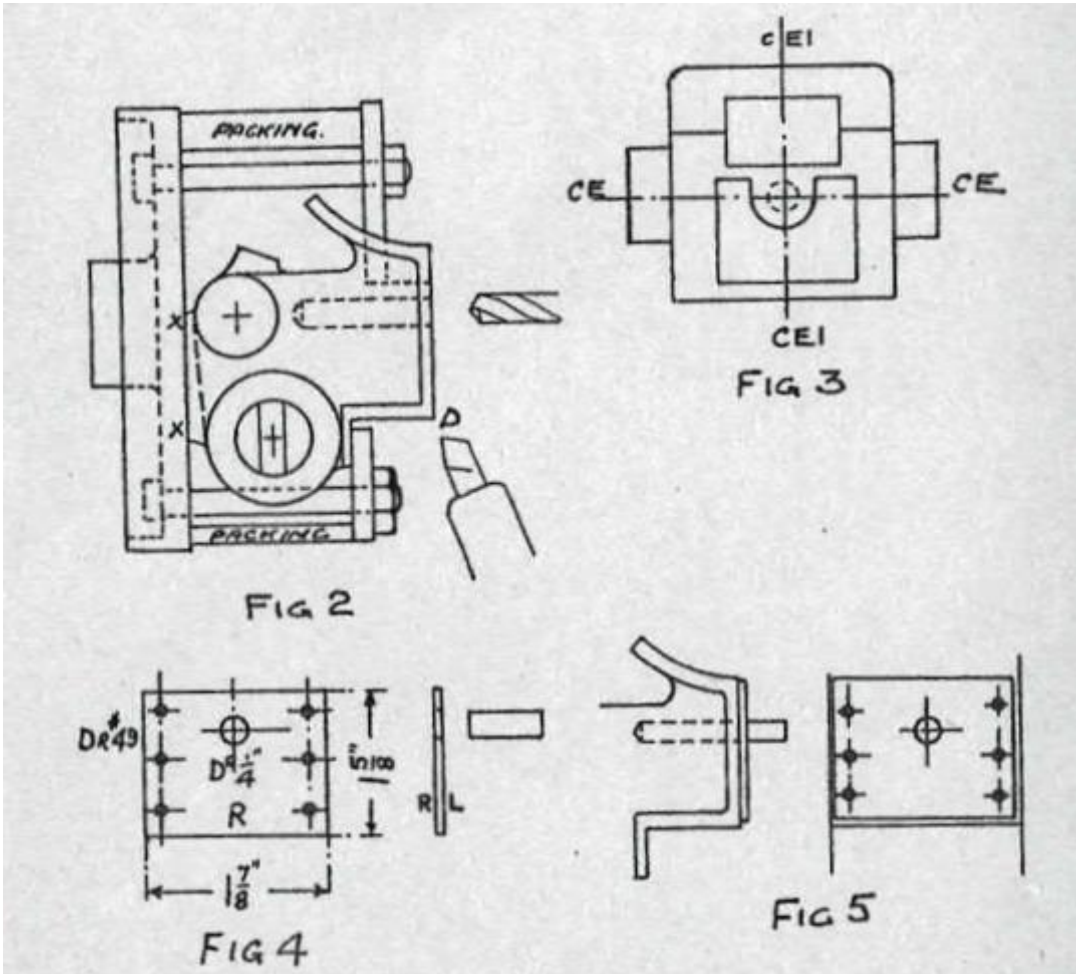


Fig 1A

Take the cylinder off the face plate and clamp it to an angle, level up as near as possible and scribe off the other line off centers **Al**, **Bl**, and **Cl** on Fig. 1A. Carry the line **Al** on to the inner flange, on both ends; in fact, it is well to mark all lines on both ends because this forms a check on subsequent work. Take off the angle and join the two lines **Al** across the inner face, **CE** on Fig. 3. This is the center line of the exhaust passage. Now intersect this line with the center line between the flanges, and you have the exact location of the exhaust passage. Prick punch this point carefully and mount the cylinder on the lathe face plate once more and shift about until this prick punch mark is running exactly on the lathe center. A scriber or other sharp point held in the tool post will facilitate this operation.

When running correctly, put a Slocomb center drill in the chuck mounted in the tailstock and drill the center. Then follow with a ¼" straight fluted drill and drill down a distance of not more than 1-3/4"; do not crowd the drill and release entirely from the hole frequently to avoid choking the flutes with chips. Observe that it does not wriggle, if it does, it is running out of truth due to either too much pressure or hitting a gas hole in the casting. This happens occasionally but if about 1/2" has been drilled satisfactorily, the drill is hardly likely to run "out." To remedy this, it is best to true up the hole with a little boring tool, and face up the bottom, re-center with the center drill, and follow with the twist drill as before. Obviously, this procedure is not practical if the hole is drilled deeply out of truth, therefore observe whether the drill is stationary, immediately as it begins to cut. Treat both cylinders alike to this point before doing anything more to either. Now make a template from about 1/16" flat steel 1-5/8' by 1-7/8". Mark off the exhaust passage and also the bolt holes according to the drawing. Drill the holes #49 which is tapping size for #2-56 screw and drill the exhaust hole ¼" diameter.



Take a piece of 1/4" drill rod, 2-1/2" long, put it in the exhaust passage of the cylinder and slip the template over the rod; Fig 5. Line up the bottom edge to the scribe lines on the cylinder, put a C cramp on one side and drill #49 holes in the cylinder saddle flange. Place another cramp on this edge, remove the first one, and drill this side. If you can get both cramps on at once without interfering with drilling so much the better. Do the other cylinders the same taking care not to turn the template over. It is best to mark the template R and L and use these faces against the corresponding cylinders. Now open out the 49 holes with a number 44 drill on one cylinder and tap the other cylinder #2-56. Slip the 1/4" steel pin in one cylinder and place the other cylinder on it. If everything has been done correctly, the two faces will come down squarely to an even bearing all over, and after the six #2-56 screws are put in, the lines on the saddle frame seats of each cylinder will be in line with each other. Having the cylinders bolted together, file up the frame seats to the lines. A 12" second cut square file will do rapid execution in roughing down and then finish with a 10" or 8" pillar file. When just down to the lines but not obliterated, take the cylinders apart and test the squareness of your work using a small square against face **D** (see Fig. 1) to test face **Cl** - Fig. 1A. Any inaccuracy can be corrected with a 6" American Swiss pillar file.

When this is correct, bolt the cylinder to an angle plate on the lathe face plate, square up along the edge **C** and locate the angle so that the cylinder center is running true. Balance with a weight; see Fig. 6.

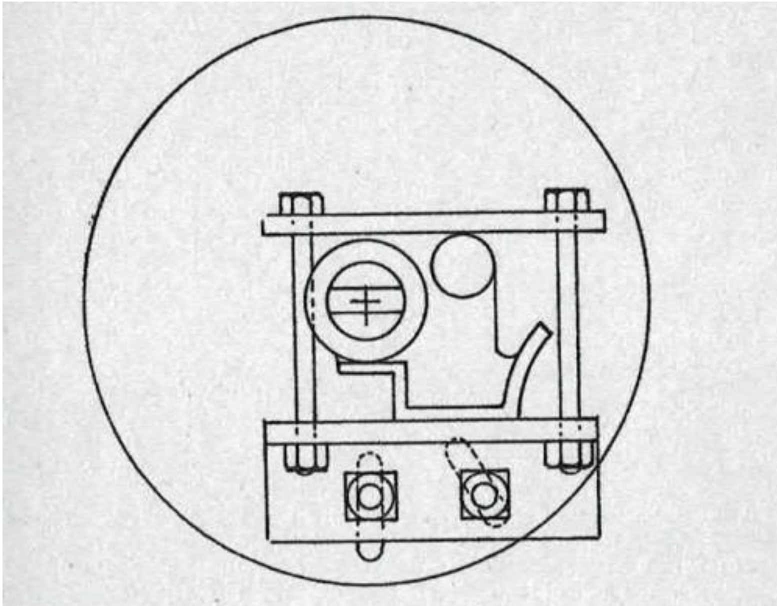


FIG 6

Bore out, finishing with a fine feed and a round nose tool that has been well oil stoned. In order to gauge the size of the bore, either set the inside calipers to the dimension and hold the setting for both cylinders, or better still, turn up a piece of steel to the exact diameter gauging with the micrometer, and use this as a plug gauge. The cylinders should be bored until the gauge just pushes in without shake.

Have the boring tool as stiff and short as the job will allow. The Armstrong[10] type of boring bar is a good tool and if precautions are taken to lock all slides of the slide rest excepting the saddle after setting of the tool for each cut, the bore should show a fine polished surface. Rough out with a pointed tool and finish with the round nose, with fine feed and light cuts.

After the cylinder bore is finished, shift the angle bracket until the steam chest center is running true. Drill with a center drill and follow with say a 5/8" drill and bore as for the cylinder or run a 47/64" drill through and follow with a 3/4" reamer. Another way is to use, say, a 3/8" drill first and follow with a counterbore tool having a 3/8" pilot and 3/4" body. If regular twist drills are used on brass, it will be found that they have a tendency to “grab” due to the keen cutting angle. This is quite easily overcome by giving the cutting edges a few strokes with a small oil stone, (See Fig. 7) held in line of the axis of the drill.

[10] A brand of lathe tools.

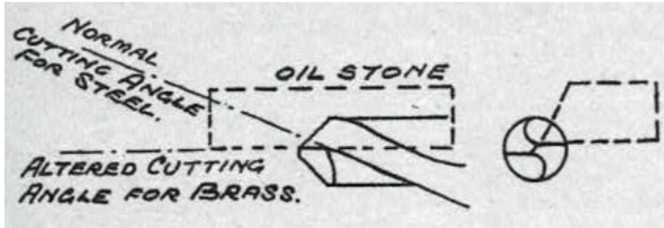


FIG 7

It will make the subsequent fitting of valve bushes easier if a ¾” reamer is used to finish, whatever the method adopted to bore, therefore allow about 0.005” on the surface to come off, either by using the 47/64" drill or making the counterbore 0.742 diameter.

Having accomplished all bores, the cylinders are ready for facing. To do this, mount on a 13/16" mandrel for the cylinder and ¾” for the steam chest. Put the 1/4" drill rod pin used for template Fig. 5, in the exhaust passage, set a depth gauge or universal square to 7/8" and face off the end of the steam chest until the gauge just slips over the face and at same time touches the pin. The face will now be 1 inch from the center in accordance with the drawing. Turn the mandrel and cylinder round and face the other end the same way. The chest should now be 2" overall. The cylinder ends can be treated in a similar manner. As a check on the work, put the two cylinders together when a straight edge laid across one face should just touch the other evenly. If it does not, reduce the higher face till it does, and use these faces to carry the back cylinder heads. Any slight error in length can be compensated by either the front cylinder head or the back of the piston as long as the error is not more than 1/64".

The 1/4" exhaust passage may now be drilled right through into the steam chest bore for remember, this was not drilled right down in order to provide solid metal for the steam chest bore. In order to machine out the smoke box saddle, if the lathe has sufficient capacity, the two cylinders may be bolted together and then bolted to the face plate by two bolts passing through to the cylinder bore; suitable packing being placed under the faces. They must, of course, be correctly located to give the required 1-3/4" radius of saddle. To do this, make a simple template like Fig. 8, of say #20G sheet brass, and solder in two pins, so that they fit under the cylinders frame seating.

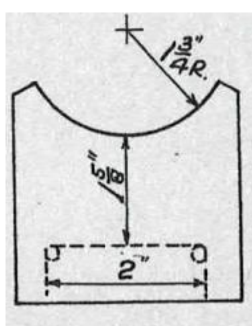


FIG 8

Mark out the radius of the smokebox, cut out and file up carefully to the line. Place the template on the cylinders and scribe the radius around the flange. Having the cylinders lightly bolted to the face plate, shift as necessary to get the line running truly. Concentricity is indicated by a scriber held in the tool post exactly on-line of the lathe centers. Balance the face plate with any suitable pieces as long as they clear the sweep of the 1-3/4” radius. Bolt up tight and bore out taking light cuts with a pointed tool. When down to a tool surface all over, compare with the template. If the protruding edge is parallel with the template, you will know the job has not moved and it can be safely finished out. If it has shifted at all, square it up again, tighten bolts well and do not take as heavy cuts. Ordinary paper placed between a finished surface and faceplate assists in holding securely.

We are now ready for drilling the exhaust exits and steampipe passage. Mark out and center punch the locations. Then remove the tool post from the lathe and bolt the cylinder down with one bolt passing through the cylinder bore. Pack up the cylinders until the center of the cylinders coincides with the lathe center. It is convenient to place the cylinders square with the top slide of the slide rest and then set the slide over the required 30°. Put a center drill in the chuck and feed the job up with the saddle following with a 7/32" drill and then tap 1/4"-40 Model Engineer standard. Feed the slide over until the exhaust exit is on the lathe center, and this time instead of drilling, put a 1/4" end mill in the chuck and with light feed of the saddle, mill through into exhaust passage. The drilling of the steam ports in the cylinder is easily accomplished by means of a simple jig, the principle of which was fully described in my note published in July, 1926 issue of Modelmaker [Appendix 6].

Drill the drain holes and tap for the drain cocks. Outside lagging maybe made and fitted with an #0-80 screw top and bottom each end. Make a short brass plug, turned 0.249" one end and 0.251" diameter the other; press one end in one exhaust passage taking care that it does not block the exhaust exit. This little plug serves a dual purpose - first it tends to prevent the blowing over of exhaust from one side to the other, second it locates the cylinders correctly. This will complete the cylinders at this stage. Next month cylinder details will be taken up.

Cylinder Details

Under this heading, we will deal with Valve Bushes, Piston Valves, Steam Chest, and Cylinder Heads, Valve Spindles, Piston Rods, Pistons, and Crossheads.

Steam Chest Bushes - Take a piece of 7/8" round Tobin Bronze, chuck it allowing about 2 1/2" standing out. Face off one end, center with a center drill, follow with a 23/64" drill. A regular twist drill will be found best for this tough metal, so do not back off the cutting edges as was described in the last article. Then ream 3/8" using a mixture of oil and white lead as lubricant. It will be necessary to drill down at least 2-1/2"; the reamer need not go as far. Now cut off a little over 2" long. Make two pieces like this. Next put each piece in the chuck and run the reamer right through. Face off the rough end so that the piece is exactly 2" long. Now mount the bush on a 3/8" mandrel and turn the outside to exactly half a thousandth larger than ¾”. The finish should be smooth; the final cut being taken with a fine feed and light cut. Tools that are satisfactory for steel will be found to work well on this material. When getting close to the finished size, test the diameter frequently when the tool has traversed not more than 1/8 inch or so. When the tool has reached the end of the work, run the lathe saddle back without touching the tool slide. Now engage the clutch and let the tool go over the work again still leaving the tool slide exactly where it was on the previous cut. Generally, a small amount will be removed. The actual amount depends somewhat on the peculiarities of the particular lathe. Test the work with the micrometer at both ends and in the middle. If any point shows more than 0.751 it is best to reduce the part with a No.4 American Swiss hand file. One or two even steady strokes with the lathe running on the middle pulley of the cone will rectify.

Before removing the job, reduce one end with the file to 0.749 for not more than 1/4 inch from end, and at the same time just touch the sharp edge with the file. This will facilitate pressing the bush in the cylinder later on. Now the ports must be marked out. Lay the bush in the centering - head of the universal square and scribe a center line across the end. Then place in a V-block and scribe the line alongside. Now cut a triangular template of 1/4 inch slope in 1-3/16" and with the short edge on the surface plate, turn the bush round in the V block until the line just marked is in-line with the sloping edge of the template. Hold it in this position and scribe another line on the side of the bush with the same setting of the surface gauge needle as before.

We now have the center line of the steam and exhaust ports in one diameter. Get the center of the bush on each line and having the dividers set at proper dimensions to give center of ports mark each line at each end. Set the bush on end upon the surface plate and scribe these points around about 1/4 inch. On these lines prick punch carefully for two 3/32" holes each - it is as well to slip a piece of 3/8" drill rod in the bush to prevent any possibility of springing out in this and the subsequent operation. Drill the 3/32” or No. 42 holes carefully, using a little thin oil as lubricant. The next job is to mill the exhaust passage and steam port clearance. To do this in the absence of a milling attachment mount the bush tight on a mandrel and hold the end of the mandrel in the tool post packing it up until the center line is on lathe centers. Put a plain pointer in the chuck of the lathe and run the top slide across near to the pointer. This will soon tell whether the job is square with the lathe bed. If not, adjust the top slide itself. Now put a 1/4 inch end mill in the chuck. Put on top speed, bring the saddle up carefully, and take a light cut. Lock the saddle and feed the top slide forward to the end as required. Return the slide, unlock the saddle, take another cut and feed forward again. The grooves should be about 3/32" deep. The ports can be cleaned out with the end of a round needle file. Take off the burrs with a No. 4 file, and this finishes the valve bushes at this stage.

The **back valve chest covers** or heads are the next items. First file the guide faces flat, then clamp the casting by the face to an angle bracket attached to the face plate of the lathe [Fig 9]. Mark off the center 1/8" below and get this point running true on lathe centers. Turn, face, and drill at one setting. The 3/8” spigot should fit without shake in the steam chest bushing. The front cover is a simple turning job best made from the piece of 7/8” round bronze left over from the bushes. Chuck the piece, center, drill, tap and face, then turn the spigot a neat fit in the bush. Change the tool for a cutting off tool, run in for 11/32", withdraw, bring up the saddle to give a 3/32" boss length and cut right off. To drill the bolt holes, make a template 1/16" thick with a 3/8" reamed hole in the center. Set off the bolt centers and drill No. 52. A 1/16" slice off the 7/8" bronze rod will make the template. Slip the template over the spigots on the valve chest heads, secure with a small tool makers cramp and drill through.

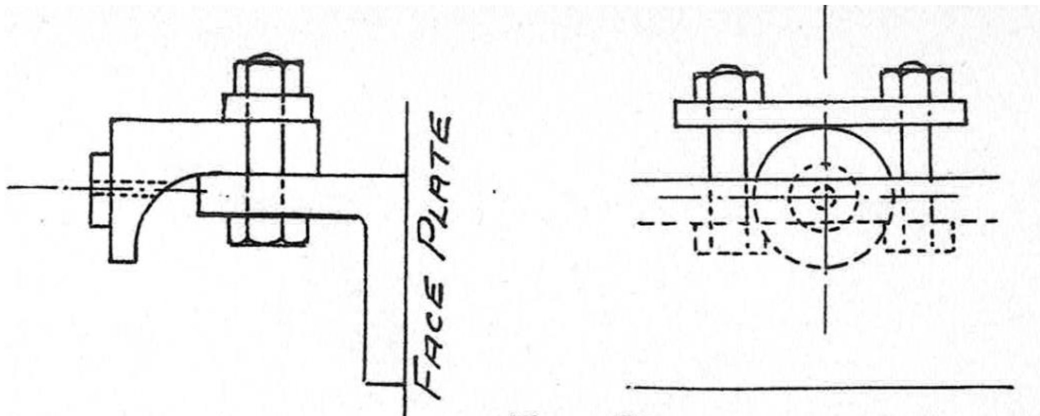


Fig 9

The **valve crosshead guides** are simple pieces of brass with a groove filed or milled in to receive the crosshead and attached to the back head with two 0-80 screws each. This should not be done yet, however.

The crossheads are made from 1/8" thick steel having a boss turned and tapped 2-56. It is a good plan to make such jobs as this in pairs. See sketch Fig. 10.

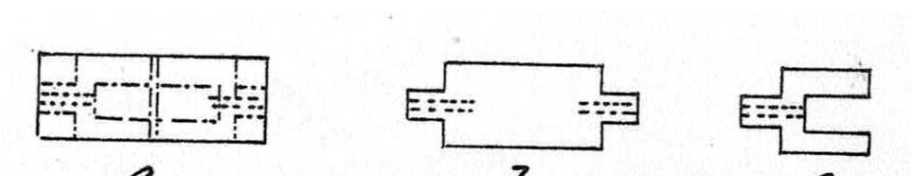


Fig 10

Piston valve spools are a straightforward chuck turning job, and can be turned, drilled, and cut off as a finished job. The back cylinder head should be held in the chuck by the flange, and the 1/4" hole for the piston rod drilled and faces machined to a close fit in the cylinder at one operation. The stuffing box can be opened out with a 3/8" counter-bore having a ¼" pilot, after removal from the chuck. In order to machine up the outer edge of the flange, mount on a short mandrel held in the chuck to fit inside the stuffing box; Fig. 11. Face off outside at the same time and this will give a square face from which to file off the top of the lug which carries the crosshead guides. The screw holes may be drilled in the same manner as described for the valve chest head. Glands can be chucked, faced, centered, drilled, reamed and then turned and finished on a mandrel.

Piston Rings. -In order that rings shall be effective in making a steam tight seal, it is necessary that they make contact with the surface all around and that this fit should be maintained by the spring effect of the ring. In other words, the ring should be a true circle after splitting. Proceed as follows: Chuck a piece of 7/8" Tobin bronze, bore out 21/32" about 1" deep and turn the outside to 27/32", cut off about 1-1/4" and saw through one side. Now take a piece of steel or brass about 1-1/4" diameter, bore out 27/32", remove from the chuck and cut into two, thus making two half clamps. Put the split ring between the clamps and grip in the chuck, allowing about 5/8" to stand out. Now turn the outside to exactly 0.812" and bore inside to 0.688" or 11/16" using very light cuts and fast speed. Remove the turning tool and replace with a very narrow cutting off tool, made as Fig. 12.

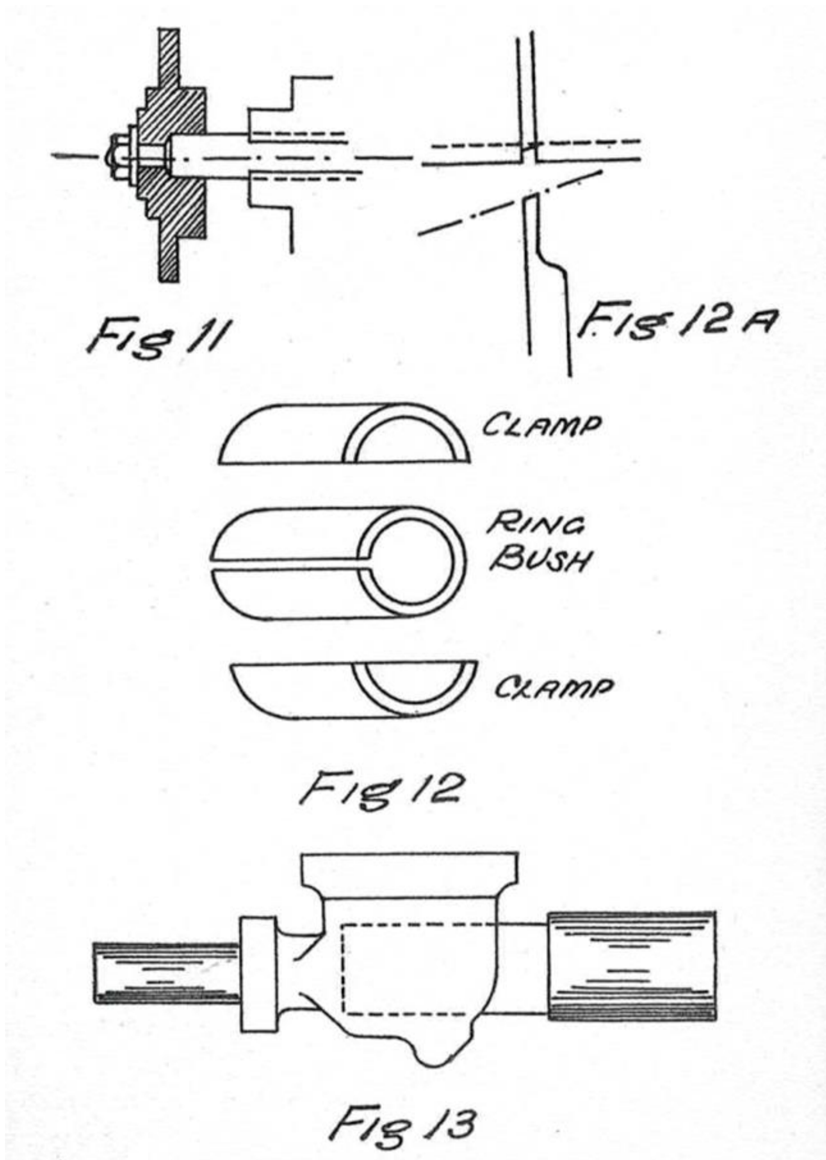


Fig 11

Fig 12 A

Fig 12

Fig 13

With reasonable care, the ring can be parted off perfectly without any fin left. Make two like this for pistons and four similarly but with the appropriate dimension for the steam valves. Pistons are a plain chucking job and rods can be turned between centers. Make the rod a good fit in the piston. It would be advisable to make a taper reamer for the crosshead and while the top slide of the lathe is set, make the piston rods. The tapers will all be exactly alike then.

Crosshead. —These are castings having a cored pocket for reception of the stub end of the main rod [Fig 13]. Clean out any sand and file up a piece of 5/8" brass rod to fit inside, solder this in leaving about 1" of the round part standing out. Put this end in the chuck, and turn, face, drill and ream for the piston rod. Push the piston rod in and then file up the outer face, getting them flat and in line with the rod. A straight edge laid on the face should show parallel with the rod, and away from it. Then lay the rod in a V block and with a surface plate and gage; mark out the centers and slipper faces. Next take a small piece of cold rolled steel, say 1/4"x 1/8" and clamp this close to the slipper line and with the safe edge of a file kept close to the steel, file down for 3/32". Then go down another 1/16" with a slotting file or a warding file. Make this groove 3/32" wide. Do the same to the other side when the slipper should be close to the drawing dimension. Dress up as found necessary to give the proper contour of the slipper. Drill holes for the wrist pin by holding the rod in the V block, the wrist pin hole will then be square with the rod. Place some packing under the crosshead face to take the thrust of the drill. The wrist pin is a plain turned flange piece secured to the crosshead by three 0-80 screws.

Having all the parts satisfactorily machined, we are ready for the **assembly of the cylinders**. First take one cylinder, make quite sure there is no burr around the edge of the steam chest, and clean out all dust and chips with gasoline. Then swab the inside of the steam chest bore with a mixture of white lead and lubricating oil. Take the mating steam chest bush and treat it the same. Now having the ports in the proper line, enter the end which you made 0.749. This should go in between 1/4" and 1/2" and will be square. Place in the vise between lead clamps and screw up. The bush will go right up without "seizing" but with a fair resistance on the vise handle, and the joint will be steam tight. The end of the bush may embed itself in the lead clamp somewhat, possibly 1/32". This amount can be taken up by placing two pieces of flat steel between the vise jaw instead of the lead clamps.

It will be found that due to the compressing of the bush, the bore has contracted slightly. Therefore, run the 3/8" reamer through, and then lap out. Turn a piece of hardwood or lead a close fit to the bore. Oil it and sprinkle some crocus on it evenly. Run the lathe at a moderate speed and slide the cylinder on at the same time, turn it round and round the reverse of lathe rotation, and also reciprocate it along the lap. This will produce a true and smooth hole. Wash away all traces of dirt and crocus with gasoline.

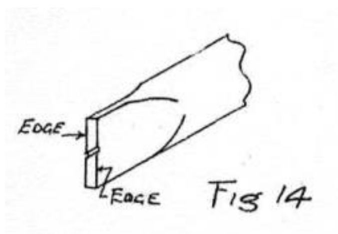
Bolt both cylinders together and then insert the back steam chest heads. All that is necessary in order to line up the heads is to lay a straight edge across both valve crosshead guide faces. Clamp the straight edge and everything is ready to drill the screw holes in the cylinder. First spot each hole a with No. 56 drill, and then follow through with a No. 52. Do all holes and then tap #0-80. Don't force the tap. They are fragile and you do not want to be compelled to drive out the bush and make another, which would be necessary if the tap broke in. Hold the tap in a Starrett pin vise, and twist with the thumb and first two fingers. Use white lead and oil as lubricants. Back the tap as soon as it gets too stiff to turn with safety, knock out the chips and go ahead again. With a little practice and patience, you will get months of service from these small taps, and only have to discard them for being worn out, and not by breaking.

Back Cylinder Heads can be fitted up same way using No. 2-56 screws tapping drill No. 49. The front head will present no difficulty. All that is necessary is to locate the holes neatly on diameter. Mark all parts (a set of 1/16" figure punches are useful for model work) take all apart and well wash in gasoline. The pistons, rings, piston rods and crossheads can be assembled, also the valves, spindles and crossheads and laid aside, until the steam pipes, exhaust pipes and nipples are fitted, which we will take up next month.

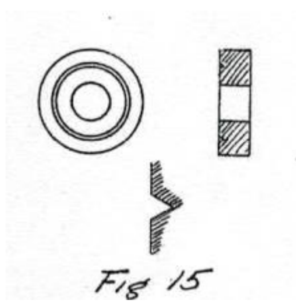
Steam and Exhaust Pipes, Lagging and Guide Bars

The **Steam Pipe Union** consists of a nipple, nut and sleeve which is ultimately connected to the steam pipe from the superheater by means of a long nut. To make the nipple, chuck a piece of 3/8" round brass, face off the end, center, drill 5/32", then turn down for 1/4" length to 1/4” diameter and screw 1/4”-40. Thread the 3/8" part 32 threads per inch and cut off with the small cutting off tool 9/16" overall. It is a good practice to slightly chamfer the ends of all screwed work because this tends to eliminate the sharp burr left by the first thread. Make two nipples, one for each cylinder. The nut is made of hexagon brass; chuck a piece, face off the end, center, and drill first 1/4” diameter then with a Q letter size drill for 5/16" deep.

Now, square out the bottom of the hole with a counterbore made like sketch. Fig. 14, and then tap 3/8"-32 Model Engineer thread to fit on the nipple previously made.



Two **sleeves** are also required, turned from 5/16’ round brass. Before cutting off try the nut on to see whether it slips on easily, then cut off, reverse in the chuck and take a light facing cut across the collar, and turn a small V groove in the face; see sketch Fig. 15. This holds the graphite jointing compound to make a steam tight joint.



The **Steam Pipe Nipple** and lock nut made of 3/8" hexagon brass need no further comment.

The **Exhaust Pipe** consists of a cast base and screwed tip. Hold the round end in the chuck and face off the flanged base. Then clip onto the faceplate by the flange, locate until the top part is running true, face off to 13/16" high, center, drill Q, and tap 3/8"-32. Next make a square end tool 1/16" wide with ample side clearance, see Fig. 16, and turn the blower annular groove deep. Having accomplished this, place the casting on its side on the tool slide of the slide rest and pack up to the lathe centers, swing the slide around to 30 degrees and end mill the exhaust passages to open into the 3/8" tapped top.

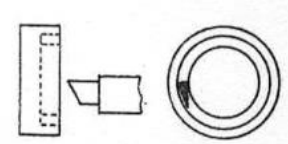


Fig 16

The exhaust tip is turned out of 3/4" round brass drilled 5/32" and turned 3/8"-32 to screw into the base. A deep flange is thus formed, which when drilled with 6 No. 60 holes come right over the groove in the base. Drilling the feet of the base for two No. 2-56 brass screws and the little boss on front to receive a 1/16" steam pipe, completes the exhaust pipe.

Guide bars are made from 5/16" square cold rolled steel. Probably the easiest way is to have some reliable machine shop mill a six-inch length of proper section, see Fig. 17, then cut in two pieces. Tin the edges marked A, clamp the two together with a neatly fitting piece of material 3/32" x 5/16" between and heat until the solder melts - Fig. 18. Mark out the bolt holes, drill one No. 52 and tap the other 0-80. Finish up the bars with a file to the drawing, but do not fit them to the cylinder heads yet. The exhaust pipe however can be fitted and screwed in place and the cylinder lagging of 26 G sheet brass attached with two 0-80 screws top and bottom. Note that the drawings you will receive contain parts that are not mentioned in the particular section. This is not an oversight, but such parts are not to be made yet. They will be dealt with in due time and order. Next month instructions will be given for frames, cradle casting and bumper.

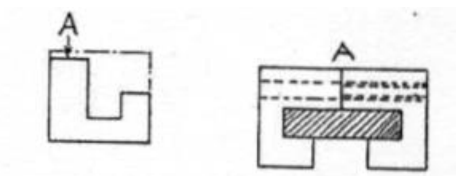


Fig 17 Fig 18

Making the Frames

There are two ways of making frames: (a) cutting from cold rolled steel bar, or (b) filing up a cast brass frame. Both methods have advantages and disadvantages. Advantages of using steel are strength, true flat and even thickness to start with. Disadvantages: labor and time required to cut out the openings.

Advantages of castings: openings may be cast in saving considerable labor and time. Disadvantages: castings have to be filed up on the inner and outer faces taking time and labor, although not as much as the steel. The casting may also be weaker than the steel and more susceptible to bending if roughly handled.

The drawing supplied will cover either material, and castings will be offered, leaving the builder the option of using ether material.

Steel Frames

Take two pieces of cold rolled steel 1-1/2 in. wide, 1/4 in. thick, and 15-11/16 in. long. This material is straight and true to size. Clean off any dirt or grime with emery cloth, take one of the two pieces and brush or sponge over one side with a solution of copper sulphate; this copper plates the steel and makes marking out easily seen. Be careful not to get any of the solution on your tools and see that the job is dry before you use the tools. Now take the “odd leg” or hermaphrodite calipers and set to 7/8 in. Place the hooked leg against one edge and scribe the axle center line from the front driver to the extreme rear. Next pull the leg in 3/32 in. or 25/32 in. from the edge, which will be known as the 'top rail" - Fig. 19. (Throughout these notes, the same terminology will be used as is used in full size locomotive engineering.) Scribe this latter line for about 5 inches. This is the cylinder center line, and as is common practice is placed above the axle center line. Now square off the first or leading driver center 6-3/4 inches from the front end. Prick-punch the intersection of the two lines, set the dividers carefully to 3-1/2 in. and step off the other two centers. Check the distance between first and last center. It should be 7 in. exactly.

Set the dividers again to 4-3/8 in. and from the first or leading axle center line, step off the distance, to cut the cylinder center line. Now we have the main points from which all other dimensions are taken, and with the square, dividers, odd leg calipers and rule, mark out the openings between the top and bottom rails, contour at the cylinder end and the screw holes. Take the other piece of steel and lay both together with the top rail edges down on a surface plate or other flat surface and clamp the two together firmly either with two small tool makers vises or C cramps. See that the two edges are evenly together, laying a square across will soon indicate this, and then drill say an 1/8 in. hole right through both steels on the three axle center lines. Countersink each side not more than 1/32 in. and rivet the two together with a snug fitting piece of 1/8 in. soft steel. File off flush and restore the center lines and prick punch, then remove the cramps. Now the contour must be drilled around. It is best to mark off another line, 1/16 in. away from your previous marking and center punch for holes close together [Fig 20]. A spacing punch is useful which has two points to it; one spring controlled which is adjustable, and placed in the previous punch mark, the other being tapped with the hammer to mark the new space. Use, say a No 35 drill and drill all-round the outline and openings. Leave 1/32 in. metal to be filed away later around the “pedestals” or axle bearing openings [Fig 21].

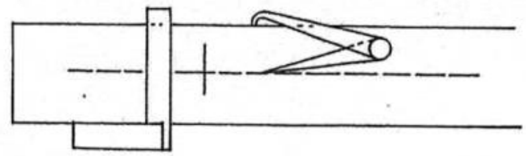


Fig 19

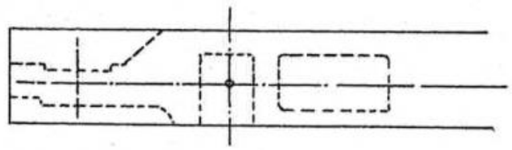


Fig 20

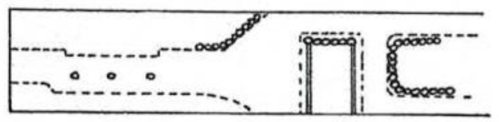


Fig 21

A hack saw will now quickly remove the superfluous metal around the cylinder end and also the pedestals. Removal of the metal from the pedestals will of course separate the two frames, but because we have a number of holes already drilled together it is an easy matter to line the two frames together again by putting in pins of No. 44 drill rod. A jeweler's saw will be found very useful for sawing between holes drilled around the "between rail" openings. We now have two roughed out frames, and it will not require an indicator to see that the top rail is no longer straight. It will have a decided bend in it [Fig 22].

Fig 22

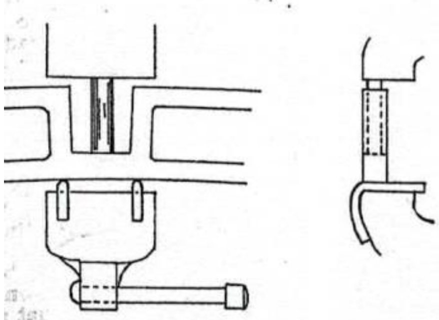


Fig 23

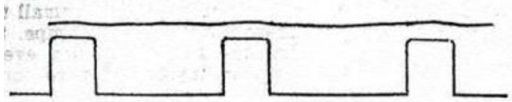


Fig 24

This is due to the internal stresses in the metal set up by the cold rolling process, being released on one side by the removal of the pedestal openings. It is not difficult to eliminate this. Take two pieces of round brass or copper and bend them over one vise jaw, place the frame in the vise with the top rail against the coppers and another stout piece of brass between the other jaw and the top of the pedestal. Screw up gently, just a little at first. You will feel the frame spring and perhaps go back to its bent form. Try again with a little more force. Proceed with the other pedestal openings the same, with a little patience and good judgment you can bring the frame back to almost its original rectitude (Fig. 23). If you lay a straight edge along the top rail, you will probably have an effect like sketch Fig. 24, very much exaggerated of course. Touch the high spots down with a file, and now from this new straight top rail mark off the pedestal openings for finality. Remember we left 1/32 in. on in anticipation of this distortion. Remove these markings, mark out again and file to the line both frames being pinned together as described above.

It is as well to check the cylinder end of the frame for straightness with the main center line. Lay the straight edge along the top rail. Its end should be parallel with the cylinder center line. From this stage it is a question of file and “elbow” work. A 14-inch rough or bastard file is the one to use for removing the greater part of the metal finishing with a 10" second cut, filing close to the lines and keeping both frames together throughout. Test for squareness along the cylinder seating and rail and faces of pedestals, frequently.

The next job is to reduce the front end to 1/8 in. thick. A piece can be sawn out and then finish with the file. Do this to the outsides of each. If you keep the frames together, you cannot make a mistake. Now counterbore holes that require this as shown on the drawing outside of each frame. Square off the center lines of the cylinder and axles across the top edges of the frame and score plainly. These lines will be useful when we come to the erection. Take the frames apart and mark out for the 1/16 in. recess on the inside of the rear end, which must be milled out by bolting the frame vertically to the tool post with suitable packing under in a similar manner to that adapted for the valve bushes. Work carefully to the lines; get the frame square with the lathe bed, take light cuts and feed, using lard oil or solution of soap and soda, and with a little of the chief ingredient of good model making - patience - you will have a job that could hardly be excelled by a milling machine. Clean off burrs with a fine file and the frames are finished. It only remains to make the binders of 3/8 in. square cold rolled steel; hold to frames with a C cramp and drill and tap the frames for No. 2-56 screws.

Cast Brass Frame

If a cast brass frame is used, the openings and contour are already formed except for the pedestal openings which must be cut out. First file up the frame to an even thickness of 1/4 in, and file the top rail straight and square. If the castings are bent or out of shape, no fear need be had of hammering or bending flat and straight. Good red brass will stand a considerable amount of this treatment. Cut out the pedestal openings allowing a liberal amount to file. Then file the top rail straight and square, and proceed exactly the same way as for the steel frame. For roughing out use an 8 in. or 10 in. second cut hand file and finish with an 8 in. smooth hand or 8 in. No. 2 American Swiss pillar file. A 6 in. No. 2 narrow pillar file is useful for producing sharp corners.

The Vise. To the uninitiated the following note may be of assistance although filing being an art there is no royal road to its acquirement. The bench and vise should be firm. It is a mistake to imagine any small cheap vise is good enough for small work. A regular machinist’s vise with 3-1/2 in. jaws will be found best for all round small work. If fitted with a swivel base and ground smooth jaws, so much the better although this adds to cost. The height of the vise should be such that when you stand erect with your right forearm bent up to the shoulder, your elbow just touches the top of the vise jaws. If your vise jaws are truly parallel (and they should be), it will be found a very light pressure on the end of the handle is all that is necessary to hold securely almost any job you are likely to get in model work.

Always have the surface to be filed as level as possible in the vise. Stand a little to the left of the vise with your left foot pointing forward and right foot slightly behind and at 45 degrees to it (Fig. 25[11]). See that the file handle is firm on the file tang, and grasp the handle so that the end bears in the palm, with thumb extended lying on top and fore finger extended alongside. Swing the file with the arms only (keeping the body as still as possible), throughout the whole length of the file, but avoid hitting the vise or work with the file handle. If you do, there is a likelihood of the handle being knocked off, the end of file instantly drops, the tang flies upward, the workman's head and shoulders drop forward, and conditions are ripe for a serious injury to face or eyes.

Next month the rear frame cradle and bumper will be taken up.

Cradle Casting, Bumper Beam and Coupler Pocket

The rear frame cradle is a one-piece casting which will require very little work to finish. The front portion fits between the frames in the milled recesses, while the back contains the drawbar pocket and cab support. The boiler is carried on plates which will later be screwed to the front and rear of the cradle. Drill and tap the brake hanger lugs, also the holes for the drawbar and trailer truck pivot pin. Saw and file out the openings for the brake hangers and this will complete the cradle for the present [Fig 26].

The **Bumper Beam** is another one-piece casting that will be easy to finish. It should be cleaned up all over, and parts marked finished with file to the exact dimensions given. The semicircular recesses or outer corners are known as push-pole pockets and are to be drilled or milled with a round edge flat drill. To make the drill, take a piece of 1/4 in. drill rod and turn the end semicircular, then file flat to make the blade, say about 1/16 in. thick. Back off the cutting edges carefully with a fine file. To harden small tools made from drill rod, it is advisable to first anneal, by making red hot and allowing to cool slowly in ashes or lime. Then again make bright red preferably in a gas flame or blow torch and quench in oil. Do not simply drop the red-hot tool in the oil and leave it there, but keep it in the tongs and agitate the whole for a few minutes. Take it out and clean it up with emery cloth, until bright. Then dip it in thick oil and move in and out of the flame until the oil just catches fire. Quench out in water and the tool should be hard and tough. Another way is to harden in water; clean up bright and hold it in the flame turning the tool over and over until the bright natural color changes to first bright straw and then orange. Quench in cold water at this point.

The **coupler pocket casting** may be filed up to the dimensions and attached by four No. 2-56 screws. Having the cradle and bumper ready we are in a position to **line up the two frames**.

[11] This figure was not printed in THE MODELMAKER.

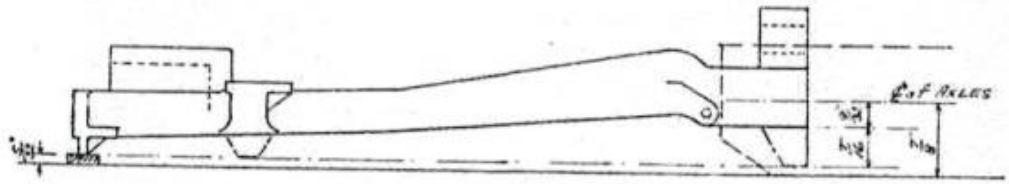


Fig 26

Take one frame and the cradle and fit the recess in the rear of the frame over the faced end of the cradle. If you have done the milling carefully the fit will be firm, if you have to use light taps with a small lead hammer so much the better, but be very careful in using the hammer and have the frame well supported on a flat surface. Another method would be to gently squeeze together in the vise. Inspect carefully to see that the surfaces of the frame and cradle at the joint are "home.” Now lay the top frame of the rail on a flat surface. The cab support flange at the end of the cradle should then show 5/32 in. above the frame top rail. See Fig. 26. Next place a 5/32 in. parallel strip under the cab support flange, and seat the cradle firmly upon it. Take the square and see if the frame is fair and square. If the work does not check in either or both tests, ease down the cradle end at the joint very carefully. Remember, a mere scrape taken off the inner or outer edge of the joint will raise or lower the cradle considerably at the cab support flange. If you are so unfortunate as to make the fit "sloppy” the situation may be saved by tinning the joint liberally with solder. Treat both frame and cradle, then have the frame on the flat surface with the 5/32 in. parallel under the cradle end. Heat the joint until the solder melts and cramp together with a C cramp.

Assuming everything is correct, drill and tap for screws.

The bumper can be fitted and lined up the same way, adjusting the surfaces so that when screwed up it will be square and “lineval" with the other end of the frame namely the cradle. If the work is all done carefully and made correct, it will be a simple matter to fit the other frame. To do this lay the three units you have already done top rail down on a surface plate with the 5/32 in. parallel under as before. Take the other frame top rail down and slide it right up into position. It will go without any persuasion or protest if correct. If it will not fit, ease down as required and cramp it in position using a C cramp at each end. Check everything over and see if the pedestal faces are square with each other from frame to frame and when satisfactory, drill and tap for screws. If you have not made a good job of the joint on this last frame, do not solder because it will be necessary to take it apart to fit the cylinders.

By this time you will have something to show for the labor spent, and no doubt you will wish to try the cylinders in place without being told to do so. They should slide down over the frames nice and snug. If they do not without forcing the frame in, ease down the frames a little each side, or ease out the cylinder frame seats. If the fit is a loose "rattly” one, the only thing to do is to take up the “rattle” with shim brass or copper equally each side.

Now take one frame off and detach one cylinder from its mate. Place the frame and cylinder together, cramp in position and give the frame edge a gentle tap with a soft hammer to make sure it is bearing. Spot through the holes in the frame with a No. 30 drill, just a countersink is all that is needed to give a true lead to the No. 39 which will be tapping size for the required No. 5-40 screws. Be careful in drilling that you do not go too deep or you will go through into the cylinder bore. 3/8" from the face of the cylinder seat is ample depth. Screw the cylinder on firmly, then take the other cylinder and bolt to its mate - place the frame in position and screw to the cradle and bumper. Cramp this last cylinder firmly to the frame. Now take out the screws holding the two cylinders together, also the screws holding the frame to the cradle and bumper and cradle. You now have the frame only with its cylinder cramped in position. Drill and tap for No. 5-40 screws as before and reassemble. If every screw goes in without undue force and all is square you may well afford to congratulate yourself. One more test may be applied before setting this portion aside. That is, to check the parallelism of the cylinder bores to the frame. Place a 13/16 in. mandrel or any good fitting length of stuff in the cylinder bore. Then feel between the mandrel and frame with the inside calipers. They should slide through evenly at any point and the dimension should be 19/32 in. Next month, the frame braces, motion beam and guide yoke will be taken up.

Frame Braces, Motion Bean and Guide Yoke

The **Frame brace**, only one of which is required is a simple channel section casting which only needs filing up square on its faces and reducing to the correct dimensions, or it may be faced in the lathe in the following manner. Lay a piece of flat cold rolled steel on two jaws of the universal three jaw chuck, place the casting on this a piece of packing on top and screw up the jaws. Face off one edge, remove, turn round and replace with a parallel strip between the face of the chuck and previously faced edge.

G**uide yoke** – This casting carries the guide bars and also acts as a brace between the frames. It should be carefully marked out and filed close to lines. First, file the top edge straight and flat and also the edges of the flanges. Lay the casting in a tool maker’s vise. See that it is reasonably square, if not, place thin slips of packing against the jaws to rectify. Now with the aid of a surface plate and gauge, scribe out the faces, and then clamp to the angle bracket and again mark center lines and frame faces. This is a similar operation to the marking out of the cylinders. Drill holes shown on the detail drawing in the correct location. It will be noticed that the bottom edge of the side face slopes up. This should be scribed off from frame because it follows the frame contour at the location of the guide yoke between them. This little operation can quite well be left until final assembly.

The **Motion Beam** which carries the expansion link brackets is to be treated in an exactly similar manner to the guide yoke, and should present no difficulty after a satisfactory guide yoke has been made. Note that the top edge and one side of the overhanging portions are to be finished flat and square. Also be careful to work close to the dimensions. The outer ribs will have to be filed to clear the wheel later on.

Boiler Waist Sheet Bracket - This casting can be filed up and holes drilled for screwing to the top of the frames. The 1/16" brass plate can be made later on from material left over after making the cab deck. Therefore, do not tap the holes in the casting for this plate at this stage.

The castings can now be fitted to the frames in their proper position, as indicated on the frame detail drawing. The motion beam is located 4-7/8” between the face of the guide yoke and the face of the valve chamber.

Next month we will take up the bearing boxes and trucks.

Bearings, Engine Truck & Trailer Truck

The **main bearings** are cast brass in the form as Fig 27. One and a half bars will be needed. If you have a milling machine or attachment, mill faces **a.a.a** square and parallel 3/4" side to side. If you cannot mill them, it is best to saw up the bar into pieces on lines **bb** and treat each one separately with the file. Take two bearings and cramp together as shown on Fig. 28. Now mill or file out the gap **c.c.c**. 9/16" wide and 9/16" deep [Fig 28]. Do this to all six and then fit blocks of brass 9/16" x 5/8". Solder in with a good fillet of solder as shown at “**d**” in Fig. 29.

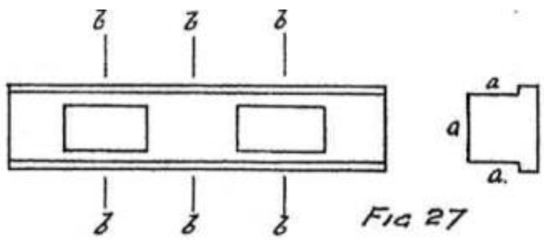


FIG 27

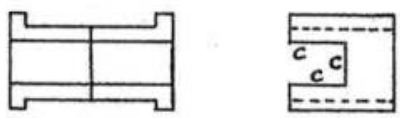


FIG 28

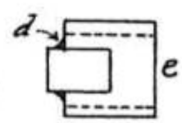


FIG. 29.

Face off the top “**e**" to dimension, and the bearings are ready for boring. To do this first make a simple jig as shown on Fig. 30 made of a piece of cold rolled steel say 1/4” thick. Lay off three equidistant points and drill for 1/4" reamed holes. Mark side R. & L.

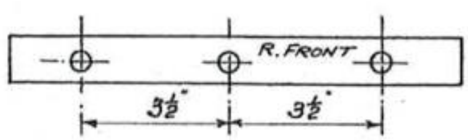


FIG 30

Now take the frames apart, slip the bearings in place and wedge tight with a small wooden wedge driven against the binder. Lay the two frames together in line as shown on Fig. 31, getting them square and true, then put in pins through three or four available holes, and clamp at each end.

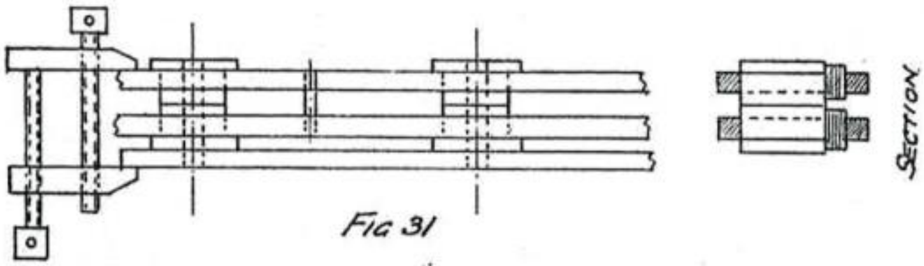


Fig 31

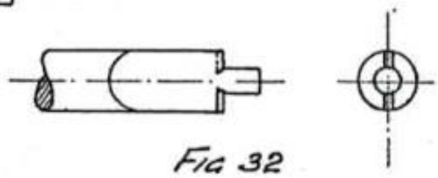


Fig 32

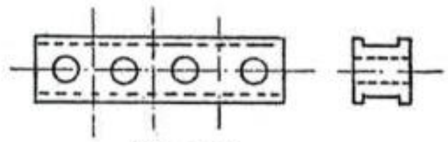


Fig 33.

Mark off a line on the main driver bearing which is the center one, 7-7/8” from the cylinder center. Center punch exactly on the intersection of this line and joint of the "keep” or cellar. Drill with a center drill and follow with a drill.

Now lay the jig on and put a 1/4” drill rod pin through the jig and main bearing. Set the jig parallel to the top rail of the frames and inspection will show whether the other bearings are correctly located in a vertical position. If they are not, readjust the wedges. Run the 1/4” drill through, take off the jig, number all the bearings, and open out with a ½” counterbore; Fig. 32. Drill for the keeper pin and oil hole and then push on a mandrel, not too hard or you will drive out the keeper. Face off both sides in the lathe, trim off the bottom of the keeper thus cleaning away the solder and freeing the keeper.

The **engine truck bearings** are made from brass bar 1/2"x 3/8", the faces being milled or filed, and holes drilled and reamed. This may be done either in pairs or all four in one piece of stock, see Fig. 33, finally cutting each bearing off and filing up top and bottom.

Trailer truck bearings are treated similarly but first file the inner face and side square with each other. The marking out can then be done from the two faces.

Engine Truck Frame —This is a one-piece casting similar to Commonwealth Steel Co’s design. First file up smooth the facing, against which the bolster bears. Then lay the casting down on a surface plate. (You will need a strip of 1/4” parallel packing under it). Then lay off the center line of the axles and pedestal depths and binder edges. Then file up the binder edges close to the scribed lines. Now clamp the frame to an angle bracket, set up on a surface plate, and mark out the axle centers and pedestal openings. Drill, hacksaw and files will finish the pedestals. Work close to the scribed lines and when nearly down, try in the bearings, ease down the pedestal to a nice fit on the bearings.

The bolster needs drilling for the “king” pin and filing up to a sliding fit in the frame, the other surfaces can now be turned by mounting the casting on a mandrel. Similar remarks will apply to the center plate in which a mild steel king pin is rivetted.

The equalizers are made of 1/16" thick rolled steel which is drilled, sawed and filed to shape. Pin all four together and finish file together so that they are all the same. Spring hangers are cut from solid steel 3/16" square. Drill two No. 44 holes and cut out to form the hook.

Trailer Truck—This is an aluminum casting and the best file to use is that known as “Vixen.” This has a very coarse curved tooth that cuts exactly the same kind of chip as a milling cutter. These files are excellent for working aluminum because the surface produced is smooth and this file does not “pin" to cause scoring as ordinary files do on this material. Only light pressure is needed, and they are very rapid in action. If you use ordinary files, the use of kerosene will reduce the tendency to score.

First, clean up the fiat top side of the frame and from this face do all the marking out. First mark all horizontal points, then vertical points by clamping the frame to an angle bracket; Fig. 35. Drill holes in the corners at top of the pedestals, also along the top edge “**A**" Fig. 35.

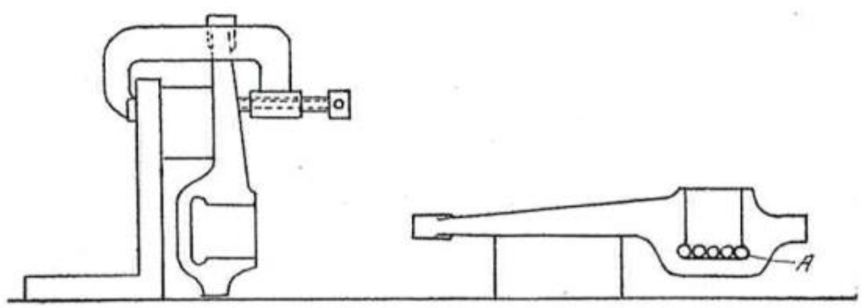


Fig 35

Take two saw cuts down and saw out the fins between the holes with a jeweler’s or fret saw. This will remove the piece. Finish with a file to fit the bearings. A slot must be cut out across the top of the pedestal through which the spring passes. It will also be noticed that there are two ¼” holes drilled on each side of the pedestals. These holes are for spring hanger clearance. Drill these first, from the bottom upwards because this is easier than attempting to start a drill on the curved surface of the top. Then saw down (two cuts) for 13/16", drill a 1/4" hole horizontally, and the piece will fall out. Finish up with a file. Drill and tap all other holes as required, fit binders and lay by until wheels and axles are ready. Next month, wheels and axles will be described.

Wheels & Axles

Wheels & Axles - The actual method adapted for turning wheels will depend upon the size of the chucks and face plates that are available. Two methods will be given, that will meet practically all cases.

Taking the trailer truck wheels first, turn up a piece of stock of thickness 1/16" less than the step of the chuck jaw, and of diameter say 1/8" less than the rough casting flange. A thick washer, disc, or even pieces of pipe make good spacers. Slip the spacer in the jaws and grip the wheel by the flange, gently tapping the wheel against the spacer while tightening up the chuck. Now set the tool post slide 3 degrees to the lathe centers. Use a tool ground with front and side clearance and top rake, and feed up with the saddle and cross slide, not the tool post slide. The operations are now as follows:

(1) Face off the hub by an amount that will leave sufficient material to come off the flange. Find this by measuring up the rough casting.

(2) Face off the wheel side face 1/32" back from the hub.

(3) Turn the tread to 2" diameter (using the saddle for feed) and 1/4" wide. This will bring the tool very close to the chuck jaws so be careful.

(4) Bring the tool back about 3/32” from the flange by shifting the saddle but leaving the tool still just touching the wheel. Now, lock the saddle and run the tool off by means of the tool post slide. This will give you the taper [Fig 36].

(5) Put a center drill in the tail stock chuck, follow with a 19/64” drill and reamer 5/16" which will give the axle bore.

(6) Check over all dimensions, then remove from chuck.

(7) Grip the wheel by the tread, that is, flange outward, and face off to the proper thickness both flange and hub.

(8) Turn the edge of the flange to the correct diameter and round the corners with a few strokes of a fine file.

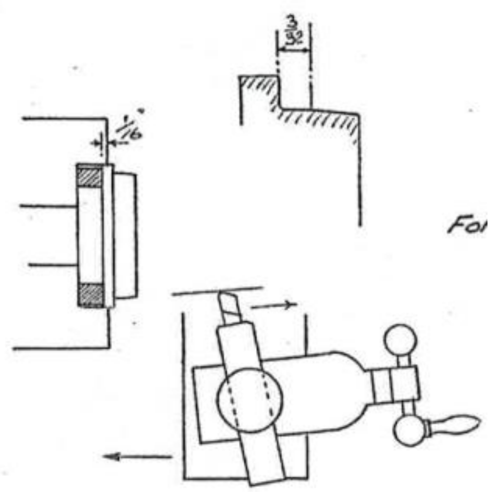


Fig 36

The same procedure may be adopted for the engine and tender truck wheels up to operation (6) then mount on a mandrel, turn the flange, round the corners, face off the back, and finish at front contour. Polish the rim with dry emery or aloxite cloth held on a flat stick against the rim while running at top speed in the lathe. Before taking it out, coat the face of the rim with clear lacquer by holding a brush well charged against the rim while the lathe is running on slow speed. About three revolutions will be all that is needed. This will preserve the polish.

Drivers - If the chuck is large enough the driving wheels can be machined in the same way as the trailers, if not, then bolt to the face plate, with two bolts passed through between the spokes. Do not screw up too hard or there is a liability of bursting the spokes. Get the casting running as true as possible, adjust bolts as required and then follow out operations (1) to (6) with the proper dimensions, of course. Reverse the wheel and face off the back. Treat all six wheels the same, then mount on a mandrel run between centers, and turn and round off the flange and polish the rim.

Now, we will need a jig made like Fig. 37. The plug portion **A** should be made a close fit to the wheel bore. If the latter is reamed with a standard reamer, the plug of the jig may be made half a thousandth less, in our case this will be 0.437. The length **B** should be about 1/32" less than the depth of the wheel hub. The hole had better be made 5/32".

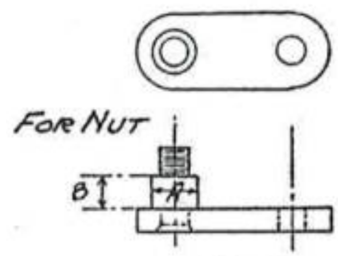


Fig 37

Slip the jig into the wheel from the front side, adjust central between the two short spokes, tighten up the nut, place the wheel on two pieces of parallel packing high enough to clear the nut and run a 5/32" straight fluted drill through. The straight fluted drill will produce a cleaner hole than the regular twist drill in soft cast iron.

The crank pin holes can now be opened out to 1/4" for the front and back and 9/32" for the main by means of a pin drill or counterbore made like that used for the axle boxes.

Axles – Cut the lengths required about 1/16" longer than finished overall dimensions. Now hold in the chuck and face off one end smoothly at the same time center drill from the tailstock. Do this to all the axles, then set the universal square to the proper overall dimension [Fig 38], lay the pieces against the blade with the finished end resting on the stock of the square, and scribe against the end of the blade. Just a short mark will do. No need to go all round. Put the axles back in the chuck and face off to this mark, and center drill at the same time.

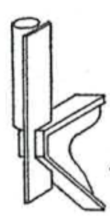


Fig 38

Check over the length. The axles may now be turned between centers in the regular way taking care to get the "fit" correct. A micrometer is very useful; in fact, the amateur should acquire one of one-inch capacity as early as he can. It will help considerably in knowing exactly what size a piece is rather than having to depend on the “feel” of calipers, etc. If you have no micrometer, turn a piece of steel so that it is a snug fit in the wheel bore; the same kind of fit as a piston. Then lay a piece of thin tissue paper on and set the outside calipers over the paper and the pin. This will set the calipers to about one thousandth more than the pin diameter, and should give a proper driving fit to the axle in the wheel bore. Before mounting the wheels, check over the axles for the "between hub” dimension. This should be 2-1/32" for engine and tender truck axles, 2-7/32" for the trailer truck axle and 2-1/4" for the driver axle, assuming no error has been made in the wheel hubs. If there is any wheel hub that is too low, the trouble can be rectified by increasing the length of the axle over the shoulders to suit.

Trailer Truck wheels can be pressed on, observing the same procedure as adopted with the valve bushes. Do not forget to dope the axle with a paint of lubricating oil and white lead. Before pressing in see that the edges are smooth and without burrs either in the wheel or the axle. Press on one engine truck wheel only for the two axles.

The driver wheels will have to be put on at right angles to each other so proceed as follows:

Make three nicely fitting plugs as shown on Fig. 39, to fit in the wheel bores so that they stand up about 1/4 inch. Now lay a straight edge against the plugs and mark the rim of the wheel. Do this on each side of the plugs and the intersection will be exactly in line with the axle center. This should be carried out on all drivers.

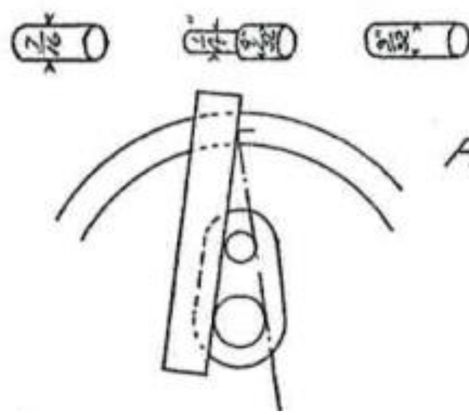


Fig 39

Now press on one wheel and lay it in a V block on a surface plate. Set the surface gauge needle to the axle center and turn the axle around so that the line on the rim registers with the needle [Fig 40]. Scribe a line across the crank pin boss and wheel hub. Now, take the square and turn the wheel and axle round so that the line just scribed is exactly along the edge of the square. Hold the axle in this position. Take the other wheel and push it on by hand. It should go on about 1/16" without force. Bring the surface gauge around and turn the wheel on the axle until the point on the rim registers with the needle. The crank pin holes should now be at right angles to each other. Press the wheel right on. Next month we will take on spring and brake rigging.

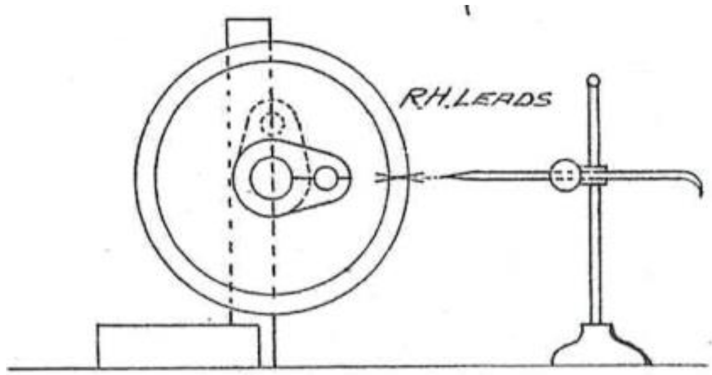
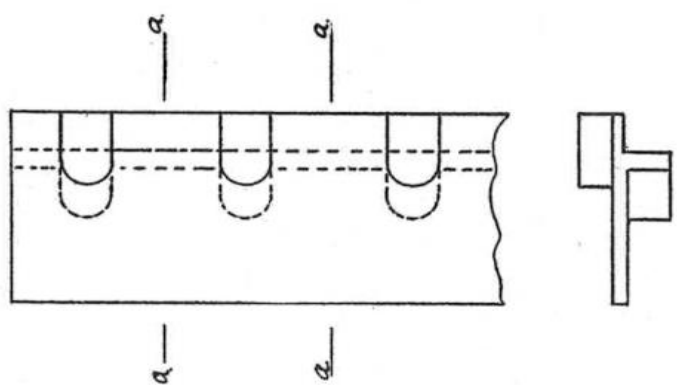


Fig 40

Spring Rigging and Brake Rigging

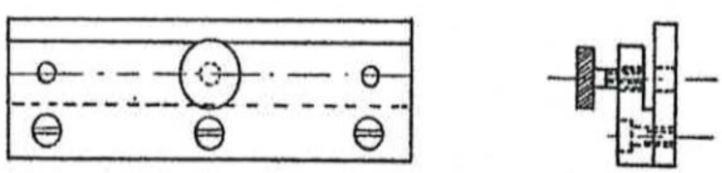
The spring rigging should present little if any difficulty, because only simple turning is involved, and the rest is a straightforward, bench and hand tool job. It will be better to make the **Frame Fillers** Part No. 468 first because they can then be placed in their proper place on the frames between the drivers. File up to the dimensions, mark out for holes, drill the bosses No. 2-56 tapping size No. 49, then cut out the 1/16" slots with a hack saw and warding file. Next open out the hole No. 44 in front and tap back No. 2-56 [Fig 41]. Fit the brackets exactly midway between the driver axle centers.

Fig 41



Now, make up the spring rigging details comprised by Drawing 64 for the drivers, and Drawing 82 for the trailer truck. The spring hangers, part number 264, are made of 3/16" - 20G strip brass and because there are quite a number, it is a good plan to make a simple jig for the drilling. The sketch Fig. 42 shows such a jig for jobs of this kind. The strips are cut off a little longer than 1-1/16" and placed in the jig flush with one end and locked with a small pinch screw.

Fig 42



The **spring hanger** part No. 164 is drilled one end for a 2-56 bolt and the other end drilled No.53, for a press fit No. 52 drill rod pin 1/4" long.

Spring saddles are made of 1/16" annealed brass bent over a small profile jig. To make the jig, take a piece of steel 1/2" x 1/4" x 9/16" long. File up to 7/16" wide at one end, 1/4" at the other and case harden. This makes a bending jig, also a filing gauge. Anneal the brass before bending by making it red hot and quenching in water.

The method of carrying the spring equalization through to the trailer truck needs a little explanation. Over the rear end of the rear driver spring is placed a special eye clip No. 664. It will be seen that this has a rectangular opening to receive the spring end and also a forked end 1/4" wide. This latter end slips over the main frame thus retaining the spring in the proper position. Connecting the two spring clips (one each side) is a double forked link or yoke No. 764 sometimes called the transverse equalizer. This in turn is connected to two hangers No. 1064, the lower ends of which hook over the ends of the trailer truck equalizer beam. It will be noted that the hangers 1064 are both well inside the main frames and the trailer truck equalizer beam slopes outwards to connect them to the trailer truck spring hangers and spring. The spring clip No. 664 and yoke No. 764 are made from solid brass 3/16" thick while the two hangers No. 1064 are turned from 3/16" square cold rolled steel. The slot in the end is easily formed by drilling three No. 44 holes and removing the pieces between the holes with a jeweler’s saw. The ends will later be twisted relative to each other by making them red hot and turning them in pliers, but this little operation can well be left until the rigging is assembled.

The **trailer truck equalizer beam** No. 282 needs no comment except a warning not to drill the fulcrum pin hole. This should be done on assembly by marking off from the trailer truck frame.

Brake Rigging – This is shown in assembly on Drawing No. 66 and details on 67 and 68. It will be seen that just behind the Cylinders is a duplex brake cylinder bolted between the frames. The pistons are plain and made a good fit and over-drilled to receive the **Push Rods**. Note that the push rods are not connected in any way to the pistons. They merely bear in the bottom of the hole in the piston. The push rods pass through the two holes drilled in the web of the guide yoke, and a spring is provided between the piston and guide yoke to pull the brakes off. The forked ends of the push rods No. 1367 are connected to the brake levers No. 167 which are pivoted on a fulcrum shaft carried in brackets bolted inside the frames. The lower ends of the brake levers are connected through equalizing levers to the brake beams, 1067 - 1267, the ends of which swing in the brake shoe hangers No. 568. These latter in turn are carried in the frame fillers that have already been described for spring rigging.

Brake Cylinder—This casting should be faced up one side and the frame fit filed or milled square to it. Then mark out the centers, clip to the face plate, drill, bore and ream. Drill steam passages and tap out 7/32"-40 for an automatic valve. Turn up the covers which are screwed to the end nearest the valve, and the steam passages. The pistons are to be made a close sliding fit in the cylinder; a few small V grooves turned in acting as seals. The 1/16" boss on the rear face of the piston is to provide clearance for the steam passage. Part No. 568 is to be filed up and made an easy fit in the frame filler No. 468. Part No. 668 is fitted to lugs on the rear frame cradle while part

No. 768 is to be screwed to the frames on the inside at the location indicated on the frame detail drawing.

The **brake shoes** are made by turning a ring of cast iron and cutting it up into pieces filed to the proper profile. The best way to turn the ring is to grip it in the lathe chuck by the outside jaws, bore inside and face one side. Change jaws to inside, place the ring in the jaws with the machined face inside, turn the outside, also groove and face off the outside.

Brake levers No. 167 may be held in the chuck, faced and bored, then mounted on a 1/4" mandrel and the other end faced off. Note that one is fitted with a set screw to secure it to the shaft while the other is free to turn. The long end is coupled up to the push rod 1367 and the lower short end is connected to the screwed fork, 267. The hexagon nut 367 connects the two portions of the screwed fork thus providing adjustment of the brake beams. The **brake beams** are built up of 3/8" x 1/16" flat brass with forked trunnions pinned and silver soldered on. Next month the side rods and motion work will be taken up.

Side Rods and Motion Work

The **side rods** may be cleaned up all over, and the joint between the back and front rods made and fitted. Do not fit this too tight, a little side clearance is desirable. Full size rods are backed off similar to sketch Fig.43 and the same practice can be adopted on the model. The knuckle pin passes through the inner limb of the jaw and tongue with the full diameter and is drawn up tight against the outer jaw by the nut and shoulder. Having made the joint and fitted the pin the two rods being coupled together, mark out the crank pin bush, center and drill it the same size as the center hole in the jig you made for setting out the bearing centers. Now, clamp the two rods to the jig with a plug in the center hole to locate, and spot drill the front and back ends. Just drill a countersink with same size drill as the holes in the jig. Then take the rods off and drill through with the proper size drill. Turn up the bushes about 0.001 larger than the hole and press them in. Note that the bushes stand out from the rod 1/32" on the inside. Drill oil holes No. 52.

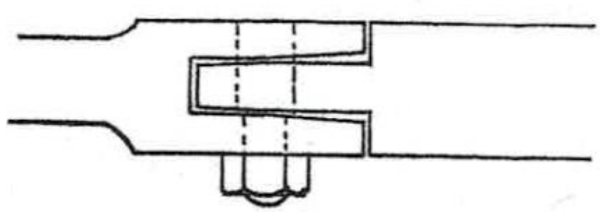


Fig 43

Valve motion —Most of the links are a straightforward filing and drilling job. File the parts up close to the dimensions because nothing spoils the appearance of a model as much as clumsy looking valve gears. Be careful to make the parts for right and left hand where they are unsymmetrical. All parts are of nickel silver except the expansion link and die block. The former is best made of steel. Lay the contour and center lines out carefully on a piece of 1/8" thick cold rolled steel and drill a series of No. 15 boles along the center line of the radius of slot. Cut out the fins and carefully file to the line using a narrow No. 2 pillar file for convex surface and a 4-inch No. 2 "Crossing" file, for the concave surface. Finish out the surface by "draw filing" with a No. 4 file.The back of the link is made square and the outer edge is to be 7/16" out: this is important.

The next job is to make the **trunnions**. These are turned from a solid block of steel 3/8" thick. The sketch Fig. 44 shows the steps to be taken. The 1/8" opening should be a nice fit to the link and the bottom should be exactly 7/16" down from the center line. It will be now seen that when the trunnion piece is put on the link, the bearing centers will be on the center line of the slot.

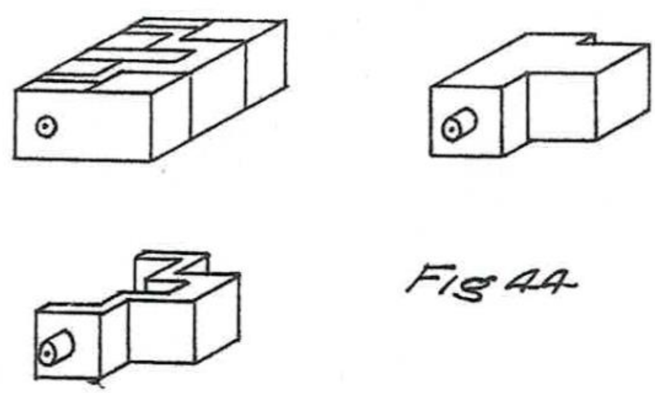


Fig 44

Drill for the rivets, right through, then case harden the link by making it red hot, then rolling it in "Kasenit" and quenching in water. Polish up with emery cloth and then rivet on the trunnion. Finally cut away the superfluous metal as shown. The drilling of the fork end of eccentric rod No. 960 had better be left until erection of the valve gear. Lifting arm No. 1160 can first be drilled, mounted on a mandrel and faced on both sides of the arms, then filed to the correct profile. It is important to obtain the profile of the lifting arm as shown on the drawing [Fig 45] because the arm must clear the expansion link path for all positions.

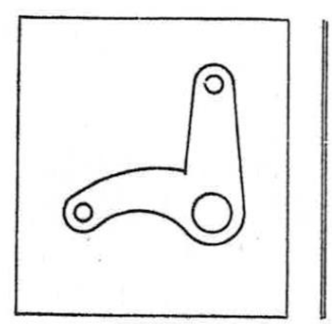


Fig 45

The easiest way to produce the contour is to carefully set it out on a thin piece of steel or brass, then drill the holes, and cut out filing close to the lines. Put a piece of 3/16" drill rod in the boss of lifting arm, slip the template over it, drill No. 44 holes; put a 2-56" bolt through one thus holding the template fast, then fix the lifting arm down to the template.

The **expansion link brackets** are castings, the two halves being cast together. Proceed to finish up as follows: First file out or mill the opening 7/16" wide, then file up the seating. Mark out for the bearings, place a piece of material between the two webs, hold in a toolmakers vise, square with the base, and drill right through 5/32". Now, take the motion beam No. 763 and mark out the center lines 4-3/4", if this is not already done. Also mark the link bracket center line 7/32" from the inside of the webs. Clamp the bracket to the beam and spot No. 44 holes from those already drilled in the beam. Take off the bracket and drill No. 49 for 2-56" tap. Now the bracket can be sawn in two pieces down the center line. Mark the brackets and beam so that they can always be properly mated.

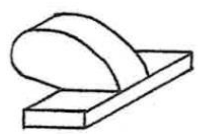


Fig 46

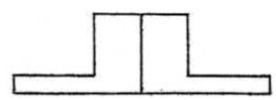


Fig 47

The expansion link may now be placed in the brackets and the inside of bracket eased out to allow the link to swing easily.

The **reverse shaft bracket** No. 563 may be made. The castings supplied will be as shown on Fig. 46. To make the brackets right and left hand, cut off the foot on one side of one bracket and the opposite foot of other. Clean up the face and sweat together as shown on Fig. 47. The pair of brackets can now be filed up and drilled thus ensuring that the brackets are in line when they are screwed to the top of the motion beam. Next month the boiler will be dealt with.

The Boiler

Boiler - The first job is to prepare all plates, tubes and stays, and do not attempt to rivet anything together permanently until all fitting has been accomplished satisfactorily. Proceed as follows:

The barrel which is hard drawn copper tube should have the ends turned off square and to dead length. To do this, turn up two wood plugs a good fit in the tube and tap in lightly. Now the tube can be mounted in the chuck, and the tailstock center brought up to support the outer end. Face off one end, reverse end for end and bring to the correct dimensions. An inner liner must be sweated to the inside of the barrel under the steam dome. Cut out a disc 2 inches in diameter of 1/16" copper. Bend it to 1-5/8 " radius and sweat it in 2-7/16" from the firebox end. Do not cut any hole.

Next, take the throat plate casting, bolt to the face plate of the lathe and turn the flange a good fit to the inside of the barrel, Fig. 48. Then file up the wrapper plate flange and clean up the surface where the mud ring bears. The “back head” is a flanged copper plate for which a hard wood "former" must be made, or one if cast iron, purchased. Cut the copper plate out to the dimensions given by Fig. 49.

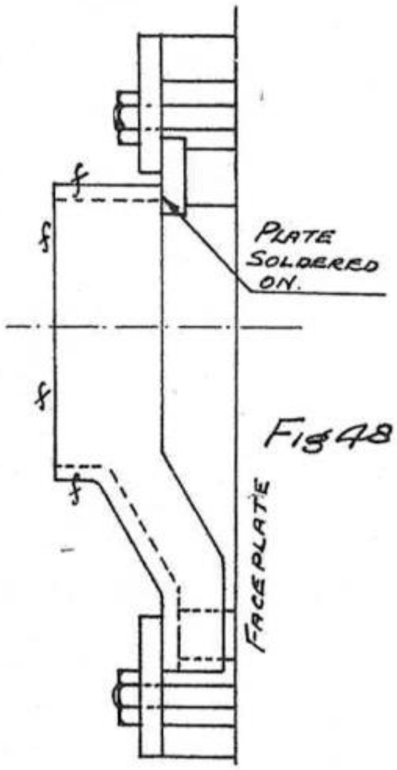


Fig 48

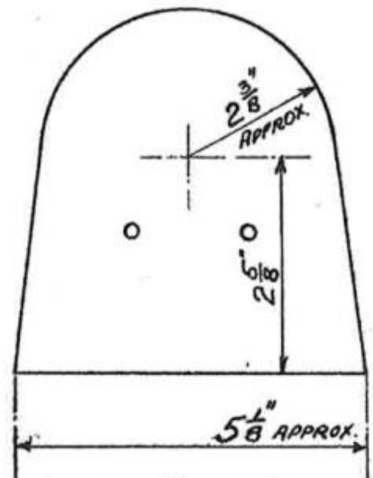


Fig 49

Drill two holes anywhere within the fire hole space, anneal the plate well by making it red hot and quenching in cold water, then screw down to the former. Now beat the edge of the plate down a little at a time with a soft hammer or wood mallet. Go all round the edge. That is, deliver one blow at the bottom say, advance a little and strike again until you finish at opposite corner. Repeat this process until the flange is snug to the “former.” You will find that the plate hardens as the flanging proceeds, and it will be necessary to re-anneal three or four times during the operation. This particular plate is a simple job and will take less time to make than the "former,” but care spent on the latter is well repaid by the resultant accuracy of the plate.

The above note will also apply to the flanging of the inner firebox plates with this further hint. The firebox plates have small radius corners connecting two straight edges and it will be found that as the flange is formed, the metal of the corner grows out considerably longer than the rest of the flange, See Fig. 50, and there is a strong tendency to buckle. This little trouble can readily be overcome by clipping back the superfluous metal before resuming flanging.

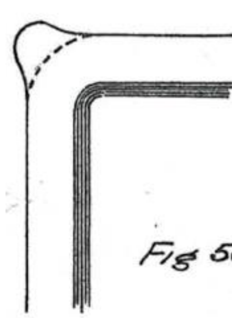


Fig 50

To sum up; the royal road to flanging is (1) Keep the plates soft by annealing, (2) Light blows evenly distributed and readily advanced along the edge, (3) In sharp corners or irregular flange, keep the flange of even depth.

Having made the backhead, clean up the mud ring to dimensions. and tin it inside and out. Now take the throat plate and clamp the mud ring to it and do the same to the backhead. Stand the whole on a surface plate and check over for dimensions **a**, **b**, & **c**. If not correct to the drawing, adjust the edges of the mud ring, remembering that a slight alteration here will make a considerable difference at **a** & **b.** See that the sides are square and when all is satisfactory, "tack" solder the two plates to the mud ring. Just a spot of solder is all that is needed to hold temporarily and solder in a strip of any convenient size brass at **x** to give the structure some stability. Now you have a skeleton outer fire box upon which a piece of stiff paper may be laid and trimmed to the edges. This will produce a perfect template of the outer wrapper. Mark the center line on top, also the center line of the barrel on both sides. This is easily done with the square while the firebox is on the surface plate. Mark out the centers of stays and rivets from these lines, then glue the paper in two or three places to a piece of 1/16" copper. Prick punch all holes and drill, then tin the edges on both sides and round all stay holes. Rivet holes are to be 3/32" drilled and stay holes drilled No. 30 for No. 5-40 tap.

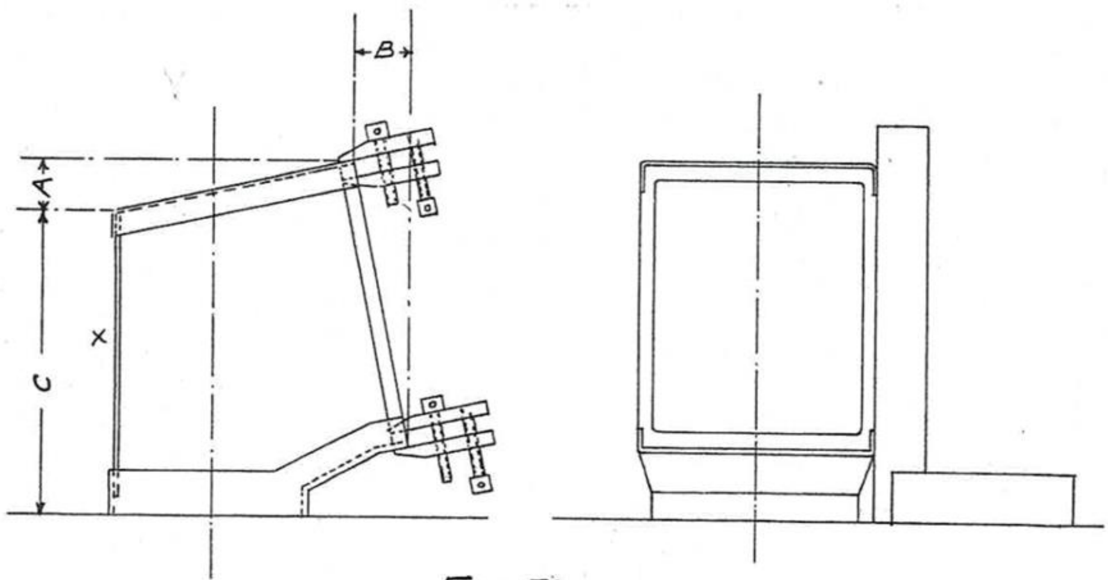


Fig. 51

The wrapper may be bent around a piece of wood turned to 3-5/8" diameter, then placed in position on the "skeleton." See that it is a snug fit all around. Clamp to the mud ring and drill through to the backhead, mud ring and throat plate. Now take all apart. Flange up the inner fire box plate and drill for the tubes, Fig. 52. line up to the mud ring on the inside in the same way as described above, cut a paper template for the firebox crown and side sheet, but this time do not drill stay holes nor the holes along the mud ring. Only the holes in the exterior sheets are to be drilled now.

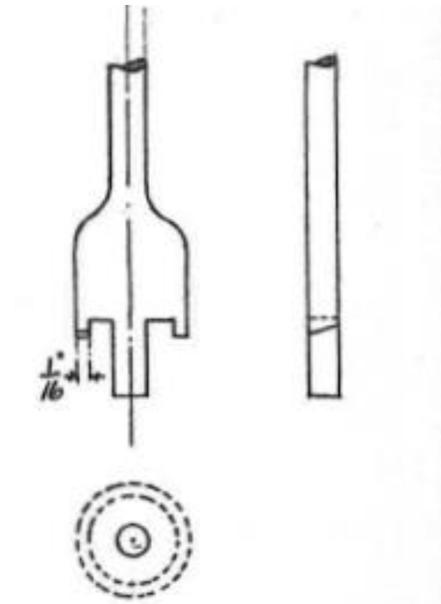


Fig 52

Tin the sheet all over both sides, then bend over a piece of wood shaped to the top of the firebox, apply to the flanged plates and drill the rivet holes. Rivet up. Put the mud ring on, “tack” solder in one or two places, and drill rivet holes in the sheet using the mud ring as a jig. Clean up the fire hole ring casting, cut the hole out in the backhead, drill rivet holes, sweat the firehole ring in place on the backhead and drill through.

Now, all is ready for riveting up the firebox. First rivet the wrapper to the backhead then to the throat plate, then the barrel to the throat plate. Be sure that all joints are tinned before riveting. Next, slip the mud ring over the inner firebox and hold it in place with four loose pins placed in rivet holes on the inside. Slide the whole unit in place in the wrapper. If it will not go up far enough to permit the rivet holes lining up, look at the firehole ring. It may be bearing hard against the inner firebox. Rivet up along the mud ring, all around and drill right through the holes around the firehole, and rivet up with round head inside and countersink heads in the backhead.

Flange up the smokebox tube plate, drill holes, fit the liner and sweat. Drill for the steam pipe and grind in the ring No. 773. Then tin the flange, put in the barrel taking care to get the steam pipe hole on the vertical center line, then drill holes and rivet up.

The rivets at the top over the superheater must have their heads well flattened to clear the super heater header. The tubes can now be fitted and expanded at the front end and silver soldered or expanded with a drift in the fire box.

The boiler is now ready for staying. To make the stays take lengths of 1/8" Tobin Bronze, put in the chuck and run a No. 5-40 die over up to the jaws, pull the rod out another three inches or so without removing the die and run the lathe on slow speed. Repeat the process until the rod has been screwed up to the last 1/2" or so left in the chuck. Cut this off. Use soap or soda solution while threading because the die will run hot. Lard oil is good but objectionable in this case because we need to “sweat” the stays later.

Now, drill right through the holes in the wrapper into the firebox using a tapping drill No. 39 for 5-40 thread. Tap all the stay holes, those on the sides of the firebox can be tapped right through from the outside because the tap is long enough to permit this. The crown sheets can be tapped from outside the wrapper and inside the firebox. If the thread is not continuous between outer and inner plates, the maximum error will not be enough to prevent the stays being screwed right in both plates.

In full size boilers, of course, where stays are from 7/8" to 1 1/8 " in. diameter, the thread in inner and outer plates must be continuous, hence the use of special long taps called “tapper taps” that go through both plates at one time.

Now, we are ready for **staying**. Clean off any burrs around the holes, take a length of the screwed bronze rod and hold in the chuck of a band brace. Screw in until about 1/8" is protruding on the inside of the firebox. Cut the stay off 1/8" from the outer plate with a pair of cutting pliers or jeweler’s saw. Do this for each stay, then screw a nut on each end. It is good practice to tin the nuts before putting them on the stays. To do this, melt some solder in a ladle, dip the nuts first in soldering fluid (No-Korode is good), then drop them in the solder. Let them stay a few minutes, take out and shake off the superfluous solder.

The boiler proper is now practically finished. Cut out the fire hole in the inner firebox by drilling around close to the ring and file smooth, then go over all the joints with a torch or blow pipe or even a good Bunsen burner. Apply the flame to all joints and stays serving in extra solder if necessary and running around all with a soldering iron. Use plenty of soldering fluid. Do not carry out any sweating or soldering jobs in proximity to good tools or they will be rusted by the fumes. If you must do all your work in one place, then put away all tools and cover up your lathe.

Now it will perhaps be noted that up to now there is only one opening in the boiler, namely, the steam pipe hole in the front. This would be a good time to test the boiler under hydraulic pressure, but before doing so, a small amount of preparation is necessary. First the hole for the steam pipe must be covered and the best cover to be found is the superheater header itself before the steam pipes are fitted. Therefore, take the header casting and face up, then drill the hole at the back. Be careful not to break through, then drill the No. 30 holes for No. 5-40 brass screws. Place a piece of 1/4" drill rod in the 1/4" hole, slip the jointing ring over, flat face to header, then insert the whole set into the hole in the front tube plate. Level up and spot drill No. 30 holes, follow with No. 39 and tap No. 5-40 into the front tube plate. Put a smear of graphite and oil on screws, also on the jointing ring. Next drill and tap the holes marked “check feed connection” also “turret” the former 5/16"-32 and the latter 3/16"-40. Make two brass plugs of any odd piece of brass, one drilled to receive a pressure gauge connection, the other drilled through 1/8" and fitted to receive either a tyre pump rubber hose or a 3/16" copper pipe connection.

Fill the boiler up with warm water till it flows out of the top, put in the plugs, fill up the tire pump with water and press on the plunger till 160 lbs. is registered. Inspect all stays and joints for any weeping. If there is, empty the boiler and go over the offending joint with the torch and soldering iron. If many little leaks are showing time is saved by pumping up a few pounds air pressure, then plunge the whole boiler in a tub of water. The issuing bubbles will reveal the leaks and the trouble is saved of filling and emptying the boiler each time. When no more bubbles show under, say 25 lbs. air, the hydraulic test can be given.

If everything is found to be tight, the steam dome opening can be cut out by drilling a ring of holes close together, then with a rat tail file cut the fins between the holes and the disc will fall out. Trim up the edge with a half round file.

Drill and tap all the other holes and the stuffing box for the throttle had better be fitted after the throttle rod and steam pipe is fitted.

The **smoke box** can be made from the piece of tube left over from the barrel. The **Firedoor** can be fitted and the hasp screwed to the backhead by two No. 2-56 brass screws. Dope the threads with Dixons graphite jointing compound.

Boiler Fittings and Lagging

We now come to what should prove an interesting and easy job. Make all the parts for the boiler fittings, then make one job of the sub-assemblies finally putting each unit in its proper place.

Throttle Valve Unit

(1) Take the Throttle Box casting part No. 3B8, hold in the chuck by the lug provided for this purpose, face off the top, turn the flange, also the collar under the flange.

(2) Take the Dome Base part No. 1B8, hold in the chuck by the flange or better still make a split ring a little larger in diameter than the flange to slip over the body part and grip in the chuck by this. Face off the outer edge, bore out the part 7/8" then 1” to 1/2" deep. Try the Throttle Box in, it should go in easily. When right, chase the threaded portion. Take it out of the chuck and lay it aside.

(3) Turn up the cap, part No. 2B8, chase the thread and fit to part No. 1B8 dome base. Be sure the two parts screw together correctly before removing the cap from the chuck. If the lathe has no screw cutting arrangement, this job had better be done by someone who has.

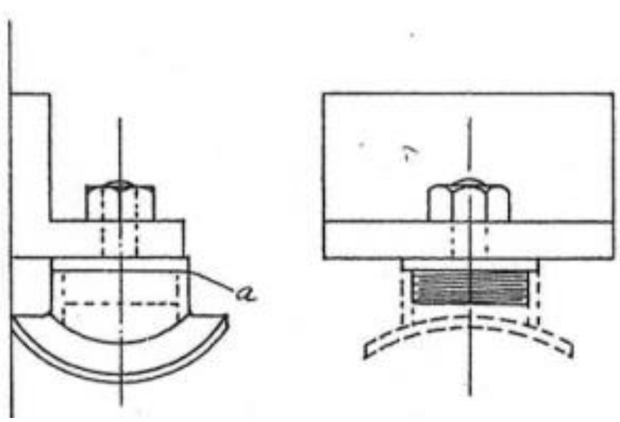


Fig 53

(4) Now make a screw plug bolt like the sketch of any odd piece of brass or steel, Fig. 53, to fit on the Dome Base 1B8. Screw the base on, then slip the bolt in the slot or hole of the angle plate and bolt the latter to the face plate. Locate it so that the top edge "**a**" is 2-1/4" from the lathe center. Now turn out the curved seat until the dome base is 1/2" high at center. Take it off and lay it aside with the throttle box and cap.

(5) Turn up the collar 4B8, also the throttle pin, and the lathe work is finished.

(6) Mark out all holes in the throttle box, drill and tap according to drawing, then file or mill the slide valve way.

(7) Make the valve part 6B8, file the flats on the throttle pin 5B8 to form the eye, and drill the same.

(8) Grind the valve and throttle box together with a little pumice and water.

(9) Drill the No. 39 holes in the Dome Base.

The throttle pull rod, steam pipe, throttle lever and fulcrum can be made, also the stuffing box No. 474 gland No. 574 and steam turret No. 274. The outer steam dome cover which will be supplied in aluminum needs only filing up smooth and to fit the top of the lagging.

Superheater - The header is partly finished because we used it as a covering for the steampipe hole. Finish out the drilling and plug the holes as indicated either with a 5/16-32 screw plug or a plain plug driven in and brazed. It is a good practice to countersink the holes say 1/32" wherever plugs or pipes are to be brazed.

To make the “elements”, a simple bending device is needed, made like sketch Fig. 54. The bottom roller can be made of hard wood, cast iron or steel in which the handle is fulcrumed, carrying a small steel roller. Larger radii may be bent on the pipe than the bottom roller provided merely by pulling the lever over a little, then pull the pipe back a little, bend again and so on. The smallest radius capable would be that of the bottom roller when the pipe is pushed through between the rollers and the handle brought right around. The bottom roller can be held in the vise during a bending operation. Take a 11-1/2" length of 1/4" copper tubing and bend one end to 1" radius. About half inch of bend is all that is needed, then file the end parallel with the straight portion. This will produce the “spear” end. Do four tubes the same. Then change the roller of the bender to one of 3/4" radius, and bend up the other ends of tubes, note that the bends on one pair start at 8-3/4” from the "spear” point and the other 9-1/4". Be careful to mate the tubes at spear ends, then no mistake will be made in bending the header ends up or down. The steam pipe outlets can be bent and screwed and then having all joints nicely cleaned with emery cloth, we are ready for brazing or silver soldering.

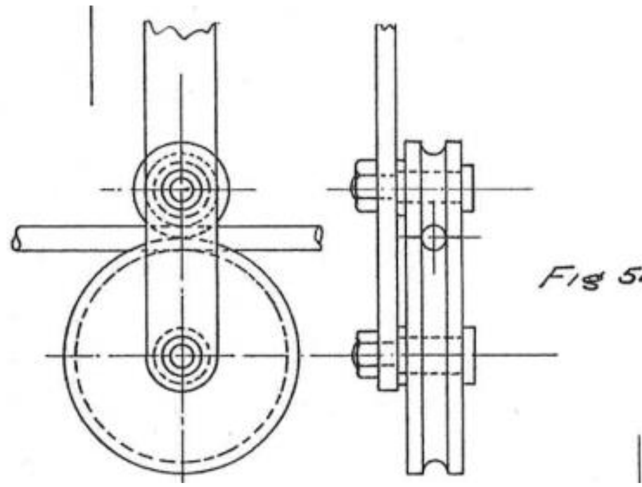


Fig 54

Bind the elements together with iron wire in their correct position, have a pan of coke or charcoal. Cut a narrow strip of silver solder and bend it around the joint. Cover it with a paste of borax and water or one of the brazing compounds, then lay it in the charcoal and put the flame on serving in more borax or solder if required. The solder will melt at a dull red heat and little doubt will be had when the joint is “made” because the silver solder will show up brightly and will quickly flow around if you take care to prevent oxidization by keeping the joint covered with the borax. An iron wire may be used to coax the flux and solder around.

The **Safety Valve** is quite a simple lathe job. Chuck a piece of 1/2" hexagon brass, face off the end, turn back for 1/4" to 3/8" diameter, screw 3/8"-32, center and drill down for about 1", and cut off with the "parting” tool exactly 29/32". Now drill and tap 3/8"-32 the piece of stuff left in the chuck. Screw the valve body you have just made in and open out the 3/16" hole to 3/8" for a depth of 9/16". This should be done with a pin drill with a 3/16" pilot, because it is essential that the valve seat has a good square edge. The outside of the body is to be threaded 1/2"-27. The **Cap** may be either knurled on its outer face or better still, slotted with a ward file in about six equal spaces. Four 3/32" or No. 40 holes drilled in the top provide for escape of steam. A 1/4” bronze or stainless steel ball, stem and spring completes the job. Screwing down the top cap increases the blowing off pressure.

Water Gauge— Castings are provided as shown on the sketch Fig. 55, which gives the top and bottom heads of the gauge. First, cut it in two, then put it in the chuck by lug **A**, and turn, drill, and screw the shank that goes into the boiler. Do not drill too far down. 11/16" is enough, measured from the finished face of the screwed portion. Take out of the chuck and put the lug at right angles in, turn, face, screw, and drill 5/32". Now file up the two side faces clean, then cut the chucking lugs off. Chuck 2 pieces of round stuff, drill and tap one 3/16"-40 and the other 1/4"-40. Screw the fitting in and face off the top and front side of the square portion. Tap the 5/32" hole to 3/16-40.

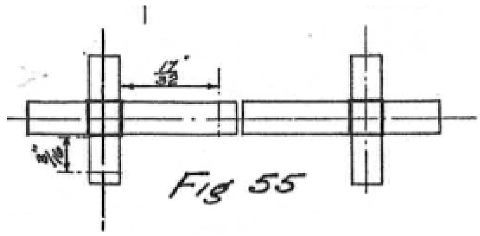


Fig 55

The bottom “stand” or head can be made similarly with the exceptions that are obvious on the drawing. The 3/32" drilled passage is opened to 1/8" at the front and then tapped 5/32" for the screw needle valve. The tapping should go in 3/8".

The nuts need no comment except that the inside should be square bottomed with a flat cutter or end mill, or a pin drill, with 5/32" pilot. Make seven nuts.

Check Valve. —Two check valves are required which should be made according to Style B No. 355B as shown on the drawing.

The **Blow Off and Blower Valves** are self-explanatory.

The **Injector** is exactly as made by the well-known London model maker, L. Lawrence (L. B. S. C.) and a full description of making one is given by that gentleman in Model Engineer for Nov. 13 and 20, 1924. The drawings accompanying the castings are made exactly to the above mentioned notes by L.B.S.C., and no difficulty should be encountered if care is taken to work exactly to the dimensions. Details of the special reamers required for the steam delivery and combining cones are also given on the drawing.

The body casting should be chucked by one end, drilled and reamed right through, faced off and screw 5/16"-32 on the outside. Then tap a piece of round stuff 5/16"-32, hold in the chuck, screw the body in and turn and screw the other end of the body. In order to machine the overflow valve chamber and water connection, drill a piece of round brass 1/2" with center 5/32" off eccentrically, split through as sketch Fig. 56, slip over the 1/2" diameter portion of the body and grip in the chuck. The water suction end can now be turned, screwed 5/16"-32, faced off, and drilled 1/8”. Make a similar eccentric collet, but tapped 5/16"-32; screw on to the body so that the center line of the casting is on line of the eccentric centers, as shown on Fig. 56 and grip tight in the chuck. Drill, tap, square out the bottom and face off the top.

The combining cone part No. 254 is to be made a tight fit in the body and carefully driven or better still, pressed in. After the cone is pressed in, drop a 1/4” steel ball in the overflow chamber, give it a light tap with a hammer, through a piece of brass rod, and if the seat is first clean and sharp square edged, the ball will find a perfect seat. Use either a bronze or stainless steel ball. If the former, you need to treat the seat as above with an ordinary steel ball; if the latter, the ball itself may be tapped to form the seat, and then used as the valve. Drill and tap the overflow outlet 1/4”-40. Make three union nuts and sleeves, also the steam and delivery cone which should slide into the body easily.

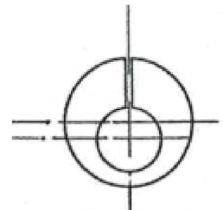


Fig 56

Three screw down stop valves will be needed, one No. 2 for the injector steam and one each No. 1 for the blower and brake. The machining operations are similar to injector parts. [Appendix 7]

Smoke Box Front — This should be held in the chuck by the flange and the screwed portion turned and threaded, facing the flange at the same time. If your chuck will not take the flange, clip to the face plate with the curved door portion outward and then turn the "door'' 1-3/4" dia. 3/32" back. Now hold it in the chuck by this step and turn the threaded part. Next, take the ring, chuck or mount it on the faceplate, then bore and cut the thread to fit the front previously made. Screw the two parts together, grip the front by the step in the chuck as before, and turn the ring to a nice fit inside the smoke box. This being done, take it out of the chuck and reverse, holding it in the chuck by the ring. Do not grip too tightly or the flange and ring may be distorted. Drill a No. 49 hole in front and bring up the tailstock. This will prevent the job from coming out of the chuck if it is not held sufficiently tight. Now finish the front right out and round the edge of the flange. There is ample allowance on the casting to permit of turning the front all over. Before removing from the chuck, screw the front out. If it will not come by hand, grip it, take it out of the chuck, and drill two holes No. 44 diametrically opposite, on the edge of the ring. Slip two pieces of No. 44 drill rod in, lay a piece of steel across them as a lever. With the step portion held in the chuck, a pressure on the lever will start the ring.

Smoke Box Door Dogs — It will have been noted that the smoke box door is solid with the front, the reason should be obvious because the standard design of an American smokebox door is too small when reduced to scale to permit of access to the inside of the smoke box. Hence the whole front is screwed into the ring, which is rivetted or screwed to the smoke box in a manner to be described later. The door dogs or clamps are dummy, and when neatly made and applied, give a very pleasing and realistic appearance. Proceed as follows:

Take a piece of 3/16" square brass about 2-1/2" long and mill or file. a step 1/16" deep. See sketch Fig. 57.

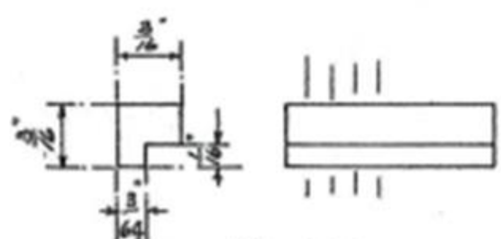


Fig 57

Now cut off slices of this bar, 1/8" wide with a jeweler's hacksaw by preference. If you have not succeeded in cutting them off of even width, tin one side with soft solder also any piece of flat brass plate, heat up the plate, lay the dogs on, cool off and then a few strokes of a fine file across the whole set will soon make them all of same thickness. Heat the plate again and wipe off any adhering solder from the dogs. Next make two dummy hinges and butts like sketch Fig. 58.

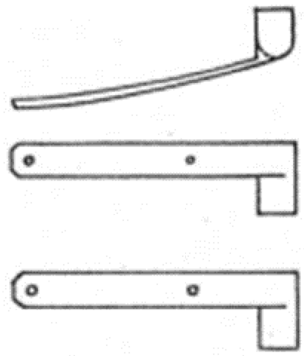


Fig 58

Now all is ready for application. First tin the under sides of all dogs and also the hinge pieces using a minimum amount of solder. The smoke box front must also be tinned all around the door. Wipe off superfluous solder with a clean cotton rag. Now, support the smoke box front level and steady high enough to get a Bunsen burner underneath, then brush over with soldering fluid and lay all the dogs and hinges on, distribute them evenly (a pair of tweezers is almost a necessity in model making.) Everything being located nicely, light the burner and warm up the whole set till the solder melts, cool off and it will be found that every dog is tight and no solder showing as fillets or nodules. All that is necessary now is to drill each dog and tap through to the smokebox for No. 0-80 hexagon screw. If neatly done, the result will meet the approval of the most critical. Wash off the soldering fluid in warm water and then screw the smokebox shell placing the hinges horizontal. Mark the smokebox also the flange of the front, then pull out and transfer the mark to the ring. Screw the ring off and put it in the smoke box shell mark to mark, then drill through from the shell spot with a No. 44 drill, and follow with a No. 49, and tap 2-56 for round head screws. Shorten the screws as found necessary.

The **Smoke Stack** is first held in the chuck, then bored through 23/32", then pressed on a mandrel and the outside turned and threaded as indicated. The **Stack Base** No. 570 can be bored, and the outside cleaned up with a file. The same remarks apply to the curved ring or washer No. 271.

The **Petticoat** or draft pipe must be first bored and threaded to fit the smokestack, then it may be screwed on a short stub held in the chuck, and the bell mouth machined out.

All the boiler parts should now be assembled, and fittings mounted. In order to mount the fittings such as the gauge glass, screw the collars on tight and make a mark on the collar and fitting, and slip the collars with the top and bottom heads into the boiler backhead having a piece of 5/32" drill rod or pin connecting the two heads. Mark the collars and back head, screw the fittings off the collars and sweat them into the backhead mark to mark.

The **glass or water gauge** can be made tight with a small coil of worsted treated with boiled oil and graphite, or a small washer of rubber may be cut to fit the glass and stuffing box. This can be done with a sharpened piece of tube, or a specifically turned and drilled piece of drill rod.

Lagging—The front portion of the boiler should be covered with a layer of asbestos cloth 1/16" thick and No. 26 gauge brass wrapped around. Now, cut out a piece of No. 26 brass according to the template as on Drawing No. 93; when this is rolled around it will give the conical portion. Wrap around the boiler with the joint on the underside and tack solder in two or three places to the front sheet. The straps should be made of strips of the brass and a 1/8" screw and nut fitted at the ends with clearance between so that they may be drawn up tight.

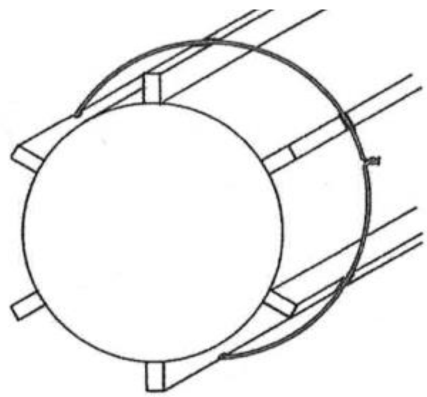


Fig 59

See that the conical section is concentric to the boiler barrel and then ram in asbestos wool or magnesia. The next section of barrel is 4-1/8" dia. giving a 5/16" space all round to be filled with asbestos. The best way to do this is to cut some slips of wood 5/16" wide and lay them around the tube, binding on with wire as shown on sketch Fig. 59. Now fill in the spaces with asbestos wool mixed to a putty with water and smooth off. Allow it to dry and apply the jacket. An alternative is to wrap the barrel in layers of asbestos cloth to 5/16" thickness and apply the jacket as before. Next month we will take cab and running boards.

Cab, Running Boards and External Details

Taking the **Cab** first, it will be seen by Dr. 75 that one side and half of the front is all one sheet of 20G brass. The 7/16" gap left at the top is provided to clear the steam turret. The connection of the cab to the boiler and frame is effected by means of an angle fitted to the top of the boiler and angles inside the sides of the cab screwed to the deck plate. This in turn is attached to the rear apron plate, thus the boiler is free to expand due to the flexibility of the furnace bearer plate and the cab apron plate; the smoke box end being securely screwed to the cylinder saddle.

The **roof of the cab** is made to slide right off for convenience in driving and the roof ventilator slides back for access to the throttle even if the roof is on.

It is a good plan to set out the **side sheet** on stiff paper or thin card first, obtaining a correct template to cut the sheet brass to. It is cheaper and easier to alter a paper template than to use the brass right away. The window sashes are cast, thus saving cutting out but they should be filed up neatly and the framework made even. The runners are sweated to the inside of the cab and the roof clip is attached to the top sash runner. This may be done with three 0-80 screws tapped into the runner or it may be sweated. The windows in front and openings inside are best cut out by drilling a row of holes around the outline and cutting the fins with a small sharp chisel. Another method is to drill a hole in the corner, clamp a piece of wood, say 1/8 " thick on the underside and then saw out with a fret saw.

The **roof** may be bent over a block of wood cut to shape. The beading is easily put on if the following note is observed. Take a length of 1/16" half round brass wire and tin it on the flat side by rubbing the soldering iron along. Try to prevent the solder from running around the curved side. Tin about 1/8" of the edge of roof sheet and then clip the wire with a clamp so that the wire is just over the edge of sheet. Now take a hot soldering iron with a minimum amount of solder and apply to the edge. If done carefully, no superfluous solder will show on inside edge of the wire to spoil the appearance of the heading. Move the clamp back a distance and repeat the process. It is best to use two clamps and sweat between them, leave the last one on and put the first one in advance, then leave this one on and bring the other one in advance and so on. When you reach the corner, bend the wire round carefully with round nose pliers.

The **Deck Plate** is a very simple job, all that is necessary is to follow the drawing. From the scrap left after cutting out, the boiler waist sheet may be made and attached to part No. 290 which it will be remembered was left unfinished. The reverse gear reach rod and reverse rod also the bracket and pawl can be made up and located on the deck plate. Then turn up the reverse cylinder (dummy) and drill 5/16" as shown on the drawing. Mill or file the sides away thus forming the crosshead guide. The cylinder end is drilled 1/8" or No. 30 to allow the reach rod to pass through. Cut out the reverse cylinder bracket from a scrap of 1/16" brass left from the deck plate. Shape and fit it to the boiler barrel jacket, then screw to the cylinder. The bracket will be soldered to the jacket later.

Similar remarks apply to the **air compressor**. The headlight **turbo generator** is turned from 5/8" brass bar, and then soldered to a bracket made of No. 20 G brass. This in turn is sweated to the jacket at a point 1-1/2" up from centerline of the boiler and 1-3/8" out, on the LH side.

The **headlight** is turned from a casting and the inside bored out to a parabola. The bezel should be bored a “push” fit; this would be about one quarter thousandth less in diameter than the headlight. The curved base may be filed up to fit and soldered to the headlight and the bracket bent up of 1/16" brass for attachment to the smoke box front.

Bell Stand - This is a casting that needs filing up clean, and base turned by holding in the chuck with the lug cast on. The trunnion bell carrier must be filed to a fit between the horns of the bracket, then sweat it in place and drill No. 52 right through. Unsweat, and file off the solder, then slip pieces of No. 52 drill rod in and secure by a little touch of solder on the end on the inside of the bell trunnion. The trunnion will be found to swing nicely. The little lever on the outside can be made and applied the same way. Turn the bell up from a piece of 3/4" brass, being careful to get the outside profile correct. A poorly shaped bell spoils the appearance of a model locomotive.

The **Whistle** may be built up as indicated, sweated together, and a light cut taken over in the lathe and polished.

Couplings are made in two parts sweated together. First, clean out the knuckle pocket, shape up the knuckle, drill and fit all together, and when satisfactory sweat the parts together. It is best to sweat the shank only, then there is no fear of soldering everything up solid.

The pilot is built up of strips of 20G brass 1/8" wide soldered to a 1/8" x 1/16" framework. An aluminum former is supplied upon which to make up the pilot. The solder will not stick to the aluminum and being a good conductor of heat, the joints will be quickly cooled as soon as made, thus preventing previously made joints from fusing.

Bend a piece of 1/8" x 1/16" around the bottom of the former and another across the top. Let the ends stand over. Cut up fifteen strips of 20G x 1/8" and lay them one at a time on the top bar and solder in place. Now tap down the slats in contact with the former and lay on the bottom bar and solder in the same manner. Trim the ends and solder on the support bars.

The **uncoupling gear**, **oil reservoir** and **brackets** are self-evident from the drawings.

The **ashpan** consists of a piece of 20G brass bent up at each end and having the sides brazed or riveted to it. The sides are of brass gauze or screen. The ashpan rests upon the rear cradle and is merely slid into place; the two angles shown acting as stops. Next month – Assembly and Valve Setting.

Assembly and Valve Setting

Assembly and Valve Setting - After proceeding with the assembly one more item has to be made. That is the springs. If leaf springs are made to scale, it will be found that they are far too stiff; in fact, practically as good as solid metal dummies. There are two methods of making working leaf springs. One is to provide a sufficient number of spring steel leaves to take the load and deflection, and interspace with leaves of leather. Another is to place washers between the leaves so that the dimension of the spring is to scale. The sketch, Fig. 60, illustrates both methods. If the builder does not care to go to the trouble of making leaf springs, dummies may be used and spiral springs may be inserted in the buckles (see sketch), which in turn bear upon the tops of the spring saddles.

Fig 60

The two top leaves should be cut full length and the remainder graduated. Soften the extreme ends of the two top leaves, and cut out the center as shown on the detail. This can be done with a punch the same shape as the slot. Place the spring on a block of lead, hold the punch in position and give it one good blow with a hammer. The piece will be cut out clean. A similar process can be adopted for the hole in the center of the spring leaves. The unannealed spring steel cannot be drilled but it can be punched in the above manner.

The hoops can either be drilled and filed out of solid or 1/4” x 1/16" brass bent around a piece of steel and the joint soldered; see sketch, Fig. 61. The leaves, leather and hoop can then be rivetted together with the round head of a rivet on the underside and countersink the head on top formed by the riveting.

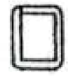


Fig 61

Final Assembly

Now, we are about ready to put all the parts together. It will be remembered that we already have the frames, motion beam, rear cradle, bumper, guide yoke and cylinders erected. First locate the boiler and smoke box. Screw the furnace bearers on, one to the throat plate and the other to the backhead bottom flange. Now, place the boiler on the frame. If everything is ideal the two furnace bearers will seat nicely in the cradle, at the same time the smokebox will be so located that the exhaust will be exactly on the center line of the stack. It is probable, however, that the ideal will not be attained, but we have two lines of compromise. The furnace bearers may be bent slightly, either backwards or forwards, and the position of the stack may be shifted say 1/32" either way on the smoke box as may be found necessary.

The stack should be located exactly on the center line of the exhaust pipe. To do this, turn up a disc and drill a small hole in the center to take the cord of a little plumb bob. Set the disc in the stack and lock the latter with the screwed draft pipe; locate the boiler so that the plumb bob is exactly over the center of the exhaust pipe. Now, observe whether the furnace bearers are seating in the rear frame cradle. If they are, mark off the holes from the throat plate bearer with a bent scribe. The backhead bearer holes can be transferred directly with a #44 drill, countersink, then drill #49 and tap 2-56. It may be found a little awkward to drill and tap for the throatplate bearer. It will be quite satisfactory if this bearer merely rests in place, and the boiler secured with the backhead bearer. The cylinder flange should be drilled #42 and the holes transferred to the smokebox.

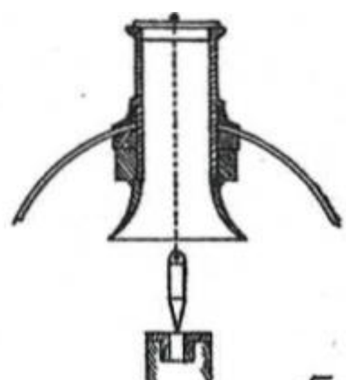


Fig 62

Now, take the boiler off and fit up the guide yoke and guide, the cylinders, pistons, covers, etc., being already assembled as a unit. The guide bars fit over the lug of the back cover and are held here by a 0-80 screw tapped into the inner guide bar. The two halves of the guide are held together with two 0-80 screws and the outer bar is tapped on top to receive the screws passing through the guide yoke. Of course, the guide must be fitted so that the crosshead slides freely. This can be accomplished by carefully scraping away the surfaces of the lug on the cover and the end of the guide yoke. If undersize already, shim up with thin shim brass or copper.

Before going any further, slip the main driving wheels and boxes in place and then put the main rods on; turn over to see if proper clearance exists between the covers and piston. There should be 1/32" clearance at each end of the stroke. If this is correct, remove the rods, and turn the frame upside down; support at the ends. Handle carefully now as it is an easy matter to bend a frame of "bar type" with the pedestal binders off. Put the frame fillers in place and all the spring rigging for the drivers. Then, put the three pairs of drivers in place, observing that the boxes slide easily, and then put the pedestal binders on. The side rods may now be put on and the wheel turned round. If the rods stick on dead centers, first find out which of the four rods is causing trouble. Also test out the quartering of the wheels. If the quartering is correct, try the front or rear rods, each pair separately, and by this process of elimination the offending rod can be discovered. A slight amount of easing out of the bush with a small scraper should rectify the trouble if the previous work has been done correctly. Full size locomotive rod bushes are bored as much as 1/32" oversize when new, so do not be alarmed if the rods will not pass over dead centers due to too good fits.

When the rods are fitted correctly remove the wheels and proceed to assemble the brake rigging. The brake cylinder should be located, and holes tapped from the frame. Piston rods, brake levers, brake lever fulcrum shaft, and brackets may be fitted up. The equalizing beams, pull rods and brake beams may be assembled as a unit and then placed in position on the frame by means of the brake hangers.

The **Valve Motion** may now be erected. Take the piston valve and steam chest head out and take the valve spindle cross head guides off the head. Now set the valve on the spindle, tighten the nuts, slip the steam chest head on the spindle, and screw the little crosshead on the spindle so that the center of the hole for the combination lever is 1-25/64" from the outer edge of the valve. This dimension may have to be changed when setting the valves, but it is near enough to start out with. Now, put the combination lever in place, also the radius rod. The pin should be an easy fit through the crosshead. Next, put the whole unit back in the steam chest, and screw up. A pair of tweezers and a little patience will get the top screw in, and also it will be apparent why the crosshead guides were removed. These latter can now be put back, and the combination lever coupled up to the union link and crosshead. The radius rod is next connected with the expansion link and die block, and then the reverse shaft, reverse arms and lifting link coupled up. Put the side rods on, also the main rod, then the eccentric cranks.

Now, it will be necessary to locate the eccentric crank arm in the proper positions to give the correct travel of the expansion link. First, set the main crank pin on front dead center. To do this run the piston rod in and make a mark on the crosshead and guide bar. Also, at the same time make another mark on the rim of the wheel with the surface gauge. Turn the wheel over until the mark on the crosshead passes the mark on the guide bar and continue turning in one direction until the marks coincide again. Now, make another mark on the rim with the surface gauge. Divide the distance between the two marks, which will give the dead center. Bring the wheel around so that this point registers with the surface gauge needle and the engine will be on dead centers.

The surface gauge should be set to the axle center during these operations. Now with the crank on front dead center, push the eccentric crank arm on to the end of the main crank pin. We have next to set the crank arm at right angle plus a small amount to compensate for vertical distance of the end of the expansion link above the engine center line.

This will automatically be taken care of if the center of the eccentric crank pin is set 0.35” above the center of the axle. If you have no rule divided in hundredths, set it midway between 11/32" and 23/64". Tighten up the bolt in the eccentric arm. Now, when the engine is on dead centers, the eccentric arm is exactly in the middle of its stroke and consequently the expansion link is also, and again in this position if the radius rod is moved up and down the slot, no movement whatever is given to the valve stem. This feature is common to all radial valve gears and forms a test of the accuracy of the related parts. Therefore, with the radius rod in place, set the link so that no movement is produced when the radius rod is moved up and down the slot. Now, measure the distance with a pair of dividers from the center of the eccentric crank arm pin to the center of the hole in the end of the expansion link. Transfer this to the eccentric rod, which, it will be remembered, we left undrilled at the fork end. Center pop and drill for the screw and connect up.

If everything has been done correctly so far, the valves should be very close to the correct setting. For a final check, connect up an air supply (foot pump and small tank will do), or auxiliary boiler, and try the engine over. Open the front drain cock. With the crank on front dead center, the air should issue from the cock; turn the wheel over in the forward direction with the radius rod in the bottom of the expansion link and air should continue to issue until the piston has reached about 85 or 90 per cent of its stroke. Open the back cock now and continue to turn the wheel over. The piston should almost reach the end of its stroke but not quite before air starts to issue from the back cock. A low air pressure is all that is necessary; that is, not sufficient pressure to drive the engine. If adjustment of the valve is necessary, screw the valve spindle into or out of the cross head with a socket wrench applied to the nut on the front of the valve spindle.

If any error has been made in the width of the port or its relative location, find out what the exact dimensions are, and a little hook gauge is useful for this. (See sketch, Fig 63.) Push the hook in against the inner edge of the port and make a mark on the gauge flush with the face of the chest, pull back until the hook is bearing against the front edge of the port and mark again. This will give the width of the port, also its distance along the bush. Do the same for both parts. Measure the widths of the valve rings, also the width over the face of the valve spool flanges. Add the distances over the valve spool flanges to the widths of the rings. This should equal the distance between the outer edges of the ports. If it is slightly less no harm is done, because this will form “exhaust clearance” or “negative lap,” thus reducing compression at the end of the stroke by delaying exhaust closure. Negative lap must not be overdone, or “expansion” will be reduced.

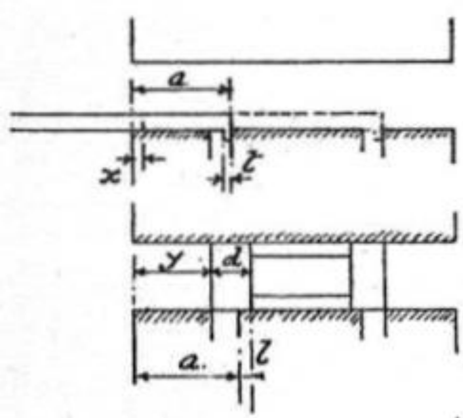


Fig 63

Port width = $x + t$

y - a + lap - d.

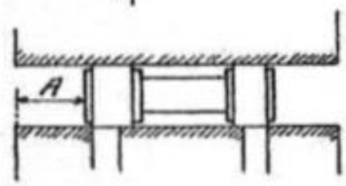


Fig 64.

Knowing the various dimensions as they really are, it is an easy matter to figure up what the distance **A**, Fig. 64 should be in order to place the valve exactly over both ports. Set the radius rod in mid gear and the engine in mid stroke; the combination lever will be vertical and the crosshead in the middle of its stroke. Put the valve in the chest and screw the spindle into the crosshead until the valve indicates dimension **A**. Now use the air and go over the gear as described above.

The engine can now be run from an auxiliary air or steam supply, but first give the cylinder and motion a good oiling. The exhausts should be clear and even. If not, check over the valve setting. See that the nuts at each end of the valve spool are tight and that the valve spool flanges are smaller than the steam chest bore. A bevel turned on the edge is beneficial. Plain plug valves without rings are easily and quickly made and are quite suitable if the model maker does not care to make rings or desires to experiment with different amounts of lap.

Having the valve gear satisfactory, the boiler can be mounted. A brown paper or asbestos paper gasket should be laid on the cylinder saddle, first smearing both sides with graphite and boiled oil. The smoke box should be airtight.

Couple up the steam pipes; the running sleeve and lock nuts will give the correct adjustment for the union to the steam chest. Connect up the “air reservoirs,” which are lubricated by running a 1/16" pipe from the 5/32"-40 tapped hole in the steam pipe boss to the top of the tank. First make a little nipple of 3/16" hexagon brass screwed 5/32" and drilled 1/16". Solder the pipe in, screw into the boss and solder the other end into the tank. A small needle valve may be placed in the pipe line if desired. Connect up the blower line and solder the end of the pipe into the boss on the exhaust pipe, or a small union can be made and connected up.

The injector may be placed alongside the firebox or under the cab deck and connected to a check valve and the top feed. The delivery from the injector is connected on the left hand side of the boiler, while another delivery pipe is run from the top-feed connection on the right hand side which is hose connected to the pump in the tender.

For **testing** purposes, this can be connected to a separate pump and water supply, or testing of the engine can be left until the tender is made. Probably, however, when this stage is reached, the builder will not feel disposed to wait for the tender but will be anxious to get the model running under her own steam.

Everything being satisfactory, all screws tight and pipe connections sound, pump a few pounds of air in through any boiler fitting. The plugs at the top of the turret and feed connection are good points to connect. Pump in about 25 or 30 pounds. Open and shut the blower valve, injector steam valve, gauge glass and brake valve. This will prove whether all passages and pipes are clear. Put the reverse rod in full forward gear, open the drain cocks and then open the throttle a little. Shut the cocks and open the throttle wider; the engine should turn over evenly. Try both directions. The engine should, of course, be supported clear of the rails. During this test the wheels are merely running light.

To **test under steam**, fill the boiler with hot water two-thirds up the gauge glass. Connect the blower elbow at the smokebox with an air supply or pump or separate steam boiler. Break up some charcoal not too small, about the size of a pecan nut, put them in a wire basket and hold over the gas flame till well alight. Shovel them in the firebox. See that the grate is covered and turn on the air to the blower. Put in some more charcoal; larger pieces, and as soon as the pressure gauge needle shows a few pounds, take off the air supply and turn on the steam blower. Pressure will rise steadily. While doing so the throttle may be “cracked” (just open) and cylinder cocks opened. This will warm up the cylinders and avoid the greater part of condensed water going up the stack, which would happen if full pressure was applied to cold cylinders. Look to the water gauge because the level will probably be lowered by this time. Close the throttle and raise the pressure to 80psi. Try the injector and open the steam valve. It should “pick up” quickly after a preliminary splutter from the overflow. The cold water supply should be level or higher than the suction. Test the brakes over by opening the valve and adjust the first pull rod nut if necessary. Shut off the steam, and the auto drain cock takes care of the exhaust from the brake cylinder while the spring releases the shoes. Everything is now clear for a test stand run. Open the throttle and let her accelerate, "notch up” the reverse gear, and open the throttle more. Let the engine run in mid gear for a time, but do not forget the water level. Track running with load must be delayed until the tender is finished, which will be described next month.

Tender Tank and Frame

Tender Tank and Frame - Taking the frame first, this is a one-piece aluminum casting that will merely need filing up along edges, and across lugs against which the tank is fitted. Clean out the coupler and drawbar pockets and drill for the draw bar pin. Also tap for the truck bolsters.

The **Tank** consists of four main sheets of No. 20G brass, namely, two sides, end and bottom. Additional to these are the tool boxes, coal slope sheet, firing deck, and loose top.

Cut the side sheets to the dimensions given, leaving enough at the ends to bend around. Form the corners over hardwood blocks rounded to the radius and tap down with a lead hammer or wood mallet. Then cut out the bottom, which will be 5-1/4" wide by 17-9/16" long, with 7/16" radii in the corners. The bottom fits inside the side and end sheets, to which it is secured with a 1/8” x 1/8" brass beading. This latter can be soldered to the bottom flush with the edges, and further secured by riveting with No. 20 brass escutcheon pins. In fact, it will be found helpful to first tin the edges and beading, then drill and rivet the sheets together, finally sweating the joint for water tightness. Next, cut a piece of the sheet and bend at right-angles to form the back and inside face of the valve box and lockers. Note that this box is carried right down to the bottom plate, hence it will be necessary to drill a few holes in the inner face near the bottom to allow the water to get to the valves.

Before putting in the slope sheet and firing deck, it is advisable to make the **water valves** and pump. Notes on these will be given below; in the meantime, we will assume that these parts are made. The valve on the right-hand side is connected to the delivery pipe from the pump, so the valve body should be located, secured with the nut screwed on to the body portion passing through tank bottom. The pump can also be located, and holes drilled through the bottom and tapped into the pump base flange for No. 5-40 brass screws.

The slope sheet and firing deck can now be cut and soldered in, also the side slope sheet. A plate soldered across the end under the firing deck encloses the water space. Footsteps, beading, handles, ladders, etc., can be made. Also, the angle cleats that hold the tank to the underframe can be securely sweated on. These latter are best located by placing the tank on the frame (it should fit nicely between the lugs) with a wood liner between. Then place the six cleats (four at the back, two at the front) on the lugs, drill and tap for No. 2-56 hexagon head screws into the frame and sweat securely to the tank.

The ladder is best made by cutting two pieces of 20 G brass to contour. Drill No. 52 and solder in 1/16" wire for "rungs.” Do not try to bend 20G x 1/8” stuff edge on. Cut from flat sheet and a neat job will result. Use the "drill and file” method.

The tank cover is made to lift off entirely, as is the filling hole cover. This latter is provided with dummy hinges, and the opening is long enough to provide clearance for the stroke of the pump lever. The pump can be operated with an extension socket lever slipped over the ram lever. Hinges on the coal gates are easier made by filing out of stuff about 3/32" thick and drilled No. 50 for drill rod pins. The gate frame is made of 1/4” x 1/4” angle filed to 3/16".

Tank Valve and Pump—The tank valves are quite simple turning jobs; the seat should be square edged, and the threads should be made a good fit.

The pump body is a casting, which should be chucked by the lug provided, drilled, bored and faced, then a 5/32" hole drilled right through the valve chamber and opened out each side for a 5/16-32 tap. The top is capped off with the special plug that limits the lift of the ball valve, and the bottom is screwed for the suction seat. In order to prevent this ball valve from closing the passage on the suction stroke, a small piece of wire is soldered to a hole drilled right across the chamber about 3/64" above the ball when it is resting on its seat. The ram must be turned to a neat fit in the barrel, and the gland made a good fit to the ram. The fulcrum links and lever complete the job. It is important that the ball valve seats should be square and the edges sharp; therefore, after the first hole is drilled it should be opened out with a counterbore and not with the ordinary drill, which, of course, would leave a countersunk face. It is not easy to make the ball water or steam tight in such a seat.

Trucks—Side Frames castings will only need cleaning up, drilled for bearings and stay plates soldered to the bottom of the box. To drill for the bearings, make a plain jig with two 7/32" holes spaced 3" apart. Lay the jig on the inside of the frame parallel with the bottom of the boxes and 1/4" up, then drill down for 13/32".

Bolsters are to be faced off on center, drilled 1/4" for the center pin, and the grooves filed out. The full width should be made to just slip through the side frames at the bottom, where the opening is widened out for this purpose, then the bottom of the groove forms a sliding fit inside the struts, when the bolster is raised for insertion of the springs. Next month some notes on finishing and painting will be given.

Finishing and Painting

Painting - The best way to make a thorough job of painting is to take everything apart, except the cylinders and the frames. Trucks can be taken out and disassembled and then the valve motion taken off. The brake rigging can be taken out as a unit by removing the brake hanger screws. Side rods follow next, then the drivers. Replace the pedestal binders after the wheels are out.

Clean off all dirt and oil with gasoline and give the inside and outside of the frames two coats of flat black. This applies also to the frame brace and the inside of the rear frame cradle. Spring rigging, also the brake parts can be painted flat black, excepting the brake hangers and shoes. Wheels should receive two or three coats of Sherwin Williams Palmetto Green Coach Color ground in varnish. This pigment only needs mixing with a little turpentine, is rapid drying and flows on smoothly and evenly. It is nothing near as thick as ordinary paint and should be used about as thin as water. It will then dry with a beautiful flat surface without streaks or brush marks. Use soft brushes. The following parts are painted with this green: Bumper and pilot, trucks, wheels, guide yoke, motion beam, rear cradle outside, brake hangers, brake shoes, cylinders, boiler wrapper all over, except the smoke box and stack, which are to be in flat black.

The cab is palmetto green outside, and a lighter soft green color inside. Roof should be flat black, as also the boiler back head and footplate.

The boiler may be rubbed down with pumice and water and one more of this coat of green applied and allowed to dry thoroughly. The lining out is not a difficult job if reasonable care is taken. Procure a draftsman’s drawing pen, a cheap one will do, which can be obtained for about 75 cents. The consistency of the paint to be used in the pen can best be found by a little experimenting. Mix the color with varnish driers and turpentine. If too thick it will not flow from the pen when the latter is drawn slowly across the surface. If too thin it will flow out and spread before the pen has reached the end of the required line and will also leave a blob at the end. A little practice will soon discover the right consistency. Tubes of artist’s colors ground in oil are convenient and cheap for the small quantities of colors required. Middle chrome yellow and light red are required here.

Use a straight edge on flat surfaces as a guide for the pen, and strips of brass bent around curved surfaces, such as the boiler, and tender corners.

The wheels may be lined out by mounting in the lathe centers. Take a fine-pointed brush with the chrome yellow, start the lathe revolving slowly, hold the brush close to, but not touching, the wheel, having the brush in right hand, resting on the left fist with the point of the brush making an acute angle with wheel face. Now, when the hand is comfortable and steady, make a slight movement inwards to the wheel, and the result will be a perfectly even and concentric line, much superior in fact to any found on the full-size engine. The steam dome cover may be done in a similar manner, by mounting on a plug of wood held in the chuck.

The sand box is the most difficult and therefore it would be better to leave till last, when more confidence has been obtained. Use the brass strip and drawing pen method. The cylinder lagging has a rectangular panel lined out, the line being about 1/32" wide in chrome and about 1/16" inside; this is a thin line of light red.

The cab inside below the sash is paneled the same way and the words **PRESIDENT WASHINGTON** written in. In the center below the bottom line is the engine classification P-7.

The bumper beam and ladders are paneled, and pilot slats are pin striped. The tender is lined right round with a chrome line about 3/32" wide and about 1/4" below the top edge of the tank and 1/4" above the underframe. The words **BALTIMORE AND OHIO** must be put in by a sign writer unless the builder happens to be a draftsman. Chrome yellow, shade lined with light red, are the colors to use. Let the lining dry thoroughly in a clean atmosphere and the engine is ready for varnishing. Sherwin Williams Rexpar or Valspar are suitable. Two even coats applied with soft brushes will give good results.

Warning — Do not use fast drying pyroxylin paints or brushing lacquers. They are not suitable unless used in a spray apparatus, which is obviously impracticable on a model locomotive.

It only remains now to carefully assemble the parts; endeavor to avoid marking or scratching the paint work with the screwdriver or socket wrench, but if you should do so, go over the places with a small fine-pointed brush. This will finish the engine ready for the road and if the model builder has succeeded in finishing as at this writing (November) [1929] many bid fair to do, he will not only have what the writer believes to be the best model of an actual full size locomotive as yet produced in America but he will know a great deal more of the construction and design of a modern high power passenger engine.

In conclusion, the writer would like to thank the many readers and builders who have expressed their appreciation of these notes, and for the kindly encouragement received from model makers - few of whom he has ever had the pleasure of meeting - dotted all over the north American continent.

Appendix 3 – Some Notes on Springs[12]

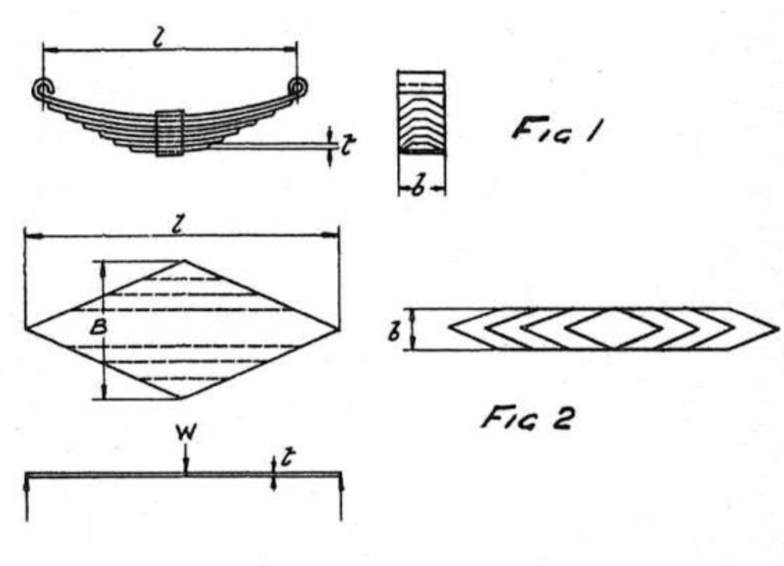
By Mr. H. J. Coventry

Springs- How many times has the question been asked by the amateur model maker “what size material shall I use” or how many springs have been made of material, different number of coils and diameters of coil springs, or different thicknesses, width and number of leaves in leaf springs in an endeavor to obtain one that will suit a given set of conditions?

If we analyze the factors that make up spring design, we will find the following interrelated main groups. Those factors that may be classed as “physical" and a second group that may be classed as “dynamic.” Under the former heading we would have the dimensions of the spring as a whole as well as its parts, while the latter would embrace the loads and the deflections or movement under any particular load.

We will now have to consider particular types of springs, and while there are quite a variety made to meet particular conditions, the amateur model maker will probably only need “leaf springs” of the type known as “semi” or “full elliptic” and “spiral springs” of round wire.

Taking a leaf spring (Fig. 1) we will note that it consists of a number of leaves of certain thickness and width also that the longest leaf is a definite distance from eye to eye or span and the others are evenly reduced or graduated in length. If we support the spring by its eyes and place a “load” on its center it will be seen to deflect and in doing so will “stress” the material of which the spring is made. "Stress” is a definite load per unit of area, usually one square inch, and this term must not be used when “load” is meant.



Now we have seven factors to deal with and perhaps it may be seen why a mere hit and miss method of spring making is likely to benefit no one but the metal merchant. All seven factors must

[12] Modelmaker, Volume __, pages 65-67, 85-87, 194-196, 204.

harmonize to produce any desired spring and this harmony can be expressed as an equation. Before doing this however, let us consider a single plate or leaf, cut in a diamond shape, Fig. 2, supported at the ends and loaded at the center with load W. The equation that harmonizes the load factors above mentioned is given by:

$$W = \frac{2\ S\ B\ t^2}{3 \times L}$$

where W=Maximum safe load in pounds
S=Safe stress in pounds per square inch
B = Width of plate in inches.
t =Thickness of plate in inches
L =Span in inches.

Now the stress in such a plate will be uniform throughout its length and if we clip off a narrow strip each side and keep on till the middle strip is reached and then pile all the pairs of strips on one another, we will obtain a theoretical ideal spring. In other words, instead of having a wide one-leaf spring, we will have a multiple narrow leaf spring of exactly the same characteristics as far as load capacity and deflection is concerned. It will now be apparent why springs of this type have leaves of evenly decreasing length, and also why the ends should be either pointed or tapered. It will also be seen that an ideal spring would have a very short bottom leaf. Practical considerations will, of course, modify, for we must have a buckle and also the ends of the top leaf must be square to take hangers or eyes, but the nearer to the ideal form the spring is made the better.

We can now write our equation.

$$W = \frac{2\ S\ n\ b\ t^2}{3\ L}$$

because instead of using one leaf of width B we will use a number of leaves (n) each of width (b). Expressed in terms this merely means that: the load W is numerically equal to twice the stress multiplied by the number of leaves, the width of leaves and the thickness squared (i.e. the thickness multiplied by itself) and divided by three times the span.

For spring steel the stress is usually taken at 80,000 lbs. per sq. in. and by placing this in our equation and eliminating the numerals we obtain

$$W = \frac{53333\ n\ b\ t^2}{L}$$

This is the usual form and may be taken for any size semi elliptic spring whether model or full size. If definite values are placed in, and the equation worked out, the amateur will very readily discover why an actual spring, say a locomotive spring, when exactly reduced to scale would be far too stiff for the model.

Now a clear idea of relative proportioning can be obtained by merely examining this formula. Thus we can say that the Capacity or Maximum safe load is:

(a) Directly proportional to the number of the leaves.
(b) Directly proportional to the width of the leaves.
(c) Directly proportional to the square thickness of the leaf.
(d) Indirectly proportional to the span.

Thus we may increase the capacity of any given spring by increasing the number of leaves, their width or both, or by decreasing the span, the capacity increasing in exact proportion with the changes, but if we increase the thickness of leaves the capacity will be much more rapidly augmented, doubling the thickness would raise the capacity four times.

Before we are in a position to design any particular spring, we have to consider the relation between the load and the deflection as in the above equation we have only considered the capacity or maximum safe load in relation to the resistance or strength of the material.

The deflection for the load W is given by

$$d = \frac{L^2}{1270\ t}$$

where (d) equals the deflection in inches and (L) and (t) are as before.

Now note that the deflection is directly proportional to the square of the span and indirectly proportional to the thickness of the leaf, also note that the width and number of leaves do not influence the deflection, (L) and (t), being constant. That is to say the addition of leaves to a spring will increase the carrying capacity but the deflection under this increased load will be precisely the same as that under the capacity load before the alteration.

To illustrate use of the above considerations, suppose we need a leaf spring of 2” span, to carry 10 pounds maximum load and constructional requirements limit the width of leaves to ¼”, and the deflection under this load is to be 3/8”. First find the thickness of leaf material from formula

$$d = \frac{L^2}{1270\ t}$$

Or

$$t = \frac{L^2}{1270\ d}$$

Putting in the known values we get:

$$t = \frac{2 \times 2}{1270 \times 0.375} = 0.084 \text{ inch}$$

Now taking the capacity formula

$$W = \frac{53333\ n\ b\ t^2}{L}$$

And putting in the known values

$$10 = \frac{53333\ n\ 1/4 \times 0.0084^2}{2}$$

or

$$n = \frac{20}{53333 \times ¼ \times 0.0084 \times 0.0084} = 21$$

To sum up above statements, if a stiff strong spring is desired use a small number of thick leaves. If a strong flexible spring is desired use a large number of thin leaves. Having found the number and thickness of leaves, it is an easy matter to so modify either or both to meet available thickness of commercial material and rework the deflection and capacity. Here is where the discussion on the relation of load deflection, width, number and thickness of leaves comes useful.

If we connect two leaf springs together upon one another, that is a "full elliptic," the capacity will be exactly the same as for the semi-elliptic, but the deflection will be doubled.

The maximum capacity of a spring is usually taken as meaning that load which would bring a leaf spring flat or a spiral spring solid and the working load is taken as sixty per cent of this.

If the above notes are followed, no difficulty will be experienced in dealing with the fundamentals of spiral spring design. The formula which gives us the capacity for springs of round wire is:

$$W = \frac{15708\ d^3}{r}$$

Where:
W = Capacity or load to close solid in pounds
r = Mean radius of coil in inches
D = Diameter of wire in inches.

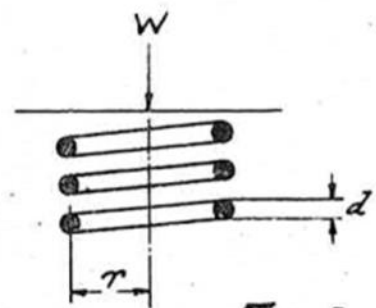


FIG 3

Expressed in terms we would say that the capacity varies directly as the cube of the diameter of the wire and inversely as the radius of the coil.

Now note that the number of coils does not enter into the equation at all, so that the capacity of one coil of any particular spring is exactly the same as a number of coils. In other words, it would take the same load to close solid a twenty coil spring as to flatten down only one coil of it. This is exactly opposite to the leaf spring where the capacity bears a direct proportion to the number of leaves. The formula will also show that due to the fact that the diameter of the wire is cubed (dxdxd) the capacity rapidly increases with even small increments of wire diameter. Thus if we double the diameter of the wire of a definite radius coil, we shall obtain (2x2x2) eight times the capacity whereas by doubling the diameter or radius of coil, we shall halve the capacity.

The deflection is given by:

$$D = \frac{.08\, r^2\, n}{d}$$

where D=Deflection in inches, n =Number of coils, r and d being as before.

In this formula it will immediately be seen that the greater the number of coils, the greater the deflection under the capacity load and also the deflection would rapidly increase with increments of mean radius and would decrease with increments of wire diameter.

Now let us take an example. A round wire coil spring is required to give a capacity of 10 pounds with a mean radius of coil of ¼” and a total deflection of ½”. Find the diameter of wire and number of coils. Taking the capacity formula we can find the diameter of wire. Thus:

$$W = \frac{15708\, d^3}{r}$$

$$10 = \frac{15708 \times d^3}{.25}$$

$$d^3 = \frac{10 \times .25}{15708} = .000158$$

$$d = .054 \text{ inches.}$$

The number of coils required to give the deflection called for is given by formula.

$$D = \frac{.08\, r^2 n}{d}$$

$$½ = \frac{.08 \times .25 \times .25 \times n}{.054}$$

$$n = \frac{½ \times .054}{.08 \times .25 \times .25} = 5$$

We now have the principal dimensions of the spring from which it is an easy matter to find the height of the spring both when closed solid and free. Thus: Solid height = number of coils x diameter of wire. 5 x .054 = 0.22 inches free height = solid height plus deflection, = 0.22+0.5 = 0.72 inches.

So that if it is desired to make such a spring, we would have to wind up 5 coils over a distance of 0.72 inches or each coil would have a pitch of 0.72/5 = 0.144.

For practical purposes, these figures would perhaps have to be modified. These points will be discussed later. But if the above principles are grasped, very much work will be saved in eliminating trial and error methods.

In consideration of previous notes we will now consider some practical points and to illustrate we will take the same springs as were used to illustrate the formulae. A leaf spring of 2 inch span to carry 10 lbs. under deflection of 3/8 inch is desired. We found that leaves of ¼ inch width would be 0.0084 in. thick and 21 were required for the load.

Blue Swedish spring steel is the material to use, and a wide range of widths and thicknesses are made. It is very readily sheared and punched but not drilled. When delivered it is usually coiled but will very readily lie out flat upon release. The first thing to do is to select the nearest commercial size - 1/4 inch wide by 0.008 is the nearest to our requirements, then run through the formulae again to see how the difference affects the deflection and load. Here the differences are too small to trouble with, for practical purposes, however by working the thickness formula through we will find that the deflection will be 0.393 inch instead of .375 and the number of leaves required to carry the 10 lb. load will be 23 instead of 21.

The buckle width may be made one tenth of the spring span and the bottom or smallest leaf can be made twice the buckle width, in length. In our particular case the buckle may be ¼ inch wide and smallest leaf ½ inch long. The top leaf will be 2 inches, but allowance must be made for the loop or bend carrying the hangers, so that we have a distance of 1 ½ or ¾ inch each side to be divided among (23-2) = 21 leaves. Thus each leaf will overlap its mate by ¾ divided by 21 or 0.04, say 3/64". Having the material, cut off 1/2" for the small leaf and say 2-1/4" or 2-1/2" for the top leaf, then one piece (1/2+3/32) another (19/32+3/32) and so on for 21 pieces. The material is best cut with ordinary snips. It will cut clean and true as long as the actual cut is shorter than the blade of the snips. In other words, do not allow the snips to close entirely while taking the cut. If you do the steel will fracture and split in a jagged edge.

The "forming" or "set up" of the leaves may be done between a hard wood male and female curved die but because the steel is already tempered, a much sharper curvature of die will be necessary than the finished spring curve. Another way to curve the material is to take the long length before cutting up the leaves and place it in a cleft in a piece of hard wood, hold the free end with the left hand and pull right through with the right hand so that the material takes on a coiled form. Check the curvature against a template. One or two passes will usually meet the requirements. Then cut up the different lengths.

Next punch a small hole in the center of each leaf. 1/16" is large enough for a copper rivet. The punch can be made of say 3/16" drill rod; turn down to 0.063" for a length of 3/32". If the top slide of the lathe is set over, about two degrees clearance will be given, back of the cutting edge. The end should be faced off square and smooth. A simple die can be made (Fig. 1) either of tool steel or mild steel; case hardened, or the die may be dispensed with by laying the spring steel on a smooth block of lead. Hold the punch square over the desired place and give it one sharp tap with the hammer. A clean hole will be produced, and the piece punched out will be found imbedded in the lead. Use a fresh place on the lead block for each punching. The ends of each leaf may be ground or clipped either square or the corners tapered off.

The top leaf usually has to be slotted with a rectangular slot for the hanger, or the end curled, or bent. If a plain slot is used it may be punched with a suitably shaped punch on the lead block. If ends are to be bent the end only must be annealed.

This is very easily accomplished in the following way. Hold the end of the piece of steel in a gas flame, so that just about 1/16" to 3/32" gets red hot, maintain for a few seconds and then withdraw slowly, but when entirely out of the flame but still very close, hold for a few more seconds and then slowly withdraw for say half an inch. The end of the spring steel will be found to be nicely annealed for about 1/4 inch and also the blue color will hardly be altered except at the extreme end. All that is required now is to hold the strip in the vise, with the correct amount standing up and tap over gently. This will give a right angle bend. If a loop is desired, place a piece of drill rod between the steel and vise jaws as Fig 3. Hold the steel by its extreme tip as at (a) Fig. 3, bend down as far as jaw will permit, then take out, bring the spring out and bend down again. Three passes will complete the loop.

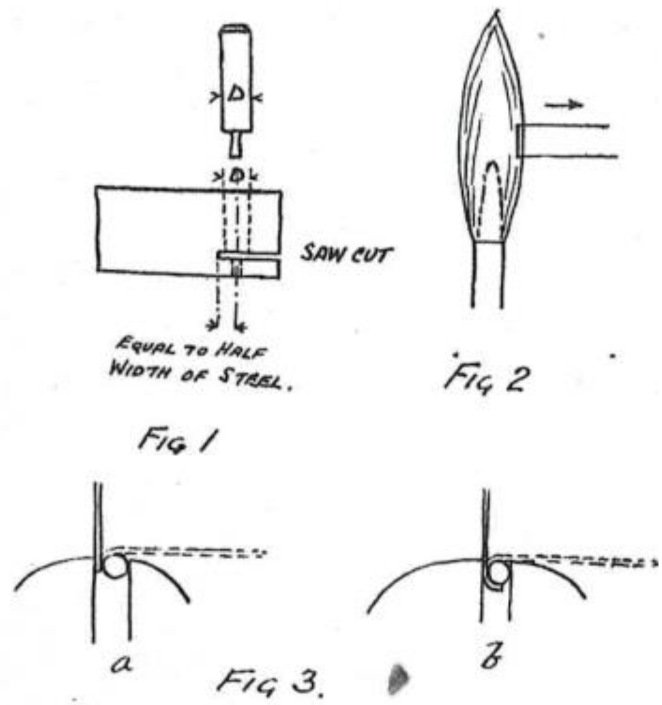


Fig 1
Fig 2
Fig 3.

In order to build up leaf springs to more or less scale size it is usual to interleaf the steel with thin leather or thin washers; Fig. 4 shows this. The buckles can be made of annealed strip brass bent around a rectangular piece of steel and the joint sweated or silver soldered. Thread all the leaves and washers through the buckle and rivet up. If the head of the rivet is located on the underside of the buckle it will form a good centering pin for the spring saddle in the case of locomotive driver springs, a hole being drilled in the top of the saddle to receive it.

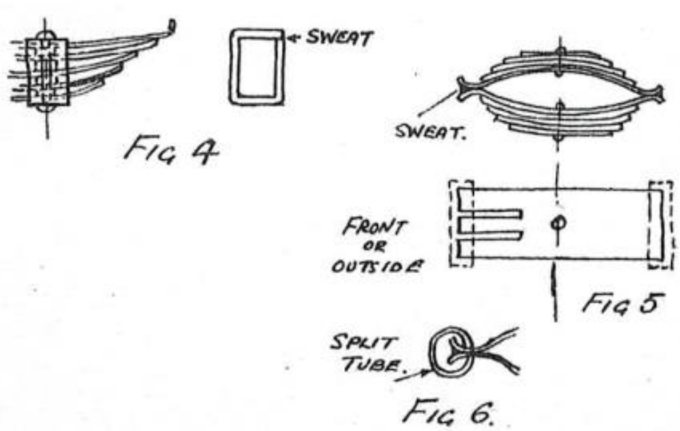


Fig 4
Fig 5
Fig 6.

The above note will cover cases of semi-elliptic leaf springs used for locomotive driving wheels. In the case of car and tender springs due to the fact that the whole load is carried on two bolsters (one for each truck) the springs are made in groups of three or four, side by side, to meet capacity requirements and are made double elliptic to give greater deflection and flexibility.

For model purposes it is not necessary to build up the group, but the same effect can be produced by selecting spring steel of width equal to the overall width of the groups and sawing or shearing narrow slots on the outside ends to represent separate springs. See Fig. 5.

The leaves may be treated exactly the same as above except for the division slots. These may easily be cut with the snips, observing the warning against cracking as given above. The ends are to be annealed as before and bent up slightly. Rivet together, then sweat two halves (top and bottom) by a touch of solder at the ends. Now cut off a length of small diameter brass tubing slightly longer than the width of the spring. Saw a slot right down one side with a jeweler's hack saw, and press over the end of the spring, Fig. 6. It may be secured by a touch of solder.

The writer has received several requests for further information on making springs in connection with his B&O President Washington model locomotive. As some of the correspondents apparently have been experiencing difficulties, in some cases the writer has sent the correspondent samples of bends, curves and punching but it is obviously impossible to supply everyone with material proof that there is no real mystery in making good looking springs without spoiling a lot of material. If the above notes are followed closely no inordinate difficulty should be experienced.

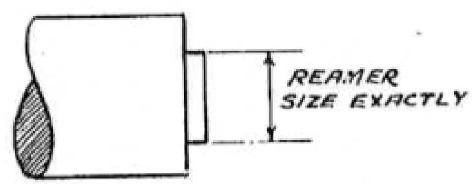
The winding of coil springs is almost self-evident, but the following notes may help the amateur. The mandrel upon which the wire is wound must be turned smaller than the inside diameter of spring to compensate for the slight unwinding and consequent expansion of the spring when taken off the mandrel. For example, if a spring is desired to be a nice fit over a 1/8" diameter pin the mandrel may be made 1/10 inch diameter. Have the mandrel in the lathe chuck, take the wire ("music wire'') and bend the end at right angles. Slip this end in between two jaws of the chuck and hold the wire tight in the right hand with a cloth or two pieces of wood. Revolve the lathe and when enough has been wound, stop lathe but do not let go of the wire. It may fly back and sting the operator. Pull the lathe belt back a turn or two as required to remove the tension and the spring can be slid off the mandrel. This method may be used for a coiled spring.

For springs of definite pitch from coil to coil or "open coiled", set the lathe as for screw cutting and pass the wire around the tool post.

Appendix 4 - Reaming a Hole[13]

By H. J. Coventry

The following tip may be useful: Before reaming a hole in the lathe it is necessary to drill and bore within two or three thousandths of the reamer size. Without the use of plug gauges it is not so easy to bore to the required limit, in any case several light cuts have to be taken. The following method will be found quick and accurate:



Say we have a piece of stock ready chucked. First face off the end and then turn a shoulder of the same diameter as the reamed hole will be. The shoulder should be gauged with the micrometer. Now center and drill 1/32 smaller than the reamer. Next, bore out until the shoulder, which has now become a ring, is a mere wafer. It is as sharp as a razor so don't finger it. The reamer will now be found to enter about 1/2 to 1 inch, according to size, and will then go through easily without scoring or grabbing. Use kerosene when reaming.

[13] Originally published in the Modelmaker, Volume 8, page 240.

Appendix 5 - Piston Rings[14]

By Mr. H. J. Coventry

The making of split piston rings seems to hold a mystery to many modelmakers, and varied and numerous are the devices and arrangement of piston used to avoid what after all is quite a simple lathe job.

The first requisite of the ring is that the pressure exerted by it on the wall of the cylinder shell be even throughout its circumference, the second is that the split or opening shall be as close as possible when in the cylinder, third that the ring shall be closely fitted in the piston groove yet free to expand. The first requisite means that the ring must be truly circular and a neat fit to the cylinder when the ring is closed.

The thickness and depth as well as the amount cut out of the ring will decide the pressure exerted on the cylinder walls and this of course, should not be more than what will be sufficient to maintain steam tightness. Excessive pressure only means undue friction.

Close-grained cast iron is the best material for rings. The smaller sizes up to 1” may be made from solid sticks, while 1 1/8” and up are best made from cored and flanged bushes, like sketch, Fig. 1.

Let us assume that rings are required for a cylinder over 1 ¼” bore. Procure a bushing and chuck with the flange outward, OP 1, Fig 1. Turn the edge and take a cut across the face. This is merely to clean up. Take it out of the chuck and reverse it by gripping the turned flange; see that the flange bears against the chuck jaw seats, OP 2, Fig 1.

Now turn the outside sufficiently far back to make the number of rings required (allowing for cutting off). Face off the end and bore. Next put a narrow cutting off tool in the holder (1/16" wide is ample).

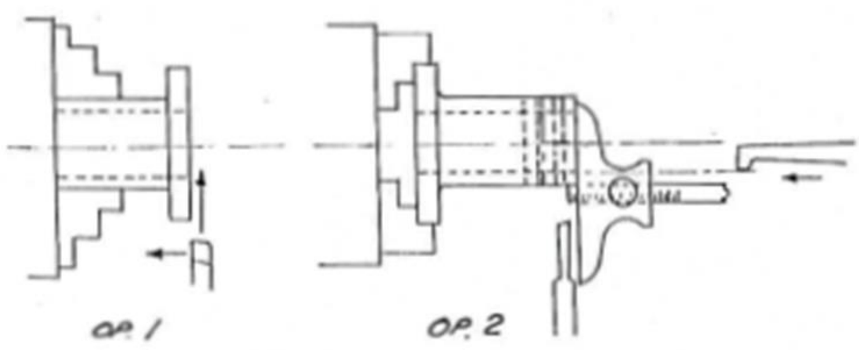


Fig 1

Set the rule of a depth gauge to the ring thickness and lay the head against the faced end of the bush, bring the tool up to just touch the rule, lock the saddle and with light cuts, part right off. Re-

[14] Originally published in the Modelmaker, Volume 10 page 40-43.

face the end of the bush and repeat as many times as rings are required. Cut off an extra ring to store away as a gauge for future replacement. Leave the bush in the chuck.

Now take the rings to the bench vise, hold in wood or lead clamps, with only just the thickness of the ring standing above the vise jaws. With a jeweler's hack saw held at 45 degrees across the ring, saw out an appropriate amount.

The bushing which was left standing in the lathe chuck must now be bored out so that the ring when squeezed shut will just slide in. Put them all in on top of each other. Remove from chuck.

Now chuck any piece of stock and turn until the ring still in the bush will just fit snug. Bore and ream say 5/8" and turn a flange a little less than the outer diameter of the finished rings. It is strongly advised to undercut the face of the flange slightly, see sketch Fig. 2a. Make a stout washer at same time also, with undercut face. Next make a shoulder bushing 5/8" dia. screwed for 5/8" hexagon S.A.E. nut and bored and reamed 3/8". This will complete the fixtures and we are ready for finishing the rings.

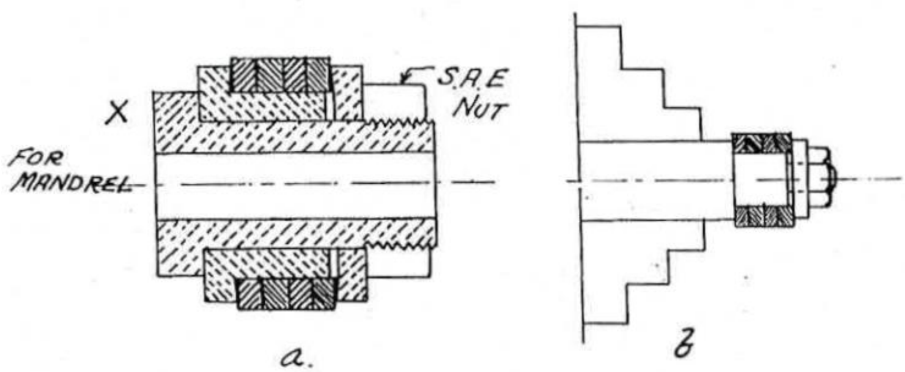
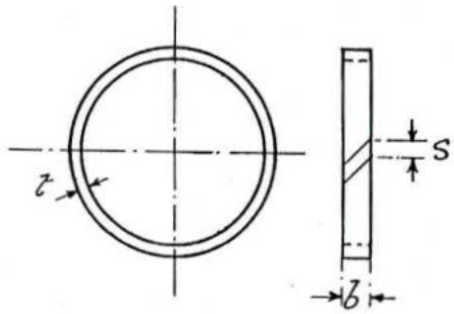


FIG 2

Take the sleeve and push it into the set of rings still held in the original bushing. Then push the flanged fixture through one end, drop the washer down the other and tighten up well with the 3/8" rod. Now push off the bush; it may need a few gentle taps. If the fixture has been made right, the rings will be found to be quite secure and the opening or spits closed.

Push the fixture on to a 3/8" steel mandrel and turn between lathe centers until a good but easy fit is obtained in the cylinder. The job can be removed from the lathe for testing without in any way upsetting the work. Light cut and fine feeds should be used with a round nose tool well oil stoned. Upon removing the rings, they will spring open and when fitted on pistons will be as steam tight as it is possible to make them.

Smaller rings can be made in exactly a similar manner, but the inner bushing x is dispensed with and a stud held in the chuck is used as shown at Fig 2b.



Piston Ring Dimensions						
Diam of Piston D	**Thickness of Ring t**	**Width of Ring b**	**Width of Split s**	**Diam When Closed**	**Initial Bore of Ring**	**Outside Diam Turned**
3/8”	0.0235	1/32	1/16	0.3950	0.348	0.415
½”	0.0312	“	“	0.5200	0.458	0.562
5/8”	0.0390	“	“	0.6450	0.567	0.660
¾”	0.0470	1/16	1/8	0.7900	0.696	0.825
7/8”	0.0545	“	“	0.9150	0.806	0.947
1”	0.0625	“	“	1.0400	0.915	1.075
1 1/8”	0.0740	3/32	3/16	1.2550	1.107	1.300
1 ¼”	0.0780	“	“	1.3100	1.154	1.357
1 3/8”	0.0860	“	“	1.4350	1.263	1.482
1 ½”	0.0940	“	“	1.5700	1.372	1.632
1 5/8”	0.1030	1/8	1/4	1.7050	1.499	1.767
1 ¾”	0.2030	“	“	1.8300	1.612	1.892
1 7/8”	0.1170	“	“	1.9540	1.720	2.016
2”	0.1250	“	“	2.0500	1.830	2.112

The table of dimensions has been prepared to cover rings from 3/8" to 2". **D** is the cylinder bore to equal ring thickness **b** = depth or width facing, **s** equals the amount to be cut out, columns 6 and 7 give the bore and diameter of the rough blanks. These columns 6 and 7 are to be followed in machining the blanks. Column 5 is useful as a guide to boring the bush used in holding the rings closed, but of course the boring should be made to fit the rings as described.

It may seem like a lot of work and trouble to make rings but once the fixtures are made the modelmaker is equipped to make rings for all models he is likely to make in a lifetime. The bushing used to close in the rings before mounting on the fixture or stud is important and should not be dispensed with by merely slipping the rings on the fixture and pinching them in by hand or other means. When a split ring is closed in by hand the ring is not truly round but elliptical. The bushing on the other hand bears on the ring all the way around and constrains it to a true circle while closing the slot. If a ring is just pinched together and then finish turned, the thickness of the ring will not be even and consequently the pressure exerted against the cylinder walls will not be uniform.

The wear in turn will also be uneven and blow-by will soon develop even if the ring fitted in the first place which will be doubtful.

Appendix 6 - Drilling of Steam Ports[15]

By H. J. Coventry

The drilling of steam ports in the cylinder is easily accomplished by means of a simple jig. It is often required to drill holes in a definite location and angle to a circular surface, such for example as ports in a cylinder bore, and while to attempt to start the drill on the angle would be difficult if not impossible, by spending a little time in making a suitable jig the job may be done with accuracy, certainty and speed. In order to illustrate, let us take a cylinder as shown in sketch, Fig. 1, which has been bored and faced. It is required to drill steam ports so that the edge of the ellipse formed due to the angle shall be a known definite dimension. Dimensions are given as illustration of the procedure, but the reader will of course apply any dimension and angle he desires.

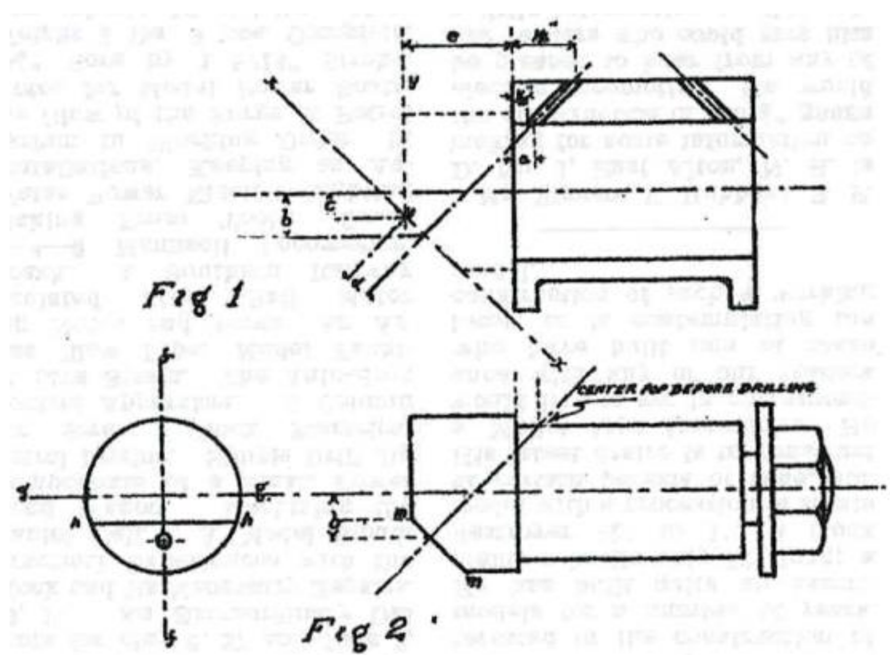


Fig 1

Fig 2

Proceed as follows: —First lay out an accurate drawing (either on paper, or tin plate) of a section of the cylinder putting in the port at its proper angle and position. Draw the center line of the port and continue it across the center line of the bore. At some convenient point below the center line of the bore draw a line at right angles to the center line of hole, **xx** on Fig. 1. From the intersection of these two lines step off a distance "**d**" along **xx**, such that it is a trifle more than half diameter of the drilled hole. The amount is not important, but the above provides the least amount of labor in making the jig. From "**d**" draw a line vertical to the bore center line **yy**.

Now we are ready to proceed with the jig itself. Select a piece of steel a little longer than the cylinder bore and turn it down to a nice close fit in the cylinder bore. Then turn the outer end to a smaller diameter, which should be screwed for a nut and washer. Don't forget to make the body port say 1/16 shorter than the bore so that the cylinder will be gripped between the shoulder at one

[15] From note published in July, 1926 issue of THE MODELMAKER. p. 107-108.

end and the washer at the other. Part off the piece slightly longer than dimension “**e**” measured from the drawing, turn round in the chuck and face off exactly to dimension "**e**” from the shoulder. Next by means of the center square scribe a line across the diameter **f.f**. on Fig. 2 and then with the jig lying in a V block on a surface plate, scribe another line at right angle **g.g**. and from the line **g.g**. scribe another line **h.h**. at a distance from it equal to "**c**” on Fig. 1.

It is as well to carry line **f.f.** along the body by means of a surface gauge and from the shoulder mark off a distance equal to "**a**,” as measured from Fig. 1. Make a center punch mark here. Now file a flat at the correct angle to the face of the end of the jig and continue filing till the line **h.h**. is met. The angle may either be maintained with the Starrett or B & S protractor or alternatively make a template of the angle from the drawing. Having produced the flat satisfactorily again lay the jig in the V block and with the surface gauge, mark off the distance equal to **b** from line **g.g.** Turn the jig round and scribe through line **f.f.**, part of which has been filed away.

Center punch the intersection carefully; this is the center of the required hole. To drill it either hold it in a machine vise on the drill press so that face **m.m**. is horizontal, or mount it on the tool post of the lathe, setting the jig so that the pop mark on the body is in line with the tailstock center, and a center pop on the angle face is in line with line center. Bolt it down securely; start with a Slocomb center drill and then run right through with required size drill. Do not feed too heavily and the drill should break through exactly on the dot made on the body. This will indicate the accuracy of your drilling.

In using the jig make the line **f.f.** which has been continued along the shoulder portion. Register with the location of the hole in the cylinder and in starting to drill, take light cuts until the drill has got well into the metal. The more acute the angle of the hole the more care must be used, or a broken drill will be the result.

Such a jig can be made in almost less time than it takes to write this note and satisfaction will be obtained in having the holes exactly where wanted and moreover the edges of the holes on the inner and outer face will be perfectly clean.

Appendix 7 – A Boiler Stop Valve[16]

By H. J. Coventry

This stop valve bears a close resemblance to the valves as used on main steam lines in orthodox practice and is easy to make if ordinary care is taken to make accurate fits and a few precautions are observed. The following notes will refer to the writer's detail print No. 117B, which should be procured, also one casting of brass, pattern No. 671.

The casting No. 671, illustrated [Fig 2], has a chucking lug to facilitate machining. After dressing off any fins with a file, place in the chuck by the top flange and locate so that there is the least possible amount of wobble to the lug. Now put a center drill in the tailstock chuck and center drill the lug, remove the drill chuck and put in a center, bring up the tailstock to support the lug and take a cleaning cut over it.

Next, remove and hold it in the chuck by the machined lug, grip tight, center and drill through with a 1/4 inch straight flute drill, [Fig 1] and face off the flange until it is just 1/2" from the center of the outlet flange. A counterboring tool must now be made, see Fig. 2a, and placed in the tailstock drill chuck to open out the 1/4" hole to 1/2" diameter by 3/4" deep. See that the counterbore is cutting a good clean sharp corner against the 1/4" diameter. The edge of the flange may be turned by means of a little hook tool similar to a boring tool except that it will be of opposite. hand, (See Fig 2b). The bottom flange that is nearest the chuck can be turned and a left hand side tool used to face off down to the lug.

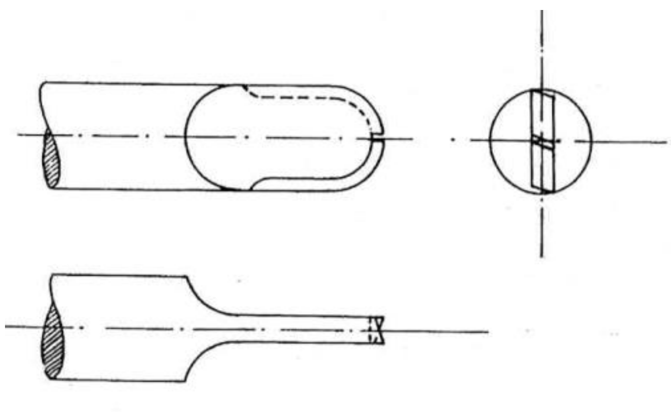


FIG 1

Remove the tool and replace it with a cutting off tool, bring it up against the turned face of the flange and part off. The next operation is to mount the casting on an angle bracket on the face plate with the top flange down on an angle and held by means of a 1/4" bolt and nut, passed through. Place a thin lead or fibre washer under the nut to prevent marring the finished surfaces, see Fig. 2c. Square up the outlet flange and locate it so that the transverse centerline of the 1/4" bore is on the lathe center, and correct the height in relation to the top and bottom flanges as illustrated. Drill

[16] Originally published in The Modelmaker, p. 20-24, Volume 9.

1/4" and counterbore the recess. The counterbore in the other flange may be done with a "counterbore" or pin drill. This completes the body of valve.

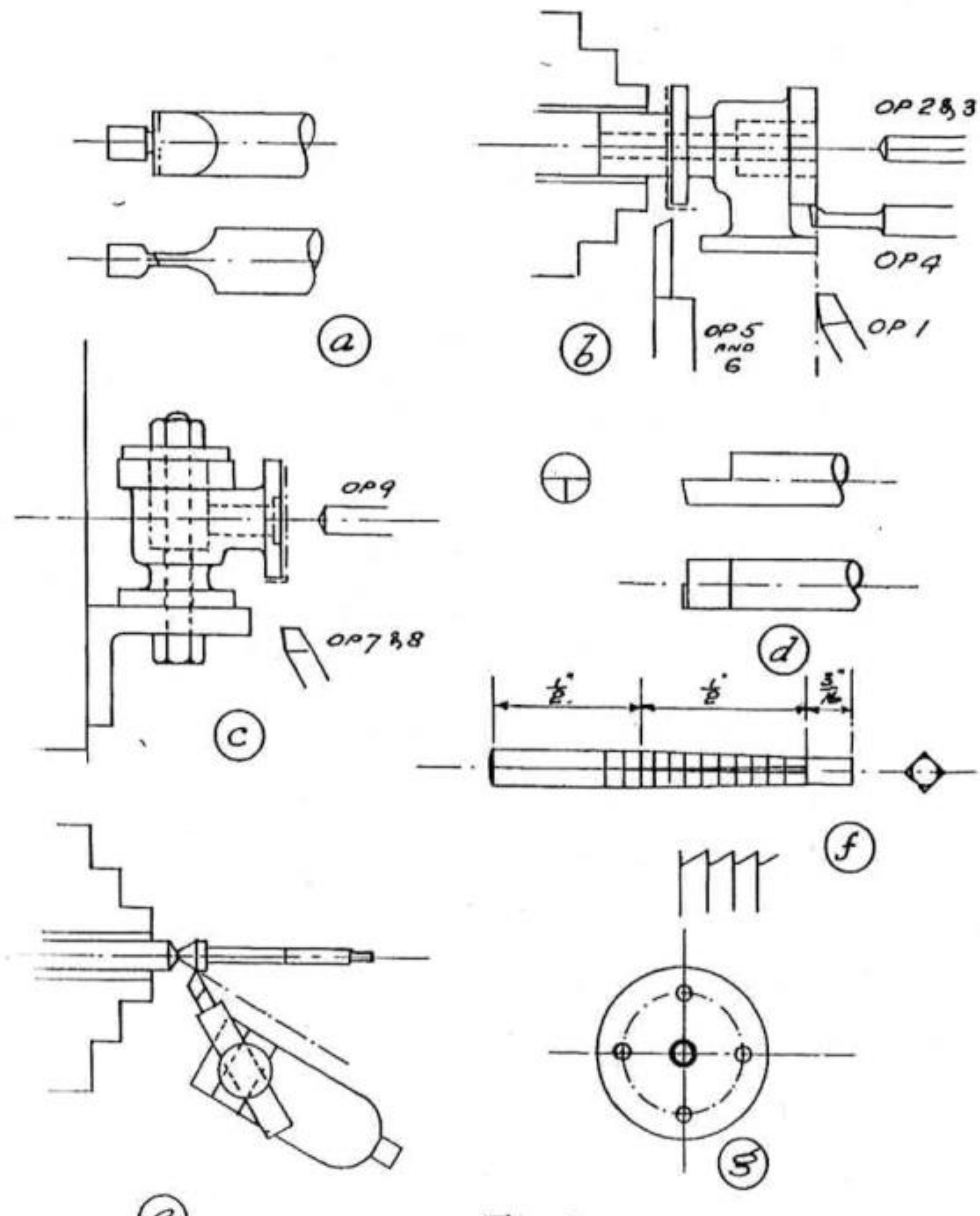


FIG 2

Now make Part No. 3117, the stuffing box of 1" round brass bar. Chuck a 1" length, face off the end, center, and drill 5/32" with a straight flute drill, open out to 9/32" with a pin drill or a little boring tool held in the tool post. Another method is by means of a tool like Fig. 2d, held in the tailstock chuck. Next tap 5/16"-32 by holding the tap in the tailstock chuck, and slide it up to the work with the right hand while slowly pulling on the lathe belt with the left. Reverse the operation by pulling on the opposite side of the belt. Use a little white lead and lard oil on the tap, it saves the taps, prevents sticking and produces a clean smooth thread. Now part off the piece about 9/16", while the brass is in the chuck, face off and drill and turn to make the handwheel No 5117, which can be made with the cutting off tool, producing the bosses and cutting off. Before cutting off it is best to knurl the edge.

Going back to No. 3117, hold a place of 3/8" steel in the chuck, turn down to 5/16" and thread 5/16"-32 for about 7/16”. Without removing it from the chuck, screw on part No. 3117 and turn to a snug fit in the body of the valve No. 1117. Face off the end to produce the 3/8” length. If only light cuts are taken the piece will screw off easily enough, but if it has become tight, wrap a piece of fine emery cloth around it and slip on a tool maker’s clamp, or even a lathe carrier of the clamp type. This will remove the piece without spoiling the surface.

Part No. 2117, the stuffing box gland, is made from 3/8" hexagon brass. Chuck a piece, turn 5/16", screw 32T from the tailstock, face off, and drill with a 5/32" straight flute drill, cut off with a cutting off tool, but just before it is completely severed chamfer the corners of the hexagon, which can be done by withdrawing the tool and setting it over at about 45°, and take a slight side cut. Restore the tool to the normal position and take a final light cut right through.

The Valve Stem, No. 4117, can be made of cold rolled steel, phosphor bronze, or stainless steel. Chuck a piece of 3/8" diameter and turn to 5/32" for 1-15/16" and to 1/8" diameter for 3/16" length at end. Screw 5/32"for a 3/4" length with a die held in the tailstock. Now replace the turning tool with a left hand side-cutting tool, set the top slide of the lathe at 30° and cut in as shown, at sketch Fig. 2e. Traverse the saddle slightly towards the headstock so as to avoid a heavy chip on the front of the tool and when a good groove is made take a light side cut with lubricant (soluble oil solution or lard oil) right across the cone. The piece can be worked right off till it is severed or it may be parted off at 1/4". Remove any fin left on the center with a file.

The hand wheel, No. 5117, has already been partly made when making No. 3117. To finish, first make a little broach of 1/8” square drill rod. Put a piece in the chuck and turn to 1/8” for about 3/16" length, remove and file the square part taper for about 1/2", then file some teeth in the four faces as sketch, Fig. 2f, harden to dark straw color. Drive this little tool through No. 5117 with light taps of the hammer. Hold the wheel in the chuck with a thin copper or zinc band around the edge and recess for the web. This may be left solid or the spokes can be cut in readily enough. To do so, lay off two lines at right angles with the center square, or with the surface gauge, and step off 1/16" each side with the dividers, drill No. 44 holes close to the lines at the rim, and No. 23 at boss between the lines. Cut out the segments with a jeweler’s piercing saw or fret saw and finish with a needle file.

The columns, No. 6117, are made of 3/16" hexagon steel. It is best to turn the two diameters at one setting and thread one end from the tailstock, turn round and thread the other end. This will compensate for any inaccuracy of the chuck. Be careful to get both shoulder distances alike. Check with the micrometer if you have one or set the calipers and make both shoulders fit.

Now a drill jig is necessary to drill No. 3117, No. 7117, No. 8117 and No. 9117. This should be made of an 1/8" disc of mild steel. Chuck a piece of 1" C.R.St., face off and drill and tap 5/32"-40 while in the chuck, and scribe a 3/4” circle with a sharp pointed threading tool in the tool post, sideways. If your lathe is fitted with a graduated collar to the cross slide, it is an easy matter to measure the necessary 3/8" radius. Feed the tool forward until it just touches the edge of the 1" diameter stock, then take the reading of the collar, add 0.125 and feed forward until this new figure is indexed, then feed the saddle up to the face very lightly and revolve the lathe so as to produce a fine grooved line. This should now be a circle of 3/4” diameter. Cut off 1/8" thick square off two lines and center punch on the circle for four No. 44 holes. Stamp a number or any mark against one pair of holes on the diameter. Case harden the jig. See Fig. 2g.

Taking Part No. 3117. First, turn up any piece of brass or steel and thread 5/16"-32, then turn a little boss 1/8" long and thread 5/32"-40 for the center hole in the jig. Screw this piece into No.3117 and slip the jig over it, hold it with a small toolmaker’s clamp and spot drill the four holes No. 44. Transfer the marks or number of holes in the jig to the piece No. 3117. Remove the jig, drill through two holes No. 44 and the marked holes drill No. 30. Part No. 3117 is now finished.

Next make Part No. 7117 from a piece of 3/16” flat cold rolled steel. Clip a piece to the face plate, drill and tap 5/32"-40. Remove, put a 5/32"-40 stud in the jig, screw on No. 7117 and spot drill through the marked holes. Remove the jig and drill No. 30. Finish up the contour by draw filing.

The valve can now be assembled. Pass the valve spindle No. 4117 through No. 3117, put a smear of graphite and boiled oil on the face and insert in body No. 1117. Bolt up with two No. 2-56 screws. Put a few coils of graphited asbestos in the stuffing box and screw the gland No. 2117 down.

Next screw in the columns which pass right through No. 3117 and screw into the body. Now pull the valve spindle up as far as it will go and thread on the beam No. 7117, then push down till the beam seats on the columns. Put two 5-40 hexagon nuts on. Finally the handwheel is pushed on.

The connection of valve to the boiler or pipe will depend somewhat on the particular application. However, a suitable connection is given on the drawing together with pipe flanges. The connections are necessary because it is not possible to pass bolts through flanges of the body from inside, but it is possible to pass the bolts through the connection and then into body flanges where they are held by the nuts.

It will be noted also that the joints between flanges are not made face to face, which in fact are clear by 1/64", but are made in the 3/8" counterbores of No. 1117 and the protruding shank of No. 8117. It is easier to maintain a steam tight joint over a narrow surface than it is over a large area.

The making of this valve is an excellent job for the new recruit to model making. Only a small lathe is required, it does not lake long to make, and results which the novice is so frequently impatient of getting are soon attained.

Appendix 8 – Forming Bosses and Radii[17]

By H. J. Coventry

A good example of model work is very often marred by steel links, levers, and other similar details being badly finished. Surfaces may not be flat, edges rounded, due to polishing with emery cloth, and small inaccuracies of rounded ends or bosses all stand out to spoil the model. By a few simple methods these faults can be avoided. The methods are quite well known by any experienced worker but the writer's correspondence indicates a growing number of new recruits to the ranks of model makers and for their benefit these notes are written.

We will take a simple lever for an example like sketch **A.** If such a lever is small enough and short enough it might be cut from a chunk of solid steel, but if more than one inch long it is easier to make a "built up" job of it. Taking the solid method first, select a piece of soft steel of suitable size and lay out the edge contour leaving an allowance all round, see OP. 1, Fig. 1. Drill say No. 48 hole at **X** and also drill the holes **Y** to the size required, then hacksaw the surplus metal away the cuts finishing in the No. 48 holes.

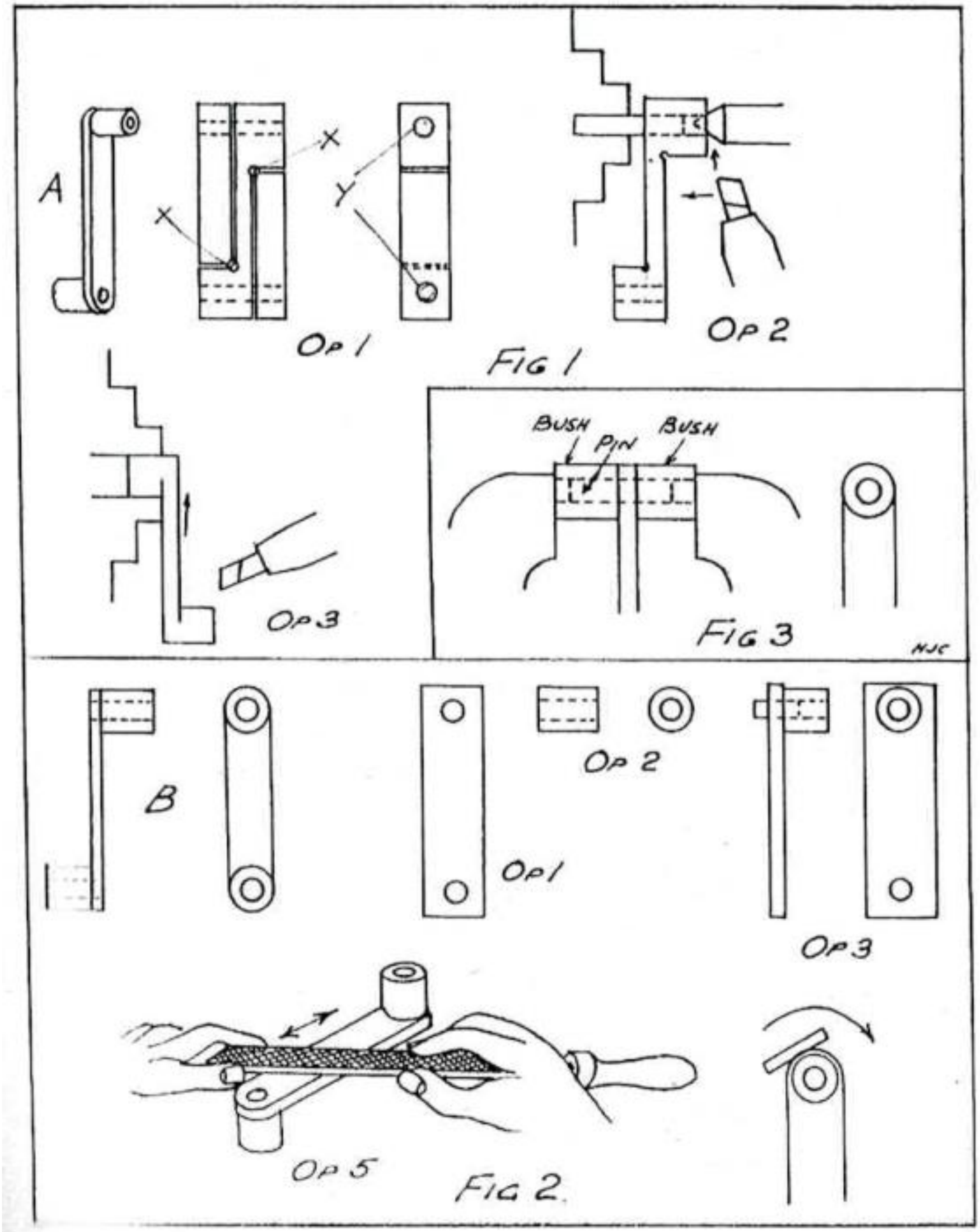
Op. 2. Drive in a hardened pin or mandrel in one end, hold in the chuck and rough turn the boss leaving it full, for later finishing. If the lathe chuck does not permit of holding the job close to the jaws, support the outer end by means of a false center held in the tailstock chuck. This arrangement will permit movement of the lathe saddle when the tailstock is brought up close.

Op. 3. After the bosses are turned fully circular, knock out the mandrel, hold in the chuck by the boss and face off the arm, reverse and face the other side. Use a keen knife tool well oil stoned, using light cuts and fine feed. Moderate speed and plenty of cutting solution will give a finish that cannot be excelled, but promptly spoiled by use of emery. The finishing operation will be described later as it is the same as a built-up job.

Refer to Fig. 2. At Sketch **B** is shown a long lever that would involve considerable labor to cut from solid, so we select a piece of flat stock of thickness equal to the arm and a little wider than the diameter of bosses. Locate and drill the hole at correct spacing. Op. 1, Fig. 2.

Now turn up the bosses by chucking a piece of round, cold rolled steel, face off the end, center and drill from the tailstock and cut off, leaving an allowance for final finish; Op. 2. Make a little pin of steel a light fit in the arm. Clean up the surface of the arm at the hole, then place the boss, faced side down on the pin. Cut off a small piece of silver solder wire and roll around the boss. Cover with Twenty Mule Team borax or brazing compound, and make it red hot in a gas flame or blower pipe. It can readily be observed when the solder melts. Allow it to cool until black yet still hot, then plunge in cold water. This will crack off the fused borax. The pin may be knocked out or if it has become brazed in, drill it out; Op. 3.

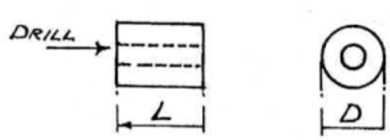
[17] Originally published in The Modelmaker, p. 350-353, Vol 10.



Next, mount it on a short mandrel and take a light, cleaning cut, fine feed and fair speed, over the boss and reduce to proper length. Op. 4.

Now for the finishing which will apply to either the “cut from solid” or built-up method. Hold the lever in the vise between copper “clams” and take a narrow or pillar file of fine cut, say 6-inch, No. 2 toolmaker’s pillar file. Lay the file across the work and hold between the thumb and first finger of each hand. Keep the file from tilting and push up and down. In other words, the file is moved sideways instead of the usual lengthways of the file, the operator being at the side of the vise instead of being in front of it. This will give a fairly good surface and finish. When even and satisfactory, do the same operation with a No. 1 file. A drop of oil on the work will prevent “pilling” of the file and produce a first-class finish. Of course the file should be brushed out with a wire brush from time to time. All flat surfaces and edges may be "draw-filed’’ as this operation is known. The illustration at Op. 5, Fig. 2 shows this, and when well done no use will be found for abrasive cloth.

The ends of the arm may be filed close but not down to the boss, leave about 1/64 over. This will avoid the possibility of marring the bosses. The final finish on the end may be given by holding the file in the right hand and the job in the left. With the job pressed against the leading end of the file push the file forward in a circular sweep for its full length. Or with care, the rounded end can be "draw filed” by rolling a fine flat file around the end.



Drill Rod Size	D	L	Drill	Suitable For
30	0.125	1/8”	55	0-80 Tapping
			52	0-80 Clear
16	0.177	3/16”	49	2-56 Tapping
			44	2-56 Clear
4	0.209	¼”	47	3-48 Tapping
			37	3-48 Clear
¼	0.250	¼”	39	5-40 Tapping
			30	5-40 Clear
9/32	0.281	5/16”	33	6-40 Tapping
			28	6-40 Clear
11/32	0.338	3/8”	29	8-36 Tapping
			19	8-36 Clear
3/8	0.375	3/8”	21	10-32 Tapping
			11	10-32 Clear
9/16	0.437	3/8”	17	12-24 Tapping
			2	12-24 Clear

Sometimes it is necessary to file a radius on a flat piece of stock. This is readily accomplished by means of hardened drill rod bushes and plugs. Place a pin in the work and slip a bush over each side, hold it in the vise and file down to the bushes. The bushes being hard prevent the file from cutting below their surface and a perfect radius is produced equal to half the diameter of the bush.

This is illustrated in Fig. 3 and a table of suitable sizes is given. The bushes should be of drill rod faced both ends, made red hot and quenched outright. Leave them alone - do not temper. The pins may be of drill rod.

Appendix 9 - FLANGING BOILER PLATES[18]

BY MR. H. J. COVENTRY

For some reason the flanging of plates for boiler construction seems to hold so much terror for the average amateur that he will avoid them, and actually undertake far more labor in making patterns to produce cast plates, sometimes of doubtful and unknown quality.

Fig. 1 shows two typical flanged copper plates of 3/32" thickness for a ¾" scale locomotive boiler. Number 1 is the throat plate and Number 2 is the firebox tube plate.

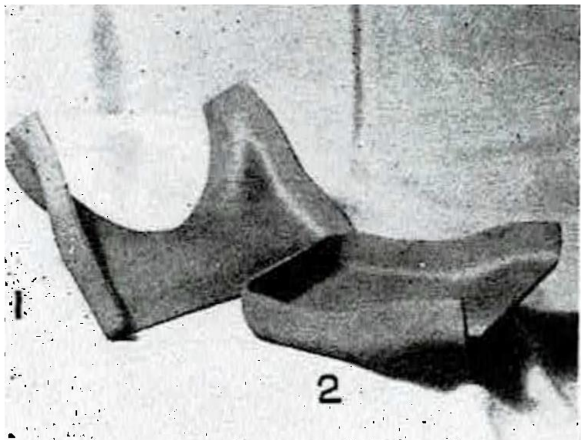


FIG 1

Taking the #1 plate first: Formers will be required of cast iron, the patterns of which are simple and quickly made. No allowance should be made for finish because none is required if the castings are clean and smooth. The first operation is to utilize the former which is marked #1 in Fig. 2 and its companion follower 1-F. Lay the copper plate on the former and drill two holes in it at the same location, within what will be waste metal. Tap and screw in two studs in the former, so that they are just below the surface of the copper plate. Then with a wood or raw hide mallet beat the copper at the first bend. The follower 1-F can now be placed on, and the whole set put in the vise and given a good squeeze. Now all is ready for turning the flanges over.

With the mallet gently hit the edge of the copper sheet all along, then go back the same way, never hitting it in the same place twice in succession. The object is to keep the angle the metal takes on even throughout, until the full right angle is made and the flange is closed down on the former.

The moment any wave starts to form, beat this area a little more until even with the rest. Both flanges on Former #1 can easily be done in twenty minutes.

Next Former #2 and its follower are made in which the plate is to fit snug. Cut a semi-circular piece out of the plate allowing sufficient material for turning over the boiler barrel flange.

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[18] From THE MODELMAKER, Volume 11, page 221.

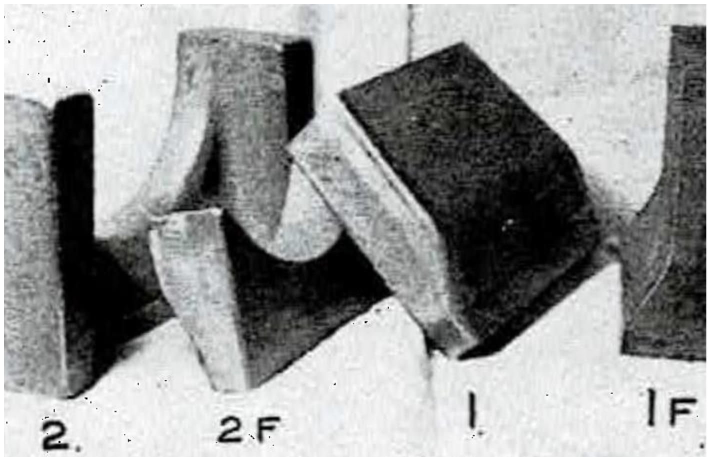

FIG 2

Lay the copper plate in, then the follower, then grip in the vise. Also put a C-clamp on the top edge of the flange. Now go to work with the mallet as before, beating evenly all round.

Keep the plate soft by annealing as soon as the metal begins to feel stiff. To do this make the plate cherry red hot and quench in water.

The finished throat plate is shown at 1 Fig. 1. The plate 2 Fig. 1 is made on a similar former to #1 Fig. 1, except of course, the corners are radiused. In flanging this plate do not attempt to bend the edge over too suddenly, because if you do, the moment the corner is reached, it will buckle. Turning the edge over ten degrees would be ample and a nice even flange will grow.

The total time taken to make plate #1 was 2 hours, while #2 took about 1.5 hours. A backhead plate is quite an easy job and the fire box back plate is similar to the fire box tube plate.