By RUDY KOUHOUPT

AS A PRIME MOVER, the steam engine came into existence over two centuries ago. From its humble beginnings, James Watt improved upon the operation of the steam engine until he raised it to the position of a great industrial and economic force. One of his innovations, the parallel link motion, functions in this captivating miniature just as Watt specified in his patent of 1784.

Briefly, this is how it works: Steam, regulated by the valve, drives the piston up and down in the cylinder in a vertical, straight line. The piston rod, likewise, travels in a straight line but is connected to one end of the beam. This is where the parallel link motion comes in. It is interposed between the piston rod and the beam. There it converts the linear motion of the piston rod into the radial motion necessary for the beam to oscillate, or walk, about its midpoint. At the opposite end of the beam, the connecting rod drops to the crank to impart a rotary motion to the crankshaft. An eccentric mounted on the crankshaft controls the valve so that steam is admitted to and exhausted from the cylinder in the proper sequence of events. The cylinder is double action.

Begin construction of your miniature...
engine by cutting out the wood base and then mark out the bedplate on 1/8-in. Dural and drill the holes for the mounting screws and column. Two wood screws, through the holes in diagonal corners, hold the bedplate to the base.

The complete column assembly is composed of the column, the two column ends, and the entablature. Machine the column first, then the ends for an exact fit. When all parts are finished, pass a ¼ x 5-in. bolt through them and anchor the assembly to the bedplate with a nut on the underside.

Next, mark out the outline and hole centers of one spring beam on 1/32-in. sheet metal. Drill it and use it as a guide when drilling the second piece. Bolt the two pieces together with 2-56 screws through the smaller holes and cut out both parts at the same time with a fine hacksaw. Finish to the mark by filing. Attach one to either side of the entablature with two 2-56 screws. Now make the stretcher and place it between the spring beam ends.

Next, make the gudgeon which spans the spring beams and acts as the main pivot for the beam. Four nuts on the threaded ends of the gudgeon hold it in place; one nut goes on each side of each spring beam. Make the two link gudgeons next. Screw one into each spring beam and add a locknut.

Follow the same basic procedure on the beam side members as you did on the spring beams. Assemble the beam by putting the shouldered ends of the center spacer through the 5/16-in. holes in the beam sides. Put the other spacers in place, using 2-56 machine screws through the sides. The 1/8-in. openings are for the pins on which the connecting rod and links move. Mount the beam on the column by passing the gudgeon through the spacer.

Shape the main and back links as shown and install with pins made from 13/16-in. lengths of 1/8-in. steel rod. The top screws in the links will hold the pins in place. Assemble the four parallel links on a simple jig to ensure that all will be exactly the same length. The jig consists of two 1/8-in. steel pins accurately placed 1/4 in. apart in a wooden block. Cut eight pieces of

THIN SHEET METAL is rolled in a sleeve to form an insulating lagging or cover around the cylinder

TWO PARALLEL LINKS go between the back and main links and two more between back link and gudgeons

BRASS TUBING is sweat-soldered into an elbow flange to form the exhaust fitting for the cylinder
1/8-in. i. d. brass tubing, each 3/32 in. long, to form the eyes of the links. Put one over each pin in the jig, and cut a length of 3/32-in. brass rod to go between. Solder the two eyes and the rod together. Remove from jig, and repeat until all links are done.

Cut 17/32-in. and ¾-in. lengths of 1/8-in. steel rod to form the lower pins in the back and main links, respectively. Spacers about 1/8 in. long must be placed between the parallel links on the lower pin of the back link. Exact size of the spacers and setting of the link gudgeons must be determined individually so the beam will swing freely and evenly.

Cut a 35/8-in. length of 1/8-in. steel rod for the crankshaft connecting rod and add the big and small ends. After assembling the three parts, install the assembly in the beam by passing a pin through the beam and the transverse hole in the big end. The pin is a 13/16-in. length of 1/8-in steel rod.

Shape the crankshaft bearing blocks as shown, and mount them on the bedplate with 4-40 screws from the underside. Use bronze bearing stock for the crankshaft bearings which should be a light press fit in the blocks. Pass a 1/4-in. reamer through the bearings after mounting to be sure that all is well aligned.

Turn the crankshaft between centers for the best job, then make the crank and crankpin and mount them on the crankshaft. Put the crankpin through the small end of the connecting rod and adjust its length by the setscrews. Its length must be such that the beam is horizontal when the crank is at midstroke. The beam ends must move symmetrically, 5/8 in. above and below the horizontal, when the crank is at either end of the stroke.

Use a block of ¾-in. square brass for the cylinder. Set it up in a four-jaw chuck, face the ends to bring it to length and mark the center of the ends. Start the bore with twist drills, bringing it up to about 7/16 in. The bore can be finished in several ways, including the use of a sharp parallel reamer. My favorite method is to use a between-centers boring bar with the cylinder mounted on the lathe saddle. Block the cylinder up and clamp it so its center coincides with the axis of the lathe. Feed the work slowly on power feed, increasing the bore a little at a time. This method will produce a cylinder in which the walls are absolutely parallel throughout their entire length.

With the boring complete, mark out the two steam passages on the midline, 39/64 in. from either end. Drill these punch marks 3/64 in. deep with drill No. 52. Mark the ends of the cylinder where the steam passages come out half way between the cylinder bore and outer wall. Drill 5/8 in. deep from either end with drill No. 52 to form the complete passages which will be L-shaped at this point. Use a small file or end mill to remove about 1/32-in. of the wall between the end of each passage and the bore to give free entry of steam.

Mark the locations of the four screws which will hold the port face to the cylinder, then drill 3/16 in. deep, and tap 2-56.

Cut a 1-in. square of ¼-in. brass for the port face. Accurately locate the center as a reference point. Working from the center, locate the four steam ports. The two ports on the vertical centerline are drilled No. 52 right through to meet the passages in the cylinder wall. The two ports on the horizontal centerline are drilled No. 52 to a depth of 1/8 in.

Connecting passages are drilled on the horizontal centerline from each side to serve as steam inlet and exhaust. Mark out and drill locations of the four mounting screws, then counterbore to form re-

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MODEL WALKING-BEAM ENGINE
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cesses for the screwheads. Now drill through the center reference point and tap 10-32 for the valve pivot. Put a gasket between the port face and cylinder side.

Machine the upper and lower cylinder covers from Dural. Use the cylinder as a ring gauge to check the register diameters. Drill the covers for the mounting screws, then spot the cylinder ends from the covers and drill and tap for the mounting screws.

Chuck a piece of Dural for the piston, drill through for the piston rod and machine the packing groove. Bring the o.d. to about .0002 in. oversize. Make the piston rod and mount the piston on it. The piston is held in place by a thin nut (3/64-in.) on either side. Next, chuck the piston rod with the piston on it and, with a very sharp tool, skim the piston to finish diameter.

Pack the piston with graphite-asbestos string rolled into the groove. Use commercial packing split down fine. Assemble the cylinder and covers with the piston in place and gaskets under the covers. Put some packing into the stuffing box and screw in the gland.

Fit the piston-rod eye to the rod with a locknut on the rod. You can now mount the cylinder on the bedplate by means of 4-40 screws through the big holes in the lower cover. Connect the piston-rod eye to the main link by its lower pin. Gently rotate the crankshaft to adjust the piston rod in the eye. Its length must be such that the piston will not contact the covers at the ends of the stroke. When you have

added the steam inlet flange and exhaust fitting to the port face, you are ready to tackle the valve and its associated parts.

Make up the valve pivot first and screw it right into position in the port face. Mark out the valve on a piece of 3/16-in. brass and work from the pivot center as your reference point. Steam grooves in the valve face are best formed by end-milling with a 1/16-in. dental burr. Set up a false pivot by mounting a 3/16-in. rod horizontally on the lathe saddle. Mount the valve on the pivot with its face toward the headstock and the mill gripped in a chuck. Set the pivot 19/64 in. off center to correspond to the radius of curvature of the groove. Feed the work in slowly, rotating the valve manually on the pivot through the proper angle. Lap the valve face and port face with jeweler's rouge to make the joint steam tight. Mount the valve on the pivot, holding it against the port face with a light spring and nut.

Chuck a piece of brass for the eccentric, and machine the o.d. and the groove for the retaining screw which prevents the eccentric strap from moving sideways. Then sever with a parting tool. Use the center mark from parting off as a reference point to locate the crankshaft opening. The setscrew must pass through the broad part of the eccentric.

Put a locknut on each end of the eccentric rod for length of adjustment. Use a shouldered screw for connecting the eccentric rod's small end to the valve.

Making final assembly

Mount the eccentric on the crankshaft in any position for now and hook up the valve through the eccentric strap and rod. Adjust the length of the eccentric rod so that the division between the steam grooves in the valve face will move equal distances back and forth across the ports on the vertical centerline of the port face as the crankshaft is rotated. The last adjustment is the eccentric position relative to the crank. The eccentric should form an angle of about 165° to the crankpin. Adjust it so that the valve will be just starting to admit steam to the appropriate port when the piston is at the end of its stroke and is about to change direction. My lathe is not big enough to handle the flywheel, so I hunted around and found the old gear which serves admirably. With a heavy flywheel and long stroke, the engine runs very smoothly on either air or steam. The proper operating speed for a beam engine is 50 to 60 rpm.

Complete plans detailing each part of the model can be obtained for $3.50 from Beam Engine Plans, 691 Garretson Road, Somerville, N. J. 28876.

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