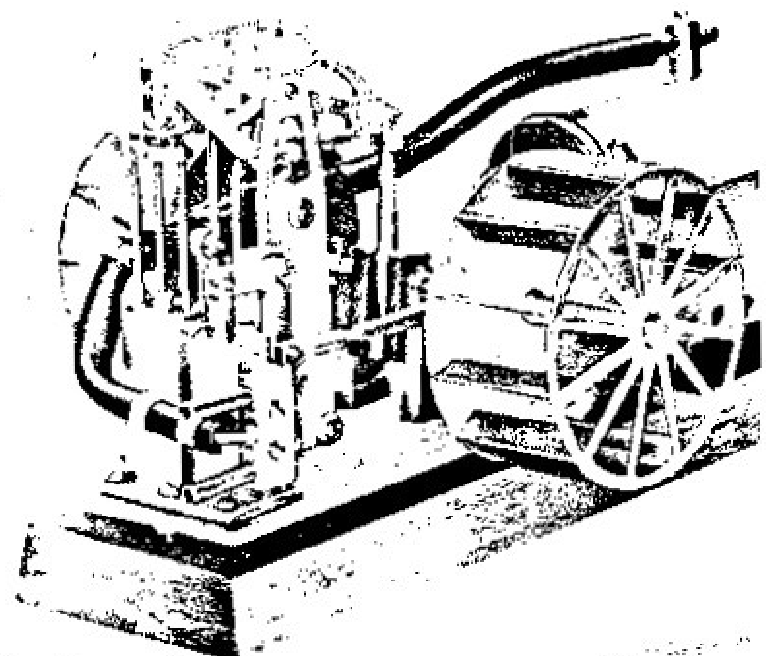
BOOKLET NO. B-110 $1.00

Building a Working-Model Hudson River Paddle Steamer Engine



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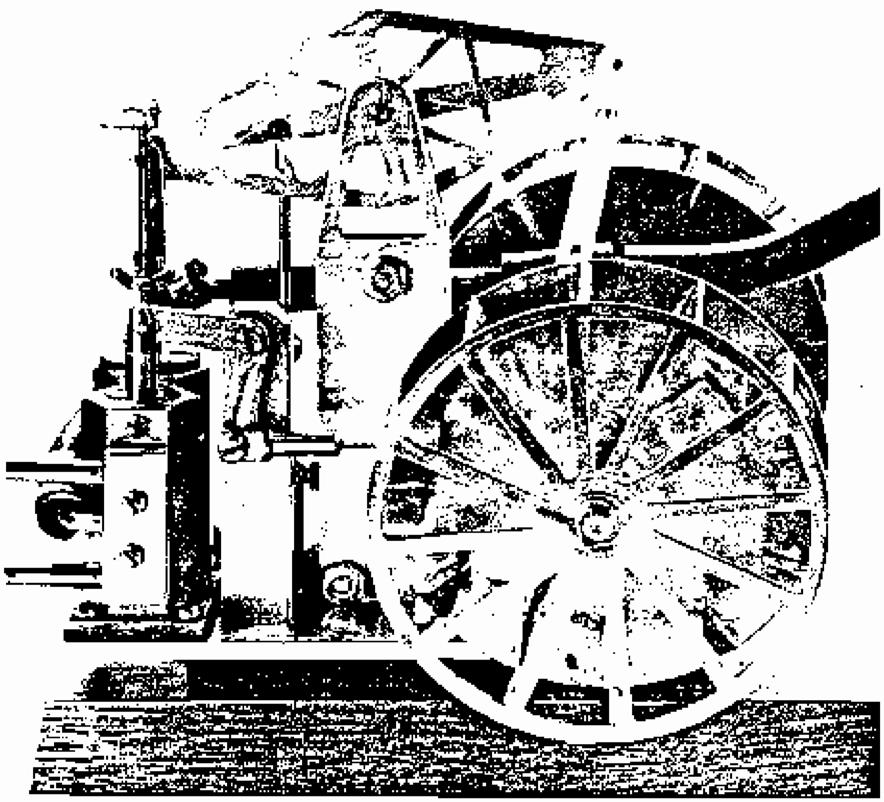

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BUILDING A WORKING-MODEL HUDSON RIVER PADDLE STEAMER ENGINE

Engine designed and built by John F. Haines

INTRODUCTION

A Pennsylvanian interested in art, Robert Fulton traveled to England and France at the close of the Revolutionary War to study painting. While abroad he met James Watt, who was then improving his newly-invented steam engine, and through Watt some English engineers who were experimenting with steam-powered watercraft. Fulton became so convinced of the potential of the steamboat that he gave up art and built an experimental steam-powered vessel himself, which he launched on the River Seine in 1802. The hull was too light for the engine and broke in half and sank.

But Fulton was undeterred. He salvaged the engine and fitted it into a larger 66'-long hull, and this craft chugged up the Seine at a steady speed of 4 1/2 mph before thousands of spectators.

Encouraged with his success, Fulton then ordered a larger steam engine from the English firm of Boulton and Watt, returned to the U.S., and began building a considerably larger steamboat on New York's East River. This new vessel, the *Clermont*, was 133' long with 13' beam. The Boulton and Watt engine had a 24"-dia. cylinder with 48" stroke, developed 20 hp, and turned matching side-mounted 15'-dia. paddlewheels, with a 20'-long copper boiler supplying steam.

"Fulton's Folly", as scoffers had nicknamed the *Clermont*, made her maiden voyage in 1807 up the Hudson River to Albany, a distance of 150 miles, in 32 hours. Sailing vessels had taken a week to make the same trip. Soon the *Clermont* together with two other steamboats Fulton built was providing regular steamer service along the Hudson.

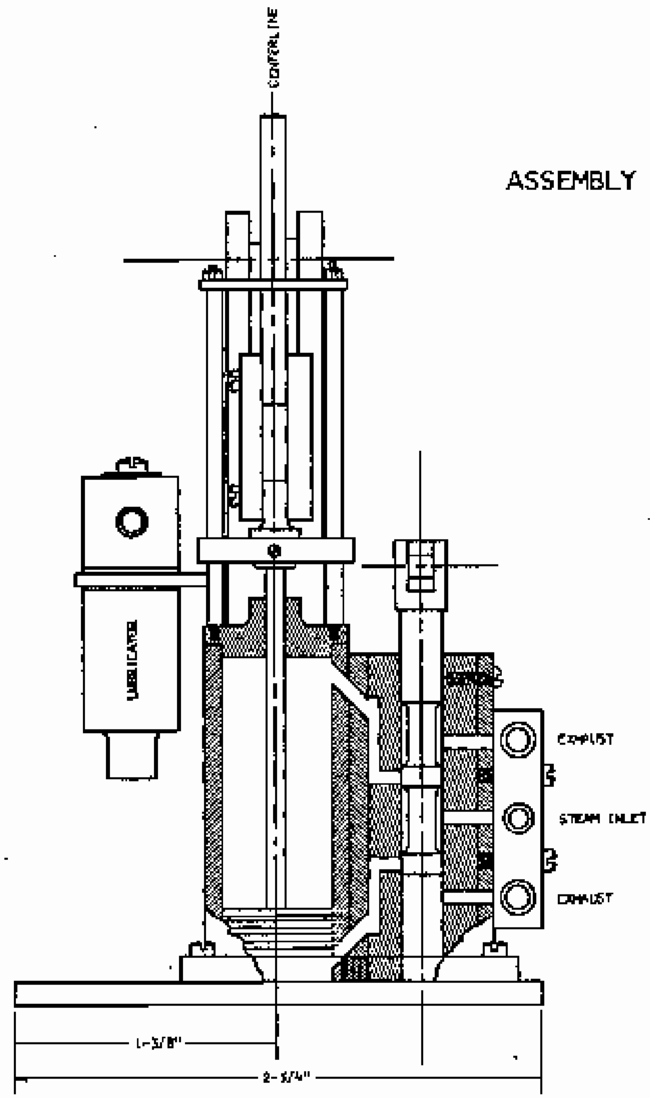
The world's first commercially successful steamboat, the *Clermont* began a boom era in steam navigation. By 1819 there were more than a hundred steam vessels in operation on America's inland waterways, with one or two as far west as the Mississippi.

Early paddlewheel steamers were shallow-draft vessels driven by slow-speed engines with single vertical double-acting cylinders. The cylinder's piston cranked twin paddlewheels through an overhead parallel-motion "walking beam", or on some craft through a crosshead and inverted-T-shaped side levers.

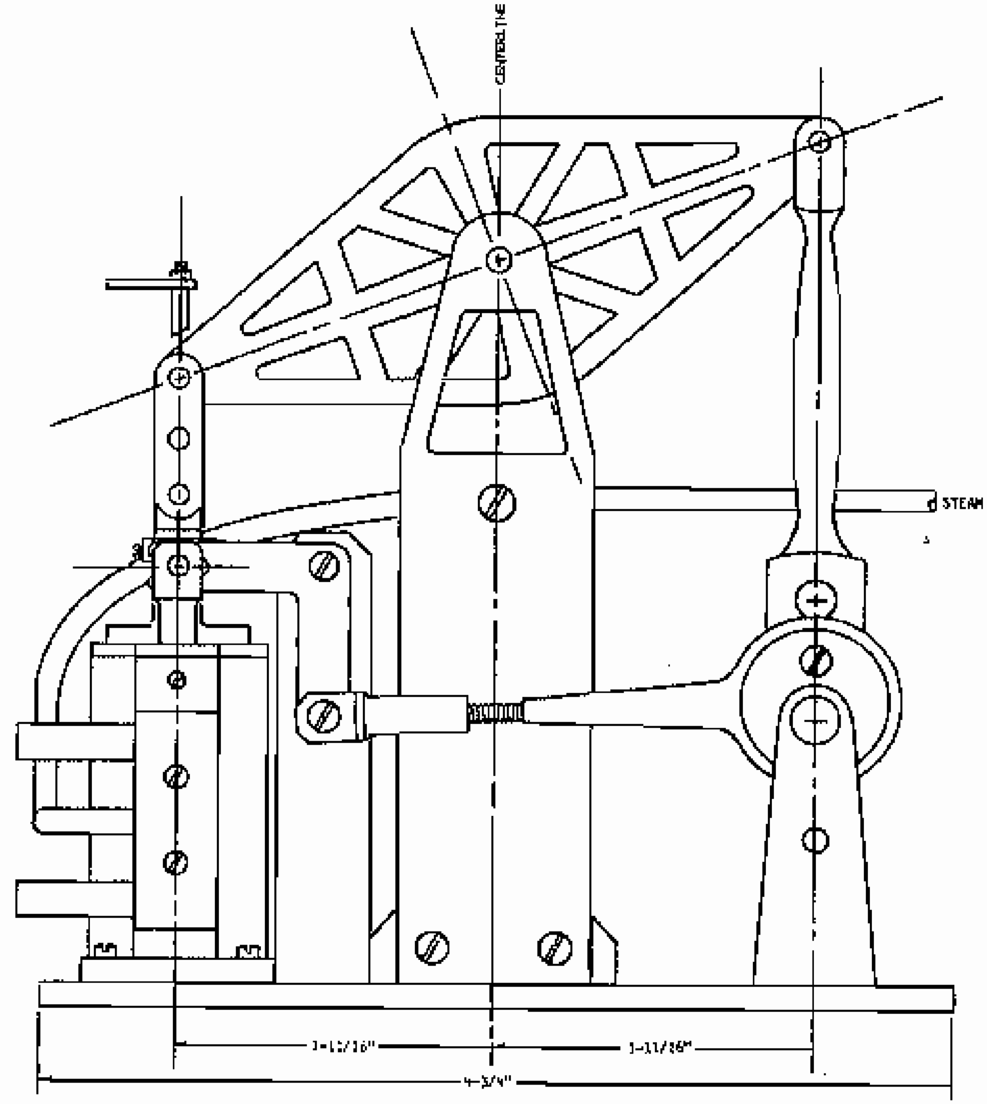
The earliest engines operated on steam pressures of 10 to 20 pounds per square inch, with their boilers burning about 5

pounds of coal per hour per horsepower. As boilers were improved operating pressures were increased to around 50 psi, which saved fuel. Later sidewheelers were built with a seperate engine for each paddlewheel to improve maneuverability, since with this arrangement one engine could be reversed—and with the paddlewheels turning in opposite directions the vessel would turn in little more than its own length. After the 1840s shallow-draft river steamers on the Mississippi became gaudy, multi-decked floating palaces.

ASSEMBLY



The model engine pictured typifies engines used in the steamers that plied Eastern navigable rivers in the 1830s. To make the model easier to build the design has been somewhat simplified. This engine has an easy-to-machine piston valve operated through a bell crank by a single eccentric, and the engine therefore isn't reversible. Actual engines had two eccentrics and rather complex valve gear (necessary in part because the valves were hand-operated to start the engines). When the vessel was under way, the appropriate eccentric rod (for forward or



reverse) was taken "off the hook" and connected to the valve.

This model is built to a scale of 1/8" = 1', representing a full-size engine with 4 1/2' bore by 10' stroke.

MACHINING THE PARTS

All engine parts are machined from brass, aluminum and mild steel. The machinework can be accomplished on an Edelstaal Unimat or other small metal lathe. When machining brass, use lathe tools ground with zero rake. When machining aluminum, use tools ground with 30° rake. When machining mild steel, use tools ground with 10° rake.

Although the parts drawings give exact dimensions, it's not necessary to machine this engine's parts to close dimensional tolerance. Instead the parts can simply be machined to fit. For example, the cylinder bore needn't measure exactly 9/16" in diameter; it can be slightly larger or smaller than nominal size provided the piston is turned to a close fit in the bore. Similarly, the exact diameter of the valve isn't important provided the valve is a close fit in its bushing.

CYLINDER AND STEAM CHEST

The engine's cylinder and steam chest are machined from two lengths of 3/4" brass hex stock, and then after machining are soft-soldered together on a brass base. Note that the lower end of the cylinder hex is turned to a tenon and inset into the base, while the lower end of the steam chest is simply machined square and butted. Both cylinder and steam chest have 9/16"-dia. bores.

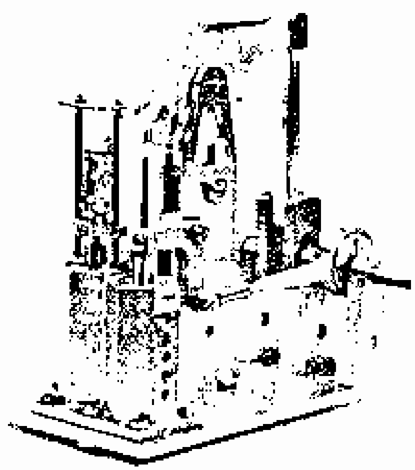
While these bores can be machined with a boring bar, it's easier to rough-bore them 1/32" undersize and finish them to exact size with a hand reamer after the 3-piece assembly has been soldered. To make sure that the cylinder and steam chest will seat squarely on the base, machine the bore and face the bottom end of each hex at the same chucking.

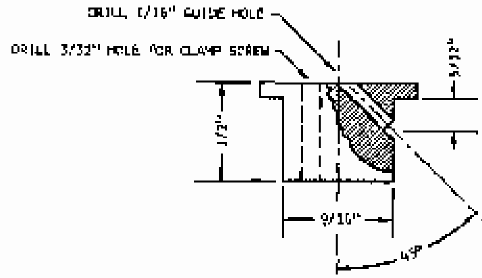
Locate and centerpunch centers for the 11/16" and 9/16" holes in the brass base. Then clamp the base on the Unimat's faceplate and machine these holes with a boring tool.

To solder the cylinder assembly, first clean, flux and tin mating surfaces, wiping off excess solder after tinning. Then bind the three parts together with fine binding wire, and heat the entire assembly gradually and evenly with a propane torch until wire solder flows when touched to the joints. After the solder has cooled, scrape off the excess and clean the brass with fine-grit abrasive paper.

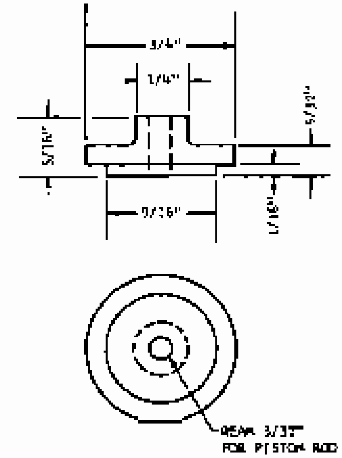
Turning a simple drilling jig with a 45° guidehole simplifies drilling the two 1/16"-dia. ports through the cylinder walls into the steam chest. Secure this jig in the ends of the cylinder bore temporarily with a long clamp screw. Use the jig as shown in the drawing to drill the top port. To drill the bottom port, insert a 1/16"-thick spacer washer turned from scrap metal between the jig and the end of the cylinder.

When machining the brass cylinder head, turn the head's 9/16"-dia. tenon and ream the 3/32" center hole at the same chucking to insure concentricity. To solder the cylinder head in the top end of the cylinder, wrap the lower part of the cylinder assembly with wet rags and heat only the top of the cylinder with a propane torch. Heat the cylinder carefully—only hot enough to make the solder flow—to avoid unsoldering the joints previously soldered.

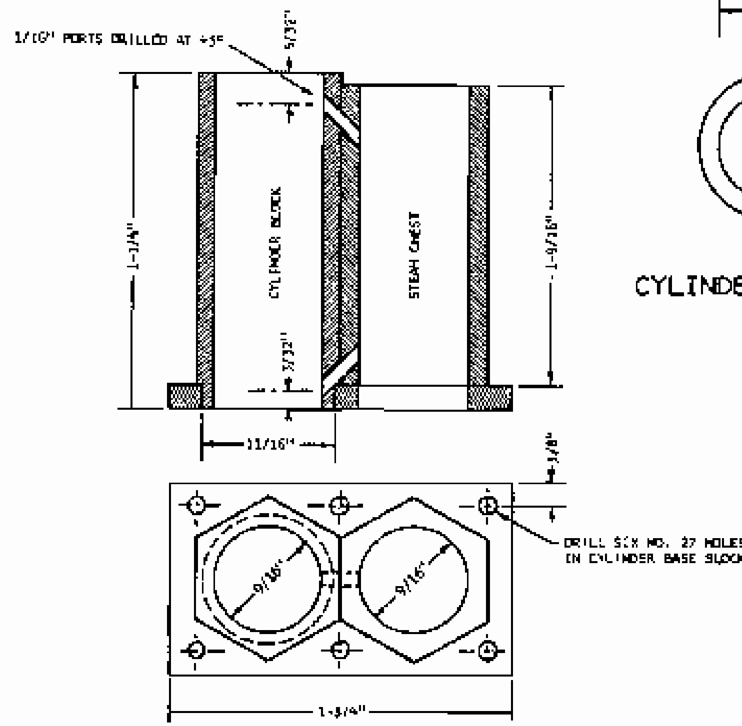




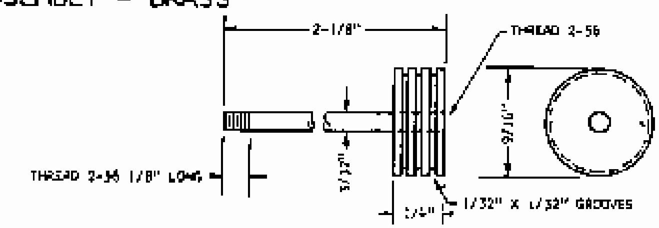
PORT DRILLING JIG - STEEL



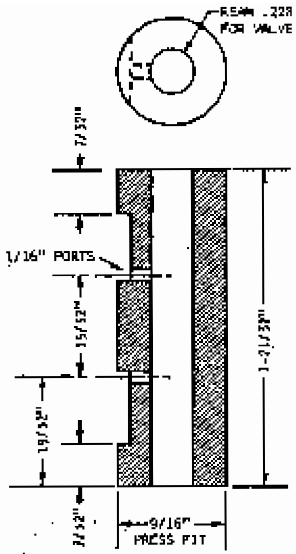
CYLINDER HEAD - BRASS



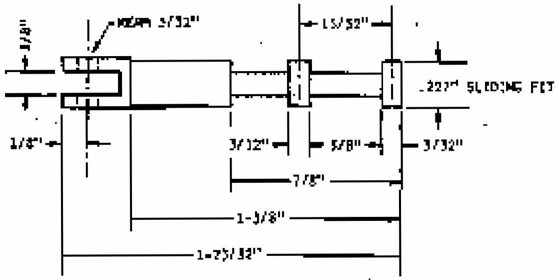
CYLINDER ASSEMBLY - BRASS



PISTON AND PISTON ROD - BRASS



VALVE BUSHING - BRASS



VALVE - BRASS

Having cut and threaded the piston rod with a die, tap the piston, screw the piston on the rod, and chuck the rod in the Unimat's drill chuck to finish-turn the piston's outer diameter.

After through-drilling and reaming the brass valve bushing, turn its OD .001" larger than the steam chest's bore for a press fit. Before pressing the bushing into place, mill two flats on one side to form steam channels and drill two 1/16" ports 15/32" apart as shown in the drawing. Check the distance between these ports after they are drilled, and if necessary adjust the 3/8" dimension between the valve's two lands.

The valve must be turned to a very close sliding fit in the bushing's bore to avoid steam leakage. The valve's two lands should overlap the bushing's two steam ports 1/64" on each side. Slot the top end of the valve with a 1/8" end mill to form the clevis.

With the valve fitted, press the bushing permanently into the steam chest using a large machinist's vise.

TOWER AND BEAM

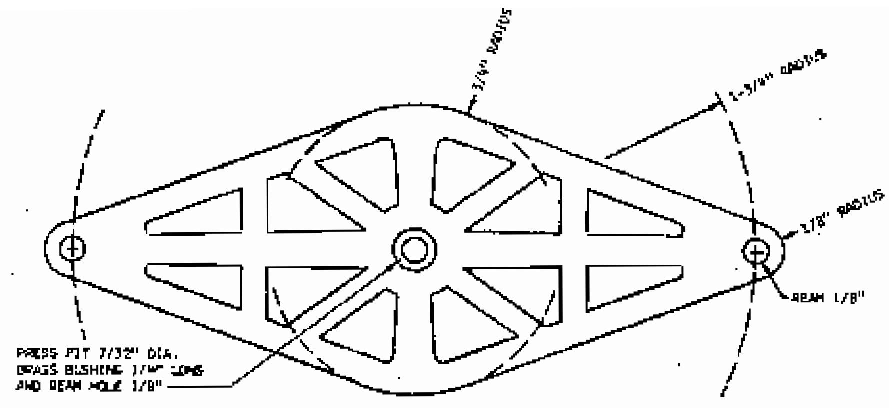
The tower supporting the engine's walking beam has two A-frame standards cut from 1/8"-thick aluminum. Spacer blocks space the standards 1/4" apart. The bottom spacer is drilled and tapped 6-32 for two mounting screws.

To cut the openings near the tops of the standards, clamp the two pieces together, lay out the opening and drill the four corners. Then saw out the open sections with a hand fret saw or with the Unimat's jigsawing attachment.

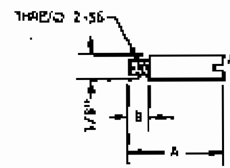
Note that the holes in the tops of the standards are not identical. One is reamed 1/8"-dia.; the other is tapped 2-56.

The beam is also cut from 1/8"-thick aluminum. Either lay out the shape on the stock with dividers, or simply cut out the drawing and paste it on the stock. Drill the openings and cut them out with a hand fret saw or with the Unimat's jigsawing attachment, truing inside edges square with needle files. Use a sanding disc on the Unimat's spindle to true the outer edges square.

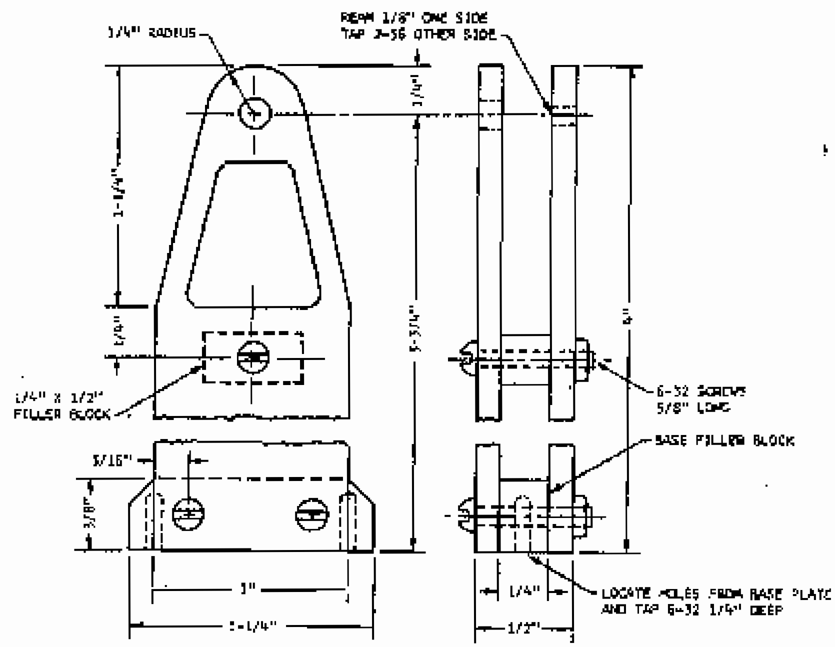
Then turn a shouldered brass bushing 1/4" long and press-fit it into the beam's center hole, reaming the hole in the bushing 1/8"-dia.



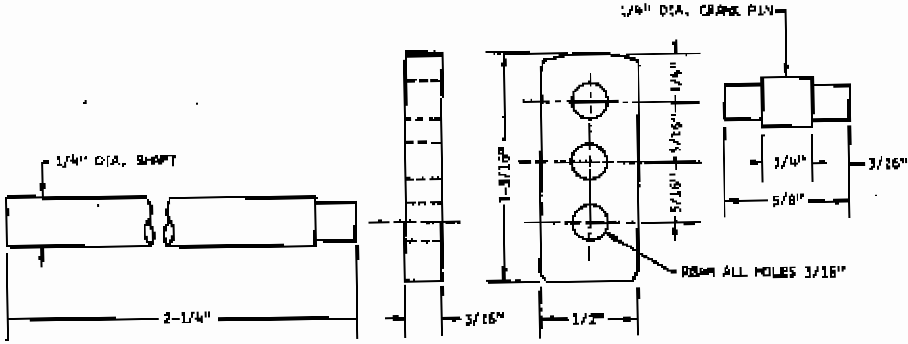
BEAM - ALUMINUM



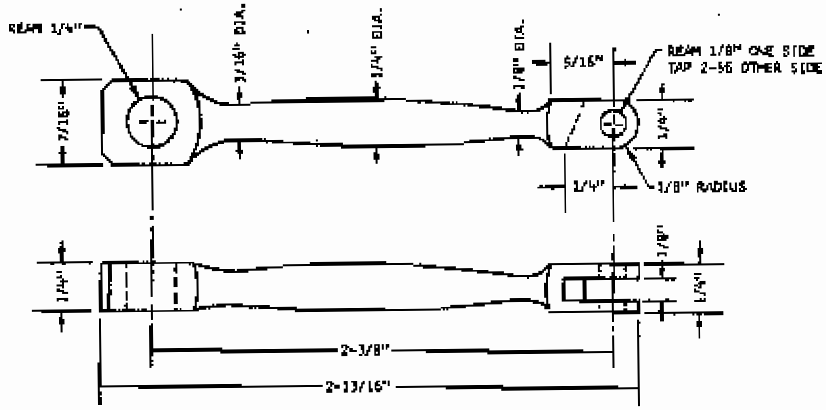
	A	B
BEAM AXLE	1/2"	5/32"
WRIST PIN	5/16"	3/16"



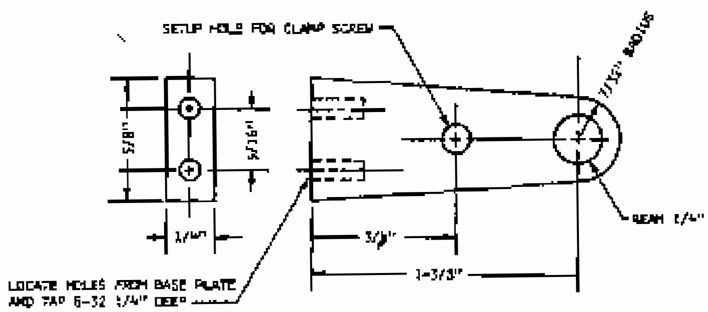
BEAM TOWER - ALUMINUM



CRANKSHAFT (2 SHAFTS, 2 WEBS AND 1 PIN REQUIRED)



CONNECTING ROD – ALUMINUM



CRANKSHAFT SUPPORTS – ALUMINUM (4 REQUIRED)

CRANKSHAFT

The engine's crankshaft is built up, assembled from two identical lengths of 1/4"-dia. shaft, two identical 3/16"-thick steel webs, and a crankpin, all press-fitted together. The setup holes in the centers of the crank webs permit bolting the two pieces together in order to drill and ream the 3/16"-dia. shaft and pin holes in exact alignment. Turn the tenons on the ends of the shafts and pin to a tight press fit in the webs, and when assembling the crank smear a little filled epoxy cement (available from Sears) on the tenons to insure against slippage. Be sure to slip the large end of the connecting rod on the crankpin before pressing the pin into the webs.

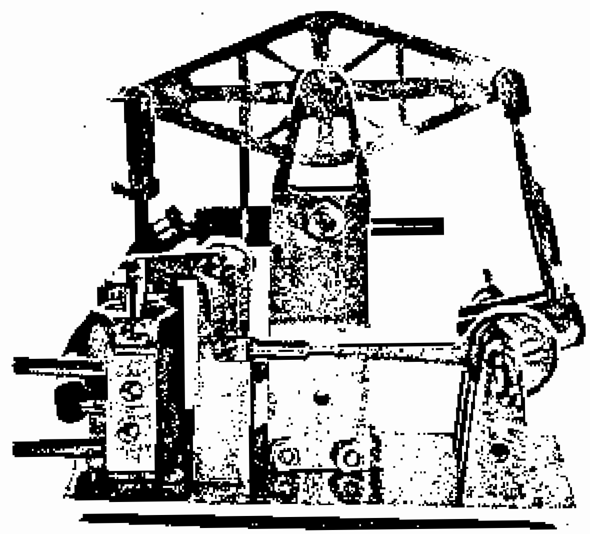
To turn the aluminum connecting rod, either centerdrill both ends of the stock and mount the work between centers, driving it with a dog, or grip the rod's large end in the 4-jaw chuck. Shape the center section of the rod as shown in the drawing, smoothing the curves with files and abrasive cloth. Then drill and ream the 1/4"-dia. hole and slot the rod's small end with an 1/8" end mill. Tap the hole through the clevis 2-56 on one side.

The four identical crankshaft supports are cut from 1/4"-thick aluminum. To make sure that the supports' shaft bearing holes will accurately align, bolt the four pieces together with a large screw through the center setup holes. Then drill and ream the bearing holes and mill the bottoms of the supports true.

ECCENTRIC

An eccentric on the crankshaft raises and lowers the engine's piston-type valve through a bell crank mounted on a support pillar. The two-piece eccentric, which has 3/16" throw, is turned from mild steel and fitted with a sheet brass end plate to retain the eccentric rod on the eccentric's shoulder.

Turn the eccentric from 3/4"-dia. stock, first facing the end and then machining the 5/8"-dia. bearing shoulder. After marking the work's center, remove the work from the chuck and lay out the 1/4" shaft hole, the center of which is offset 3/32" from the shoulder's center. Centerpunch, drill and ream this 1/4"-dia. hole, being sure the drill is accurately perpendicular to the work. Next chuck the eccentric by its 5/8" diameter in the Unimat's 4-jaw



chuck, adjust the work until the 1/4" shaft hole runs true, and turn the eccentric's hub. (If you lack a 4-jaw chuck, you can solder the eccentric to a piece of scrap sheet brass and bolt the brass 3/32" off-center on the Unimat's faceplate to turn the hub.)

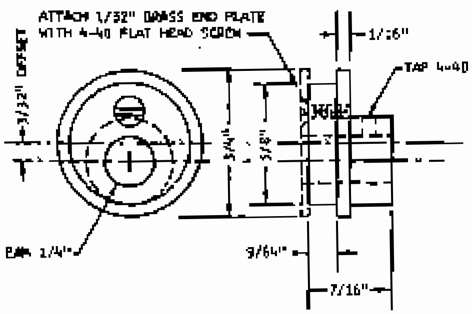
Use cutting oil when tapping the eccentric's two 4-40 screw holes. Cut the brass retaining plate the same diameter as the eccentric's flange.

Lay out the eccentric rod on 1/8"-thick aluminum and saw the part to outline with a hand fret saw or the Unimat's jigsawing attachment. After roughing out the 5/8"-dia. center hole, true this hole to a close running fit on the eccentric with fine abrasive paper wrapped around a dowel. Then file the rod's small end round and thread it with a 2-56 die. (Bend the offset in the rod's shank later when the engine is assembled.)

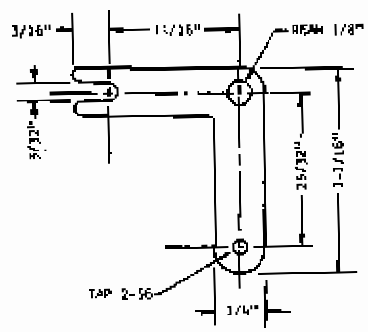
The brass eccentric rod end is turned and lapped 2-56 to screw on the eccentric rod. Mill flats on the rod end and drill and ream its 1/8"-dia. hole.

Lay out the bell crank on 1/8"-thick aluminum and saw the part to outline. Tap the hole in the lower end 2-56. The slotted end lifts the head of the valve.

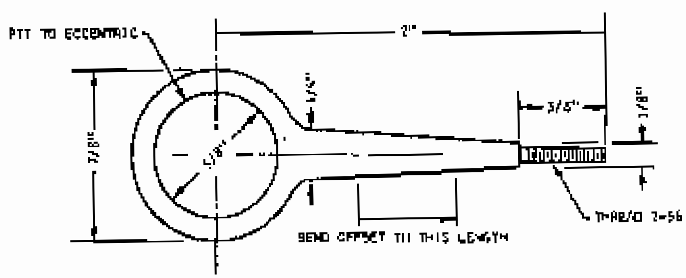
The bell crank mounts on a support pillar cut from 1/4"-thick aluminum. Chamfer the top corners of this support, and drill and tap two 6-32 holes in its bottom end for mounting screws. The bell crank pivots on a shouldered pin that screws into the pillar. You can thread this pin with a 2-56 die if you reverse the die after the thread has been started in order to cut it close to the shoulder.



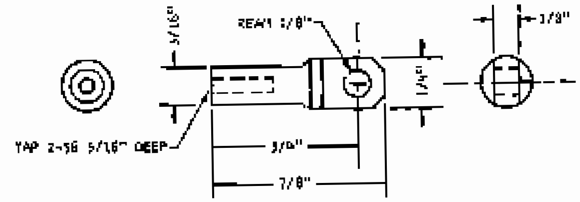
ECCENTRIC - STEEL



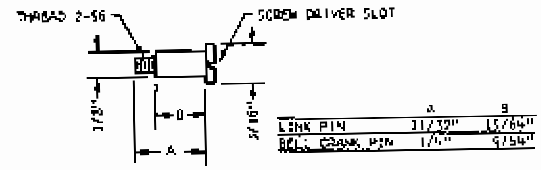
BELL CRANK - ALUMINUM

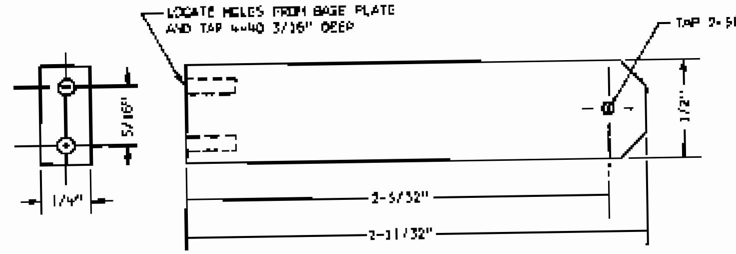


ECCENTRIC ROD - ALUMINUM

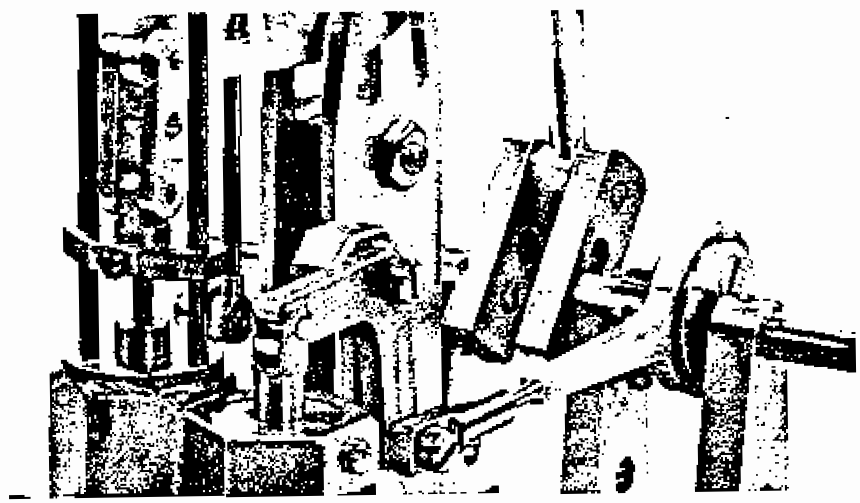


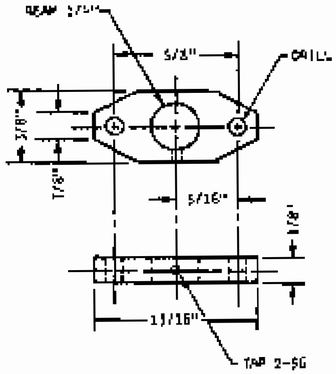
ECCENTRIC ROD END - BRASS



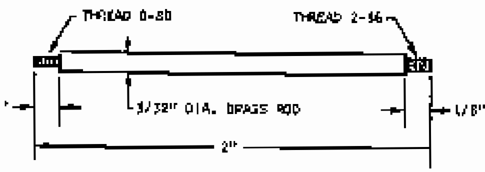


BELL CRANK PILLAR - ALUMINUM

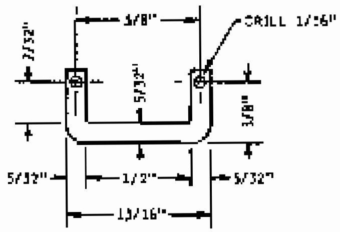




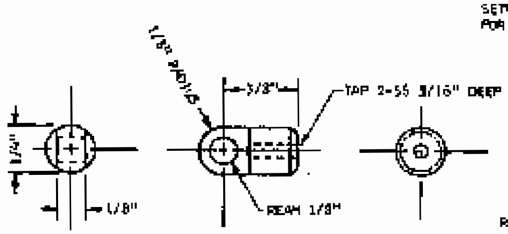
CROSSHEAD - BRASS



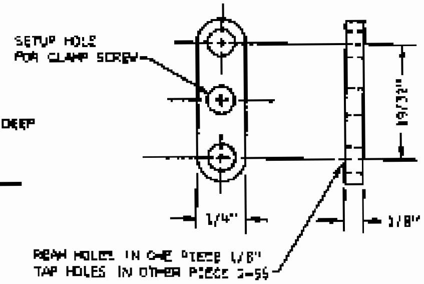
JIDE RODS - BRASS (2 REQUIRED)



GUIDE ROD BRACE - BRASS



PISTON ROD END - BRASS



LINKS - ALUMINUM (2 REQUIRED)

CROSSHEAD

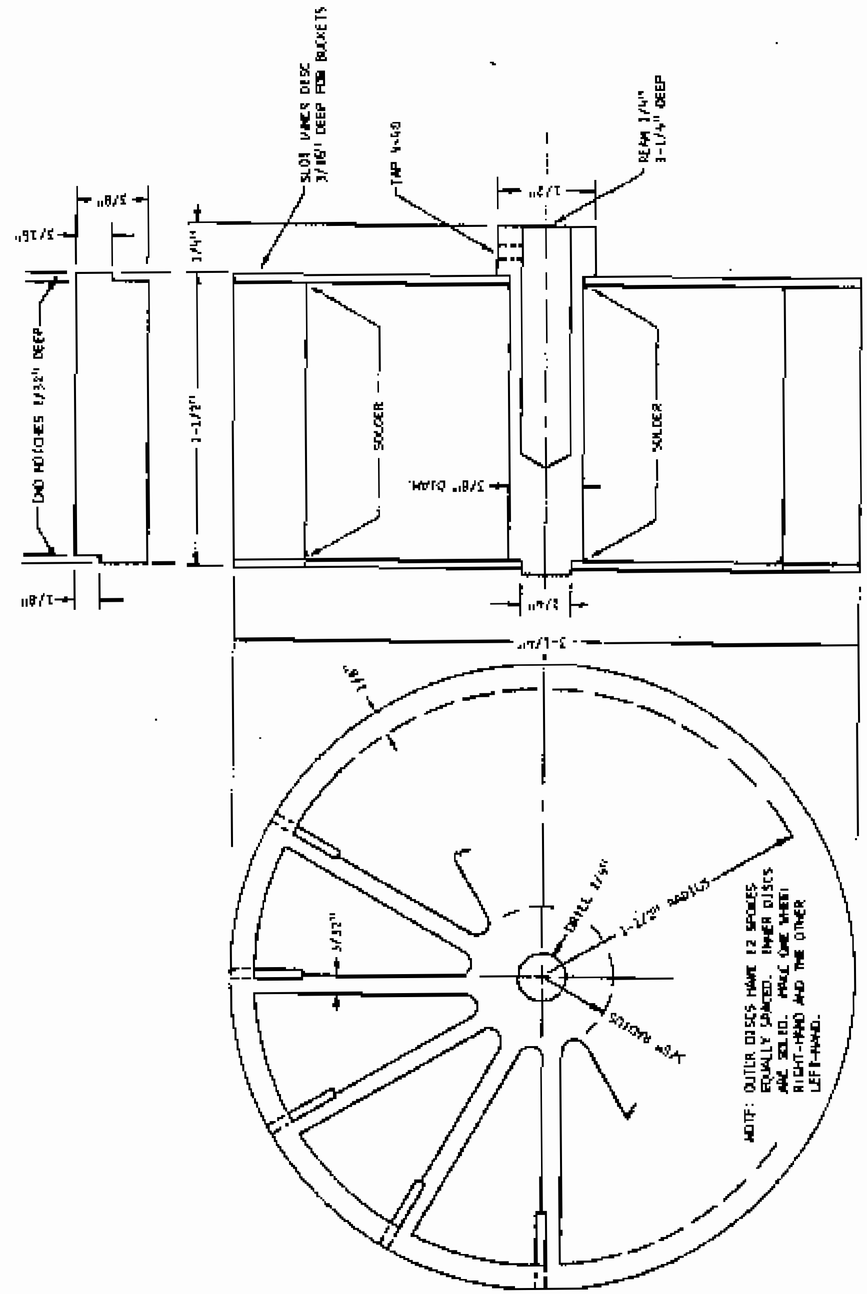
Sliding on guide rods, the 1/8"-thick brass crosshead supports the upper end of the piston rod and maintains piston travel axial with the cylinder bore. The guide rods must be accurately parallel to allow the crosshead to slide freely.

Use the Unimat to space the three holes in the crosshead. First centerdrill the centerhole. Then move the carriage exactly 7.9 turns of the feed screw either way from the center hole (remember to take up backlash) and drill the guide rod holes with a 3/32" drill. Passing the drill through the holes several times will enlarge them enough to give the crosshead a few thousandths clearance on the guide rods.

With the crosshead drilled, slip it on the cylinder head and use it as a drilling guide to locate the tapped 2-56 holes in the head. The top ends of the guide rods are spaced with a U-shaped brace cut from sheet brass. Also use the crosshead as a drilling guide to spot the 1/16"-dia. holes in this brace.

Turn the piston rod end from brass and tap it 2-56 to screw on the piston rod. Mill flats on the opposite end and drill and ream its 1/8"-dia. hole.

The two piston rod links, which are cut from 1/8"-thick aluminum, are identical in profile, but one has reamed 1/8"-dia. end holes while the other has 2-56 tapped end holes. Clamp the two pieces together with a screw through the center setup holes to drill the end holes, which will insure accurate spacing. Turn the two shouldered link pins from mild steel.



PADDLEWHEELS - ALL BRASS (2 REQUIRED)

PADDLEWHEELS

Both paddlewheels are all brass, each with a solid inner disc and a spoked outer disc soldered on a turned shouldered brass hub. Use dividers and a 30-60° triangle to scribe layouts for the 12-spoked discs on the sheet brass. Note that the wheel's spokes are offset to position the buckets on the wheel's centerlines. Make one wheel right-hand and the other wheel left-hand. Saw the openings between spokes with a hand fret saw or with the Unimat's jigsawing attachment.

After soldering the discs on the hub but before soldering in the buckets, mount each wheel on a 1/4"-dia. stub shaft chucked in the Unimat—using the headstock raising block—and true the outside diameters of the two discs. Also straighten the discs, bending them gently as needed to eliminate sidewise wobble.

When soldering in the buckets, clean and flux the area to be soldered and heat gently with a propane torch. Use only enough wire solder to fill the joint. With the buckets soldered in the wheels are completely rigid.

MANIFOLD AND LUBRICATOR

The manifold is a brass block screwed to the engine's steam chest to provide entrance sockets for the inlet and exhaust steam pipes. The block is drilled from the back and edge to form right-angle steam passages, with the edge holes counterbored. The copper-tube steam pipes are soft-soldered into these counterbores.

Transfer the 4-40 tapped holes in the steam chest for the block's mounting screws from the manifold, making sure that the manifold's steam passages align with the steam chest's ports.

The two-piece displacement lubricator is turned from brass, with the two halves held together with a long screw. The bottom of the lubricator is filled with light oil. As steam passes through the lubricator's head, some steam condenses to water. The water sinks to the bottom of the lubricator and gradually raises the oil level. This feeds a small quantity of oil into the steam line and the steam carries it to the engine, where it lubricates the valve and piston.

Bend gaskets from small-diameter wire solder to make the joint in the lubricator pressure-tight. The lubricator may be mounted wherever desired on the beam tower.

ASSEMBLING YOUR ENGINE

Cut the engine's 1/8"-thick aluminum baseplate to the dimensions shown in the assembly drawing and scribe centerlines on the plate. Mount the beam tower on the plate first, locating the mounting screw holes 1/2" on either side of the centerline.

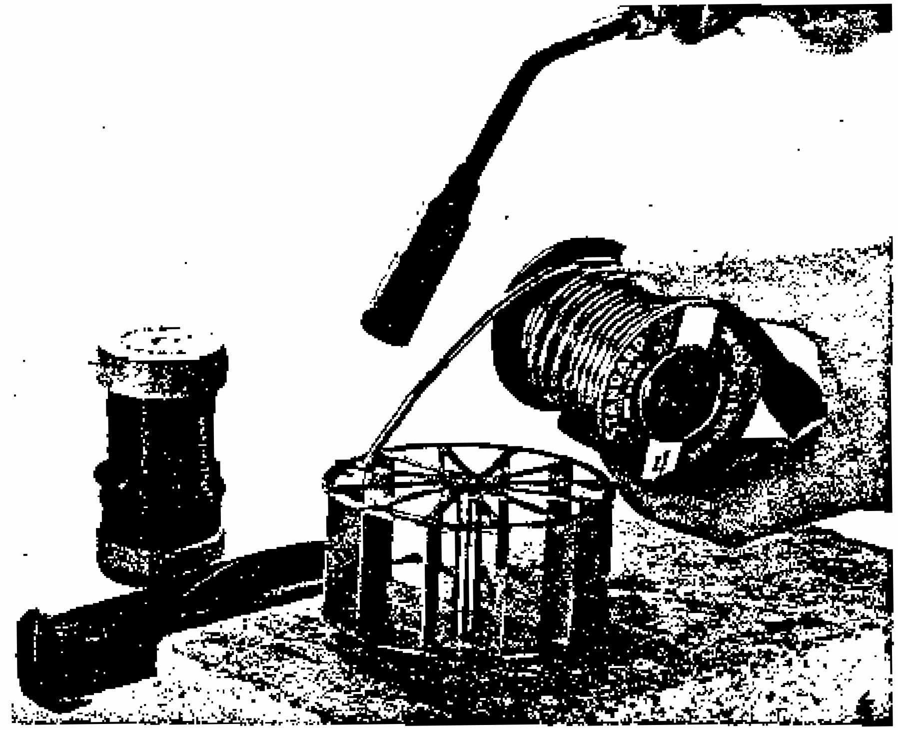
With the beam in place in the tower, position the cylinder assembly with the piston rod centered under the end of the beam, and drill and tap the baseplate for six 6-32 mounting screws. Cut a paper gasket and insert it under the cylinder assembly before screwing it permanently to the plate.

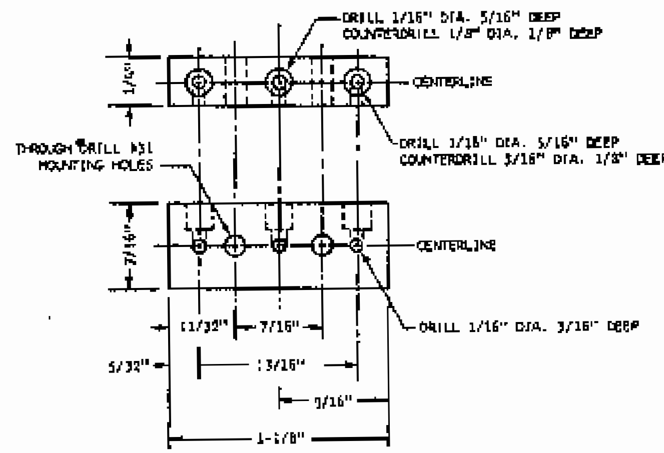
Next position the four crankshaft supports on the plate, inserting the crankshaft in the supports to align them. Set the outer supports flush with the edges of the baseplate and the inner supports to center the crankshaft's crank and connecting rod under the end of the beam. After locating and drilling 8 mounting holes in the baseplate, mark hole locations on the supports through the holes in the plate and drill and tap the supports 6-32.

Then slip the eccentric and eccentric rod on the crankshaft, mount the bell crank on its pillar, and position the pillar on the baseplate, bending the eccentric rod to an offset as necessary to align the rod end with the bell crank. Then drill the baseplate for the pillar's mounting screws.

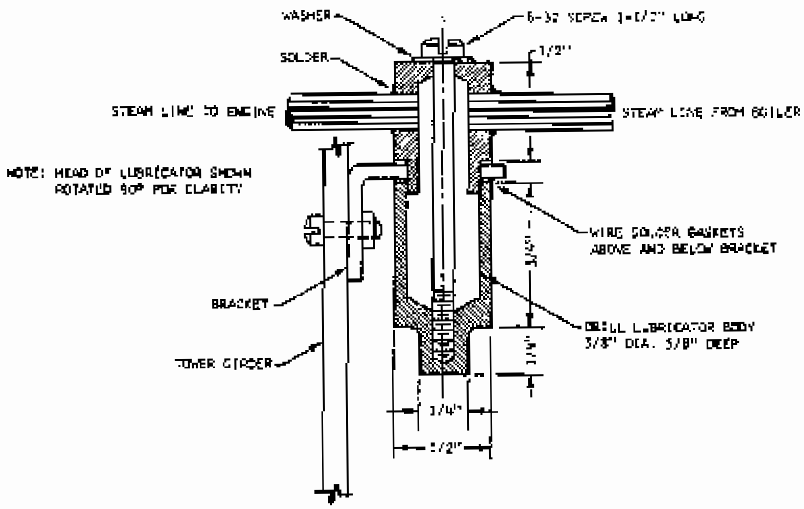
Finally, having lubricated all bearings, connect a source of air pressure to the manifold's steam inlet pipe and adjust the eccentric rod. (A tire pump can be used to supply air pressure, or a paint-spray-outfit compressor.) You can use auto windshield-wiper rubber tubing as temporary steam line.

Start with the eccentric's high point leading the crank by 5 to 10°. Then adjust valve travel by lengthening or shortening the eccentric rod (screwing its threaded





MANIFOLD - BRASS



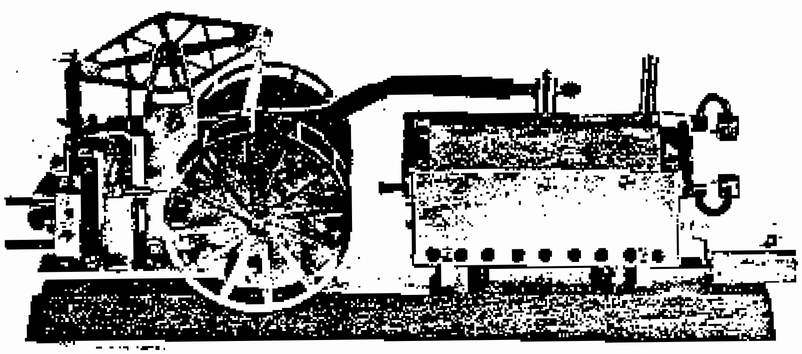
DISPLACEMENT LUBRICATOR – BRASS

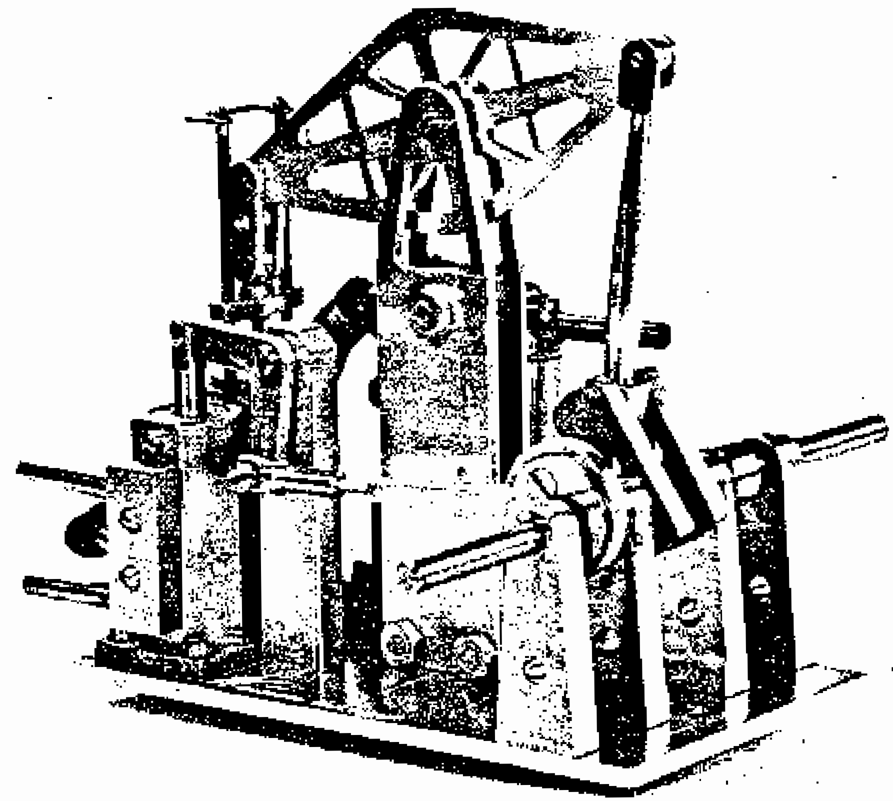
end in or out) until valve action is the same at both ends of the piston stroke. To judge this, remove the links between piston rod and beam, apply pressure to the line, and slowly turn the crank by hand. The piston should start to move just as the crank passes top and bottom dead center. Adjust the angle of the eccentric slightly as necessary.

The valve admits steam to the cylinder for nearly the full stroke, and at the low pressures used there is very little steam expansion. If carefully built, this engine will run on pressure as low as 5 psi— even on lung power if you blow into the steam pipe. Steam passages have been kept small to limit the engine's speed to about 180 rpms.

If you're equipped for silver brazing, you may want to make your own boiler, one similar to the boiler shown in the photo. If not, you may want to buy a boiler from a modelmaker's supply firm. A boiler suitable for this engine will cost around $25. Modelmaker's supply firms also have small valves, pressure gauges, and fittings for steam lines.

This model engine can be used to power a model steamboat from 20-24" long, or if your prefer, you can mount your engine on a hardwood block for display.





SAFETY CAUTION: While American Edelstaal kit projects are designed to be as safe as possible, purchasers must accept responsibility for any risk involved in building and using the models. Any metalmachining operation can entail some hazard, and we urge you to observe prudent safety precautions whenever using your Unimat. If you build your own steam boiler for the engine (boiler plans and materials are not included in this kit) be sure that the boiler's safety valve safely limits steam pressure.