DIRECTIONS

For Operating
Steam Traction

ENGINES

BUILT BY

Nichols & Shepard Company
Battle Creek, Michigan

DIRECTIONS

FOR STARTING, OPERATING AND
KEEPING IN ORDER

Nichols & Shepard

Steam Engines

FACTORY AND MAIN OFFICE AT
BATTLE CREEK, MICHIGAN

TO PURCHASERS AND OPERATORS *of*

NICHOLS & SHEPARD CO. STEAM TRACTION ENGINE

The Steam Tractor Engine has a wide range of usefulness and will last many years with proper care, or it can be damaged in a short time by neglect and mismanagement.

The material in the engine has been selected with special reference as to its greatest strength and durability, and was constructed by our most skilled mechanics who have spent the best years of their life in the business.

There is back of this engine our many years in the business, together with the experience of thousands of operators. Each engine is fired up several times and thoroughly tested under working load at its full rated power and every part properly adjusted. Therefore it is reasonable that the engine is built right, is complete and in the best running order when it left the factory.

There are many good engineers and some bad ones. If you have had little or no experience running a tractor, do not be too ready to accept the advice of those who claim to know all about it, but consider what they offer and act upon it only when there are good reasons for it. Let well enough alone, and guard against needless tinkering.

Make it your business to understand the principles of this engine and the directions given in this book.

If a bearing heats, pump or injector don't work, the engine pounds or any part wears rapidly or breaks, there certainly is a cause for it, and it is up to you to find the cause and remedy it.

Your reputation as an engineer not only depends on having a good engine, but on your own management and adjustment.

Under the heading of the different parts you will find directions for adjusting and keeping them in order.

ASSEMBLING

Take the parts out of the packing box, wipe them off clean and place in their respective position. Put some red or white lead on the threads of parts that screw in the boiler. This often prevents leakage of steam.

See that all connections to pump and injector are screwed up air-tight or they will not force water into the boiler.

Wipe off the preparation placed on the bright work to prevent rust and carefully remove all dirt and cinders that may have gathered in the oil hole bearings and on the slides.

Lace the governor belt so it will not be too tight and just tight enough so it will not slip and pound the lace down smooth.

See that the lift spring to governor valve is set tight enough to lift the valve up against the steam pressure.

The engine should be set level or a little high in front, as it will not steam so well with the front end of flues lower than the back end.

OIL AND LUBRICATION

The life of the wearing parts of an engine and the delivery of its power depend on its being thoroughly oiled with a good grade of oil.

Cylinder oil must stand a test of 600 degrees of heat without burning to lubricate in steam the cylinder and valves.

Some test their cylinder oil by pouring a little on the outside of smoke box when engine is running and the smoke box is hot. If the oil smokes or boils it is often a poor lubricant in steam. If the cylinder valves and other bearings are not oiled or a poor grade of oil is used, it reduces the power of engine and operators may condemn the engine when the trouble is all caused by want of oil or a poor grade of oil.

Use the best grade of cylinder oil not only in the cylinder but on the reverse, pins and shaft bearings. Use a good grade of hard oil on connecting rod boxes and in the grease cups.

Use machine oil in governor, glass and brass oil cups, and adjust the feed to the glass oilers.

If the engine has an intermediate pin cast hollow it should be filled

with wool waste, as the heat from boiler burns cotton waste and clogs the oil hole.

The heat from boiler dries up the oil and the bearings should be oiled every move on the road or more often if a long run, and every morning and noon when threshing, and see that the oil gets to the bearing.

The center differential wheel has a pipe with thumb-screw to oil its bearing on counter-shaft.

The outside differential wheel has an oil hole on its side and the pinion in front of it on the end.

The inside differential pinions are oiled through shaft by grease cups.

The inside rim of friction wheel where the wood shoes rub must be oiled to prevent the shoes from catching too quick when starting the traction gear and the friction ring oiled when running on the road.

When engine is not running on the road the main shaft pinion is stationary and the main shaft revolves on it. This should be well oiled.

The truck wheel can be oiled with liquid oil through the tubes, or hard oil can be used in the long steam hard oil cups packed in box.

The cogs to gearing should be oiled occasionally with liquid oil.

Oil Pump Manzel.—Fill with cylinder oil and start the pump by hand or by running the engine. It takes some time for feed pipe to fill with oil, but after once full the feed will be instantaneous as the check valve on the end feed pipe next to steam prevents the steam from backing into feed pipe.

To regulate feed raise or lower the driving rod on lever to pump. The feed can also be stopped or made to feed more or less by turning with a screw-driver the screw on top of pump. By turning to left increases feed; by turning to right decreases the amount of oil fed in the steam.

Oil Pump.—Fill oil pump nearly full of cylinder oil and start pump by hand or by running the engine. It will take a little time for the feed pipe to fill with oil, but after it is once full the feed will be

instantaneous.

To regulate feed raise or lower drive rod on lever to pump. The feed can also be stopped entirely or made to feed more or less oil by turning the eccentric on shaft to regulate more or less throw to plunger.

Sight feed, **open upper and lower valve** to glass and **close valve in body**. The glass will not fill with oil unless the ball valve or packing leaks. If glass breaks or leaks **close upper** and **lower valve to glass** and **open valve in body** and the pumps will continue to feed oil into the steam through by-pass.

If you blow out the glass or it is very hot, it takes some time for the glass to fill with water unless you hold a rag wet with cold water on the glass to condense the steam.

In freezing weather open drain valve at night and let the water out of glass or use alcohol or glycerine in the glass or feed through by-pass.

If the pump does not feed the oil:—

See if the oil is not feeding through the by-pass in sight feed.

See that the eccentric is not loose and is set tight on the shaft to give the proper travel to plunger.

See that the plunger stuffing box is properly packed and the nut screwed up tight enough to prevent oil passing back in reservoir, and not so tight but what the lever works freely.

If the check balls are dry, it sometimes will not start and it is necessary to prime it by unscrewing the coupling to feed pipe and prime with a few drops of oil down on the middle ball check under the coupling. If the balls don't seat, take a rod and drive the ball lightly down on the seat.

There is an upper and lower ball check in pump and one in the sight feed and in the check valve that screws to sight feed.

If any of these little balls are left out or the pump or pipe is clogged with dirt the oil will not feed.

See that a little candle wicking is around the end of feed pipe and

the coupling nut is screwed down tight on top of it to prevent leakage of oil.

If the pump feeds the oil and it does not oil the cylinder and valve, the water is priming or foaming, which will wash the oil off the bearings or the oil is no good for steam cylinder.

RUNNING ENGINE

1.—Fill with water. Open upper and lower valve to glass water gauge, the valve between check valve and boiler, valve between dome and throttle and the gauge or try cocks in back end boiler.

Close throttle. Blow off valve and valve to blower to smoke stack.

Remove plug in top of boiler and fill with water with a bucket through funnel, or what is better, with tank pump and hose until two inches water show in glass, then close gauge or try cocks.

2.—Start Fire.—Remove screen from smoke stack. Let the fire burn slowly at first to heat up the boiler gradually.

When steam shows a pressure of 15 or 20 pounds open the blower valve to smoke stack a little to stimulate the fire.

3.—Start Engine. When you have sufficient steam pressure close blower. If a single cylinder engine, turn the fly wheel by hand until crank is off the dead center. Open cylinder, steam chest and heater cocks and start the engine slowly by opening the throttle a little ways at a time. When dry steam issues from cylinder cocks, close the cylinder and steam chest cocks and open throttle wide open.

Let the engine run awhile before putting it at work.

Start the injector and pump and see that they work right. See that the oil pump is working.

Thoroughly oil all wearing parts and see that all parts are in proper running order before you put the engine at work.

4.—Stop Engine. Close throttle, throw reverse lever in center notch and open cylinder cocks.

5.—Run with throttle wide open and adjust the speed by the governor. It is economy to run with the steam pressure up to nearly the blowing off pressure set by the safety pop valve.

6.—Firing. Do not fill the furnace full of coal and then let it burn down before replenishing; but keep the supply regular, putting in more frequently, and not in large quantities. Keep the grates evenly covered, and allow no holes in the fire-bed; do not open the furnace door except when attending to the fire, and even then do not keep it open longer than necessary. Always keep the grates next to the flue-sheet well covered with fire so no cold air can come up through the grates onto the flues. If the coal clinkers or fills the openings in grates, it must be cleaned out so air can get to the fire, or it can't burn. During a stop if steam forms too rapidly and the pressure increases too fast, **never open the furnace door** to cool down, but the damper may be closed and the door of the smoke-chamber opened.

7.—Water. Watch the water gauge and always keep the water in the boiler high enough to show in the glass water-gauge and over lower try cock, or you may ruin the boiler. Two inches of water is sufficient when engine is level. When you can see water in bottom of glass, or there is water above lower try cock, there is two inches above crown sheet. Don't carry too much water or it will prime and kill the power of engine. Whatever you do, don't fail to keep the water over the crown sheet. Before leaving the engine for any considerable length of time, with steam up, put an extra supply of water in the boiler. If the water is so low you can't tell where it is, kill the fire immediately by pulling the fire or cover with ashes or dirt.

8.—Feed Water. When using the injector, shut the globe-valve in suction pipe to the pump and open cock under pump cylinder.

When using pump, close globe-valve in suction-pipe to injector, also pet-cock under pump cylinder. The one of these globe-valves not in use must be closed when feeding the boiler. Don't try to use both pump and injector at the same time. The angle-valve in wetting down pipe, when starting the pump or injector, should be left **open** until the pump or injector gets the water. This should be done to relieve the back pressure on pump-valve or injector of hot air and water in the pipe to boiler.

Gauge the pump so that it will supply just as much water as is used by the engine by the valve to wetting-down hose, allowing the surplus to return to tank. By so doing the water level may be kept at the same

height, without constantly rising and falling, making the engine fire more easily.

9.—Cold Weather. Do not leave any water in the pump, pipes, throttle, cylinder, steam-chest or heater overnight when the weather is cold. Always open all the drain-cocks when the steam is allowed to go down, and the engine to cool off, or the parts may freeze and burst.

10.—Keep Clean. Keep all parts of the engine wiped clean. Nothing reflects more on an engineer than to see dirty and leaky handholds, connections, gauge-cocks, rusty machinery, oil-smeared and gum-covered engine and boiler. A plentiful supply of old rags and a little labor will prevent this.

11.—Reverse. When the engine is to be reversed, the steam should be shut off entirely and the reverse lever moved on the quadrant to the opposite notch.

Always start the engine slowly. Sudden jerks on a heavy fly-wheel will not do the engine any good, and after awhile the fly-wheel may become loose and create a "knocking," which it will be difficult to locate.

12.—Clean Flues. The tubes, or flues, should be cleaned twice a day, and the grates, ash-box and smoke-box should be free from ashes and clinkers.

13.—Dead Center. When you close the throttle to stop engine, always throw reverse lever in center notch and it will not stop on dead center. When a single engine is on dead center, always close throttle before turning fly-wheel off center or it may start too quickly and injure some one.

14.—Up-hill. In running up-hill, don't carry any more water in the boiler than is necessary and keep up the steam pressure. When you get at top of hill, immediately use the pump or injector to raise the water in boiler. Always keep enough water in boiler to cover crown sheet. If front end is low you must carry higher water to cover crown sheet.

15.—Down Hill. In descending a hill, start injector or pump and keep the water over crown sheet. If engine runs too fast, shut off the

steam entirely and engine will descend slowly and easily by its own weight. If it should run too fast, reverse the engine and the pressure of air in cylinder will generally hold it back without any steam pressure. Don't stop going down hill unless you stop on a level place.

16.—Bad Roads. Sand and muddy roads and soft ground that the wheels cut through, as well as ice roads, will sometimes render all traction engines helpless.

When the wheels slip, don't make more than one or two attempts to move or the wheels will claw out the dirt and leave the engine in a hole. Stop before you dig out the hole too deep and throw something under the wheels for a footing, or use the mud and ice claws. Run slowly and **don't jump the engine**, or you may break something. In running on snow and ice, use all the ice claws to prevent slipping, and run slowly.

That it requires some experience and skill to handle the throttle, steam, water and fire in running over the hills and bad roads, is proven by some engineers running our traction engine most anywhere, while others would stall on the same road.

17.—Friction Clutch. Keep the blocks to friction-clutch set out so they will just clear the friction wheel when the friction is thrown out as far as the friction-lever will permit. The friction-clutch will then always catch. Never put sand, or anything but oil on the face of friction-wheel where friction-clutch blocks rub. In making long moves with the engine, and in going up steep hills and ploughing, you can lock the hub of friction-clutch to friction-wheel with a pin, and tighten the set-screw down firmly on the pin to hold it in place and prevent it from working out.

18.—Wash Out. Keep the inside of the boiler clean and free from mud, scale and sediment. To do this, clean out the boiler once a week by allowing it to cool down entirely, and then open the blow-off cock and let all the water run out. Then, by the use of scrapers, scrape out all the mud, slush, etc., through the hand-holes; especially from the top of crown sheet, which must be kept **clean, and be sure the sediment is all out of the sides of the boiler**. The brass plug or hand-hole plate in the flue-sheet in the smoke-chamber can be taken out, and all mud around flues and in the bottom of the round part of the boiler

washed out with force pump. In replacing the hand-hole plates, use packing; be careful to make them tight again. In replacing brass plugs, put a little graphite and oil on them, or they may stick and cut the threads the next time you take them out. Never use any steam pressure in cleaning a boiler. **"Blowing-off" a boiler is a fruitful source of leaky flues and other evils.**

A bulged crown-sheet or leaky flues are sure evidence of gross and inexcusable carelessness on the part of the engineer.

19.—Before leaving the engine at meal time or at any time when you will be absent more than a minute or so, always close the damper and open the door of the smoke-chamber. Also, be sure that there is plenty of water in the boiler.

20—Stack Yard. When setting at a stack-yard, do not set so the wind will blow the smoke into the dry straw or on anything that is liable to take fire, and after starting a fire in boiler, do not leave the engine. Let those whose business it is, attend to getting the separator ready for work. "Stick to your post."

21.—Not in Use. When the season's work is over, the boiler should be cleaned inside and out; the pumps, pipes, and everything containing water should be carefully drained; the fire-box, flues, grate-bars, smoke-box and smoke-stack should be thoroughly cleaned. Take out all packing from the piston-rod, valve-rod, governor, throttle-valve, and stuffing-boxes. Thoroughly clean and oil all bright work. Give the entire outside of the boiler a coating of boiler black. When the engine is laid aside for the season, the cylinder should be thoroughly oiled. To do this, take off the rear cylinder-head and oil the interior of the cylinder thoroughly with some good mineral oil, and then move the piston back and forth until certain that all parts are well oiled. Also take off the steam-chest cover, and oil the valve-seat. No tallow or **animal** oil should be used.

LOSS OF POWER
Or Too Much Fuel or Water Used

22. Too much water in boiler. One or two inches in glass is sufficient when engine is level.

23. Too low steam pressure which carries too much water with the

steam.

Sometimes the hand on the steam-gauge gets loose and indicates, say 150 lbs. of steam, when there is only 40 or 50 lbs. pressure in the boiler. The boiler should carry steam to nearly pop-off pressure to get the full power of the engine, and save water and fuel.

24. Poor cylinder oil or parts not properly lubricated.

25. Boiler priming or foaming.

26. Exhaust nozzle being clogged with oil and soot, which causes too much back pressure on the cylinder, or the nozzle not pointing straight up the center of smoke-stack, too small or too large exhaust nozzle. (See heading under exhaust nozzle for size generally used.)

27. Friction caused by tight-box, using poor oil in cylinder, boxes and other parts, or by these parts not being properly adjusted and oiled, or by packing set too tight in stuffing-boxes. Poor cylinder oil and journals running dry, is the most common cause of engine not developing its power.

28. Eccentric rods slipping in eccentric-straps, or valve-rod slipping in guide or side-valve, which places the valve out of correct position.

29. Steam blowing by the piston rings or slide-valve.

30. Governor valve-stem too long, shutting off the steam, or loose balancing-spring.

31. Not running the engine up to its regular speed.

32. Throttle not being wide open.

33. Poor firing or poor fuel, and not keeping grates and flues clean, and the ashes out from under the grates. Mud or sediment inside boiler, or flues limed over. Screen in smoke-stack clogging draft, or front end of boiler lower than rear end.

34. The boiler will not steam without sufficient draft by running the engine or by using the blower, as there is little draft from a short smoke-stack.

35. Water-pipe in heater bursted, which will kill exhaust, give insufficient draft and waste water.

36. If the engine develops its power under the belt, but does not haul its load on the road, it is caused by the gearing meshing too deep or by friction in the counter-shaft boxes, axle, intermediate pin, or in some other bearing. The proper adjustment of these parts and thorough oiling will correct the trouble.

37. For full directions for adjusting above parts see the instructions under the different headings in this book.

Ash-Pit.—A cavity underneath the grate-bars for receiving the ashes, and through which the air passes to furnace.

Remove the ashes from under grates. The fire cannot burn unless the air can get through the grates to the fire.

Do not allow ashes to get wet and accumulate, or they will rust and eat out the boiler plate.

Arrester.—The device for stopping the sparks at the top of the smoke-stack. The wire screen in spark-arrester should be taken out or opened at top if a straw burner when firing up in the morning. When burning coal, all screens are liable to clog and are not used in coal, but should be used when burning wood and straw. A long smoke-box will catch most all the heavy sparks.

Bed-Plate.—The foundation to which the parts of the engine are fastened, and which is bolted or riveted to the boiler. (See Heater.)

Blow-off Valve.—A valve attached near the lower part of the fire-box, through which the water is drawn off from the boiler.

Blower.—A small pipe with an angle-valve attached, leading from the boiler into the smoke-stack. To hasten the raising of steam, start the blower when you have 15 or 20 pounds of steam, by opening the valve in this pipe, thus letting steam from the boiler into the stack until you have sufficient draft.

Stop the blower when you have a sufficient head of steam to start the engine, as the exhaust steam will give all the draft required when running.

Boxes.—Blocks of brass or babbitt-metal, used as bearings for the wearing surfaces, placed on each side of the pin, or shaft, they embrace.

The heat from boiler warms up the boxes. Don't mistake this for a hot box.

In adjusting the boxes, take up just a little at a time until the pounding has stopped. Don't attempt to take it all out at once, or it may cause heating or cutting.

The main boxes are adjusted by taking out or putting in packing or liners so that the box will run without heating or pounding with nuts screwed down tight. When the packing has all been taken out and the box is too loose on shaft, the box should be re-babbitted with the best of babbitt by some one who understands setting the shaft in perfect alignment (see main shaft for babbitting these boxes.)

The connecting-rod boxes on wrist-pin and cross-head are taken up by screwing out the lower bolt, then tighten the upper bolt a little, which draws the wedge up, drawing the box together. Tighten the lower bolt again before starting the engine. If brass boxes come together, they should be filed out where the two halves touch each other, so there will be about 1-16 inch opening between them when set up around the pin. Place a shim in front of box the thickness of the wear in box to keep the same clearance between each end of cylinder and piston head so the piston will not strike cylinder head.

The labor endways, especially if the box once gets hot, wears the box more on the front and back where the labor is and binds on the top and bottom, and will continue to heat until you take out the box and **file back one-half inch each way on the inside of both halves from where it is cut into**, so there is no bearing on the top and bottom, and all the bearing is on the front and back of box. Be sure there is no dirt or grit in oil or bearing. A dirty finger or stick used to fill hard oil cups or an open can of hard oil will collect dirt and cause box to heat.

The counter-shaft boxes must be kept properly adjusted. Take a lever and pry up and down on the counter-shaft pinions each side of the engine and if the shaft is loose in box, set up the gibs by set-screw to take up the lost motion. If cut or worn so you can't take out the play, the boxes and gib must be re-babbitted with the best babbitt. In doing this place strips of wood between the box and gib. Remove the sticks, and gib can be raised after it is babbitted. Before pouring the babbitt be careful to set the shaft so the gearing is in proper mesh. Place clay

around the end of box with an opening in clay to pour the babbitt in end of box. A loose counter-shaft in box is not only liable to make leaky bolts, but throws the gear out of line and is liable to break it or bend the shaft.

Brass Plugs.—Use oil and graphite when replacing these plugs; they will then unscrew easily the next time you wish to take them out.

Bolts.—Go over engine often and tighten all bolts that may jar loose or that may become loosened by the expansion and contraction from heat and cold. Leaky bolts are caused by oil in the boiler, loose nuts, too much play in counter-shaft bearing, or axle-sleeve, loose brackets, side play in key to main shaft or counter shaft pinions or clutch to counter-shaft pinion. The lost motion jerks on the bracket bolts and is liable to loosen one or more of them. Alkali water, overworking the engine and jerking the gearing on bad roads. If a boiler bolt becomes leaky, screw it further into the boiler, and if this does not stop the leak in a reasonable length of time, put in a larger bolt. Most boiler bolts are 3/4 in. in diameter and 12 threads to the inch, and, in putting in a new bolt, it should be 25-32 in. or larger and the hole tapped out with a tap 12 threads to the inch, the same size as the new bolt. In tapping out the hole be careful not to tap it out too large. Try the bolt and see that it screws in steam tight. If it rubs on bracket, cut out the bracket hole or the bracket will crowd the bolt over to one side. The bolt must screw in at a right angle with the outside face of the casting or when you tighten the nut it will pull the bolt over to one side of hole and continue to leak. If bolt goes in too loose, it will continue to leak, or, if screwed in too tight, it is liable to strip the thread. Our boiler plate is extra thick and the best taper stud bolts are used. The bolts do not leak under the most severe test when engine leaves factory and we are not responsible for leaky bolts.

Boiler Casting.—If it becomes necessary to replace a casting that bolts to boiler, it must be chipped or shimmed to fit the surface of the plate and to throw axle, counter-shaft and other bearings parallel with each other. It is also necessary to cut out for stay bolt heads so casting will bear on the plate and to often cut out or drill new holes to fit the bolts in boiler.

No two boilers are exactly alike and stay bolts vary. The cylinder

part of boiler is not exactly round and the flat sides may not be in line.

Our castings and the bolt holes in them are as near right as can be for all boilers, but a casting that will fit one boiler may not fit another and they must be carefully fitted to their true position with bearings parallel or gearing will bind and cut.

Boiler.—The vessel in which steam is generated.

If the water should ever get so low in the boiler that you cannot tell where it is, **never try to pump in water**, but immediately pull out the fire or cover it with ashes or dirt, and let the engine run until the steam is down, and do not attempt to fill the boiler until it has cooled off.

Our boilers are made of the best steel, by the best boiler makers, and are tested twice with cold water pressure and twice with steam pressure, and they do not leak when they leave the factory. But from the expansion when fired up and contraction when cooling off and other causes, they are liable to show leakage. This leakage is caused by sweating, too sudden expansion or contraction of the iron by heat or cold, alkali water, hard water, stagnant water from ponds, by over-working engine or extra strain on the gearing or oil in the boiler. A counter-shaft with too much play in box, a loose axle in bracket, a loose sleeve on axle, or key that is loose sideways puts extra strain on bolts when gearing is started and will pound on bolts and cause them to leak. There are a great many rivets, bolts, seams and flues that can leak. The leakage may stop as soon as the boiler gets fairly to work.

If the leak does not take up and stop in a reasonable length of time, it should be stopped. If leak is not stopped, in time the rust will eat away the plate so thin as to require a patch or large plug.

If the leak is in a seam, rivet or staybolt it can be easily calked and closed by upsetting the metal with a square-nose cold-chisel over and around the leaks; strike the calking-tool lightly with hammer, and if you hold the tool in the right place, a few light taps will close the leak. If boiler bolt leaks, see directions under "Bolts."

Stop leaky hand-hole plates with new gaskets and tap with a hammer the boiler plate over the gasket and tighten nut to seat it.

Rust eats the iron. Keep the boiler well blacked. If you have no boiler black, tallow rubbed on when smoke-stack and smoke-box is hot will prevent rust.

Clean out the boiler once a week; or more often if muddy or "hard" water is used. To do this, **draw out all your fire** and let the boiler cool entirely down; then open the blow-off valve on the back of the fire-box, leaving it go until the boiler is empty. Hand-holes are provided in suitable places to admit scrapers for any further cleaning. A boiler should be cleaned out frequently, and **always** when cold. This should be thoroughly done, and the more frequently and thoroughly it is done, the better. Never use oil to soften the scale, as it will make leaky stay bolts and is liable to bulge the fire-box sheet. Care must be taken to scrape and wash out all the mud under and around the flues, as well as on the top and sides of the fire-box, or it will burn hard on the flues and plates and be difficult to remove, and if allowed to collect in the boiler will, in time, ruin the flues and fire-box. After the mud is loose, a force pump is a desirable help to wash the mud out. **Never use any steam pressure in cleaning a boiler. "Blowing off a boiler" is a fruitful source of leaky flues and other evils**. Never fill the boiler with cold water while the iron is still hot, as it causes contraction of the seams and stays, and often causes leakage.

Old boilers are tested by tapping the plate with a hammer to find by sound the thin places and by filling the boiler full of water and then pumped up with a small force pump until the desired pressure is obtained. All our boilers are tested with water pressure at the rate of 150 per cent of the working steam pressure; that is, 225 lbs. water pressure for a boiler that carries 150 lbs. steam pressure. The steam gauge will indicate the water pressure.

Check-Valve.—A valve placed in the feed-water pipe between the heater and the boiler to prevent "back-flowing" of the water. If it leaks, it should be replaced by a new check-valve, or the valve and seat ground down so it will not leak. To do this, remove the cap and place powdered emery and oil on the seat. Then fit a stick on top of valve, or plunger, and turn the valve around on the seat, adding more emery and oil until the emery grinds them to a perfect fit. If limed up, it must be cleaned off. In putting in a new check-valve be careful to

have the right end towards the boiler, with the boiler pressure on top of valve.

Connecting-Rod.—The rod used to connect the cross-head to the crank.

Crank.—On the main shaft, to which the connecting rod is attached.

Cross-Head.—The block to which the piston-rod and connecting-rod are fastened, and which moves between the guides. By removing the pin in box, the cross-head can be turned around in the guide, and by loosening the bolts in shoes, paper packing can be inserted between shoe and cross-head to take up any lost motion between shoes and guide. In doing this, be careful to put the right amount of packing under each shoe, so that the piston-rod will run in center of cylinder and stuffing-box. If there is any ice in pump it is liable to break cross-head or pump-arm.

Crown-sheet.—Top sheet of fire-box or furnace.

The sediment must be frequently cleaned from the top of crown-sheet. This is of **utmost importance**, because if the sediment is left for any length of time, it speedily forms a hard crust, called scale, which prevents the water from touching the metal, which, in time, will buckle down by the intense heat. When the scale is formed on top of the crown-sheet, it sometimes covers the end of the "fusible-plug," even if the soft metal is melted out. The scale prevents the steam from going through the plug, and, of course, no alarm can be given, making the fusible plug of no value if covered with scale.

A bulged, burned or cracked crown-sheet is sure evidence of low water, scale or oil in the boiler and inexcusable carelessness on the part of the engineer.

Cylinder.—The circular casing through which the piston moves.

When an engine is laid aside for the season, the cylinder should be thoroughly oiled. To do this, take off the rear cylinder-head and oil the interior of the cylinder thoroughly, and then move the piston back and forth until you are certain that all parts are well oiled. Also take off steam-chest cover and oil the valve seat. No **animal** oil or tallow

should be used. Use the best mineral cylinder oil.

Cylinder-Heads.—Plates fastened over the ends of the cylinder to confine the steam.

Cut-off Point.—That part of the stroke at which the steam is prevented, by the valve, from entering the cylinder. Our engines cut-off at about 3/4 stroke when in last notch, when hooked up in second notch about 5/8 stroke.

Clearance is the contents of the opening in port under slide valve and the space between piston head and cylinder head when piston is at the end of stroke. The clearance should be the same at each end of cylinder and is adjusted with a shim in front of wrist-pin or cross head box or by screwing the piston in or out of cross-head.

To set the piston, remove cylinder head and turn the engine on back center. Measure thickness of offset on inside of cylinder head and add 1/8″, gives the distance the piston head should be set from end of cylinder, and you will have 1/8″ clearance at each end of cylinder.

Dome.—A chamber placed on top of the boiler as a reservoir for steam.

Drain-Cocks.—Small cocks, or plugs, used to drain off the water from the cylinder, steam-chest, heater, pump, cylinder, lubricator, throttle, check-valve, heater and all pipes. In cold weather, when engine is not running, great care should be to let out the water from these parts and see that they do not freeze while draining. Otherwise, one or all of them may freeze and burst.

Damper.—The door of the ash-pit, by which the supply of air to the furnace is governed. Open the damper or draft-door to increase steam, and close it to reduce steam when running, or to hold steam stationary when not running engine. Use back damper under platform when firing with wood or coal and front damper when firing with straw, or both dampers if wind interferes with draft.

If steam is forming too rapidly, regulate the fire by closing the damper. Further draft may be stopped by opening the door of the smoke-chamber.

Exhaust-Pipe.—The pipe leading from the heater or steam chest into the smoke-stack, and through which the steam which has been used by the engine is discharged.

Exhaust Nozzle must be in center of smoke-stack, pointing straight up. If it shoots the steam against one side of stack the boiler will not steam. It should be looked after and all lime or sediment kept cleaned out. If the nozzle is allowed to partly close up, it will cause back-pressure in cylinder and reduce the power of engine. The present style of engine are sent out with the following opening in exhaust nozzles for coal: 1 5/8-inch, 10-H. S. and 16-H. D.; 1 3/4-inch, 13-H. S.; 1 7/8-inch, 16-H. S., 20-H. D., 2-inch, 20-25-30-H. S. and 25-30-35-H. Double. For burning straw an opening 1/4″ larger is often used by removing bushing from nozzle. Another brass bushing is sent with each engine packing-box which will reduce the opening in nozzle 1/2 inch below above size for coal, to be used in exhaust nozzle when a stronger draft is required in burning wood or poor fuel. A large nozzle should be used if you can keep up steam, for the smaller the nozzle the more back-pressure and the less power you will have.

Eccentric.—The cam or round casting on the main-shaft for eccentric strap to which the eccentric-rod is attached, by means of which the slide-valve is operated.

Eccentric-Rod.—If the eccentric rod is bent or replaced with a new one, extra care must be taken to bend the rod just right or link on link engines will jump and pound.

Tighten eccentric strap so it will have no side play, insert the round end of rod in eccentric strap and the clips on opposite end of rod must slide up and down on link with even bearing on both sides on both ends of link. When one end of rod is bent the other end of rod must also be bent to make the off-set on the two ends parallel with each other.

The rod can be bent cold and it is necessary to keep bending and trying until you get both ends of off-set parallel and right bend in center of rod for clips to slide up and down with equal bearing on both sides of link at each end.

Fire-Box.—The inclosed space in the boiler which contains the fire.

Keep the ashes cleaned out. Calk any leaks that may occur, and don't let the water from leaky hand-holes on outside run down and wet the ashes in the inside corners of fire-box under the grate, as the wet ashes will eat out the boiler plate.

Firing.—In the first place make sure that there is plenty of water in the boiler—and there should be no guesswork about this—otherwise you may bulge the plate or do other damages. Start a light fire, and heat up slowly; as a boiler should always heat up and cool off slowly. Fuel should be added to the fire in small quantities when burning coal; keep the grates evenly covered to prevent cold air passing through the fire into flues. The grates should never be allowed to clog so as to prevent draft. Never scrape the fire towards the door, and leave the grates open next to the flues, or the cold air will strike the flues and cause them to leak. Use back damper under platform when firing with wood or coal. Use front damper when firing with straw. Use both dampers if wind interferes with draft.

In managing the fire, care should be taken to have **the furnace door open as little as possible**, and if the steam is forming too rapidly, regulate the fire by closing the ash-pit damper. Further draft may be stopped by opening the door of smoke-chamber.

To fire with wood requires some experience. Use small bushing in exhaust nozzle to make a stronger draft than is necessary for coal. Keep the fire-box full to crown-sheet with a deep bed of live coals, and stir it up enough to keep the fire bright. Wood that has been dried under the shade of trees or that burns black with no blaze will not generate enough heat to make steam. You must use fuel that makes flame to make steam in any kind of boiler.

In sawing lumber and firing with green wood, the fire generally dies down when through the log, as there is little draft when engine is not in labor, and it is necessary to add twelve or more feet of smoke-stack on top of engine smoke-stack.

Remove the ashes from under the grates, as this improves the draft, and keeps the grates from burning out. Also keep the tubes clean by brushing them out twice a day. The cleaner they are kept, the less fuel will be required, and the easier it will be to make steam. **Never**

throw water in the fire-box to put out the fire, as it will cause contraction of the seams, leakage of the flues, and serious danger to the boiler. No good engineer will be guilty of such gross carelessness.

If the water should ever get so low in the boiler that you cannot tell where it is, **never try to pump in water**, but immediately pull out the fire or cover it with ashes or dirt, and let the engine run until the steam is down, and do not attempt to fill the boiler until it is cool.

Firing Straw Burner Engines.—Remove the shake grates and bushing in exhaust nozzle.

Place a cross-bar in front and one in back end with two or three straw grates resting on them. Place a side-plate on each side of fire-box to reduce side draft.

An arch of fire brick must be used over the fire.

To place the side bars for arch brick in position on a 16 H. Rear Mount Engine, mark on both sides of fire-box for front stud 14 1/2″ back from flue sheet and 16 1/2″ above the bottom of fire box. For back stud 30 1/2″ back from flue sheet and 24″ above bottom fire box.

For 20 and 25 H. Engine, mark for front stud 15″ back from flue sheet and 21 1/2″ back from flue sheet and 29″ above bottom of fire box.

Before drilling holes for stud, place the side bars and lugs and see that the marks come exactly in center of hole in lugs. If the studs are coming too close to stay bolts, move the side plate backwards to miss the stay bolt and make new marks for the studs, drill, tap and screw in the studs steam tight, bolt on the lugs and hang the side bars.

The top of back end of fire brick should be about 7″ below crown-sheet and 7″ from back end of fire box with the top of brick sloping down a few inches below the flues. A little variation from these measurements does no harm, if there is room to put a scraper in small door to occasionally scrape the ashes off the top of the bricks.

Little strips of iron can be used on the sides if the bricks are not long enough to spring an arch high enough in the center with about 3/4″ opening on top between the brick. They must be high enough in the center so they can lift up when they expand from the heat and

do not allow any water, steam or cold air to come in contact with the brick when they are hot, or they are liable to crack and crumble. Sometimes you can obtain the best results by firing close with straw packed, and sometimes by putting the straw in loose. All depends upon the draft and condition of straw.

A fireman with a little experience and good judgment will soon learn how to obtain best results.

It is best to keep an even amount of straw in the fire-box all the time, although with dry straw you can often fill the fire-box full of straw and then stop feeding until it burns up. Push the straw in over full length of grate and stir with fork to make good blaze.

Care must be taken not to put in so much straw that it chokes the fire, or you will have all smoke and little flame and heat. You can soon tell by the white smoke from the stack if too much straw is in fire-box.

Keep the ashes cleaned out.

The larger the opening in exhaust nozzle the less draft there will be and the less it will pull burnt straw over ends of flues, which must be kept clean by scraping. If not sufficient draft insert bushing to reduce size of opening in nozzle. Clean out smoke-box once or twice a day.

Open front damper when firing with straw and keep back damper closed.

Fusible Plug.—A small plug, or thimble, of brass, screwed into the crown-sheet. The center of this plug is filled with Banca tin which is easily melted. If the water becomes so low in the boiler as to uncover the crown-sheet, the soft metal in the brass plug will melt out and leave a passage for the steam which will extinguish the fire and give an alarm, unless the top of the plug becomes covered with scale and prevents the escape of steam, even though the fusible metal be melted out. To guard against this, examination should be made, and the top of the fusible plug kept clean by scraping. At the same time the entire crown-sheet should be scraped clean. An extra fusible plug should always be kept on hand (we furnish a duplicate with each engine). Care must be taken to screw the plug up into the crown sheet within about three threads of the square end. The fusible plug is screwed up into

the crown-sheet from **below**, and can be removed with a wrench. To renew an empty plug, use Banca tin or melt together six parts of tin to one of lead, with which fill the hole in the plug.

Foaming.—A rising of the water into the steam room, in shape of foam. It is generally caused by mixture of water from different ponds, wells, or creeks, and by muddy or alkali water, by oil being carried into the boiler with the feed water, or from paint on the water tank or soap from washing hands in feed water. When the water foams, the cylinder-cocks should be opened and the throttle partially closed. When the foaming ceases, close the cylinder-cocks, and gradually let on a full head of steam, and don't carry too much water. A new boiler is more liable to foam than after it has been used, and sometimes the foam does not cease until after the water has been let out of the boiler several times. Sometimes slaked lime put in the boiler or pumped in with the fed water will stop alkali water from foaming. When foaming, the water is wild; that is, up and down in the glass. (See Priming, which is sometimes mistaken for foaming.)

Fly-Wheel.—The large wheel on the main-shaft to carry the crank past the center and on which the drive-belt is placed.

Friction Clutch Single Engine. The shoes should be set out so they will just clear the fly-wheel when the engine is running with the lever thrown forward as far as it will go. Never put sand, or anything but oil, on rim of fly-wheel where the shoes rub. Keep the wood shoes well saturated with oil to have engine start the gearing without a jerk, which is liable to break something. Before going up a hill, see that the friction-shoes are set tight enough against the rim of fly-wheel with some notches on quadrant to tighten the lever more if necessary. If they slip, the engine is liable to back down the hill. The friction-clutch can be locked with pin in fly-wheel.

The rods to shoe must be bent out a little so they cannot spring in by the center and stick. New wood shoes must be fitted by hand. The bevel on top throws the shoe in line its full length with edge of fly-wheel, and the outside bevel must be cut or ground down to fit the fly-wheel to its full bearing with the ends cut back enough so they will not catch.

Friction Clutch Double Engine. Throw lever forward, set the

three blocks out until they all are alike and just touch the wheel, then let them off 1/2 turn of nut and set up the jam nuts. The blocks must be set so lever will pull back hard when it passes the center. The friction blocks will then engage the friction wheel and lock themselves with no strain on any part to hold them in place.

If the friction clutch blocks are not worn out too much they can be set out by placing packing between the wood and iron shoe.

To place new wood shoes. Remove the pin from levers to shoe. Then slide the pin from spider out with the ground off side of end of pin out against the V in friction wheel. This allows the pin to slip out far enough to remove the shoe.

Bolt the new wood to the iron shoe and replace by first inserting the pin in shoe through levers and then slide the pin in spider through iron shoe.

The holes must be held exactly in line to insert the pins. The pins will enter the holes more easily if you have a taper pin to line up the holes or by rounding off the sharp edges on the end of pin.

The friction clutch can be locked with pin and should be **locked when plowing** and doing heavy hauling to save wear on blocks.

Flues.—Small tubes running lengthwise through the boiler, through which the heat and smoke are carried from the furnace to the smoke-chamber. The flues must be kept clean by brushing them out thoroughly twice every day, or more often, so the heat can go through to the water.

The flues in our boilers are carefully put in, and expanded just enough to properly fit the hole in the flue-sheet.

If from any cause they should leak, a roller expander, sectional expander or beading tool should be used. If a sectional expander is used that forms a bead inside the flue. It must be one-half inch inside as our boilers have half-inch flue-sheet. A sectional expander with bead for one-fourth or three-eighths flue-sheet would cut the flues off and ruin them.

Drive the pin in expander lightly with a hammer and always roll the same way and continue to drive pin and roll until it strikes solid

and sounds solid. Don't roll out the flue too thin or you will ruin it, but you must go after it hard enough to make it solid. A beading tool is used to calk the end of the flue over against the flue-sheet.

To put in new flues, cut the bead off both ends of old flue and be careful to not cut the flue-sheet, cut a V in fire-box end of flue, drive in end of flue away from flue-sheet. Then drive flue in from Smoke-box with a blunt tool. Then ends must be cut off or bent in and flue taken out of hand-hole.

The new flue should be annealed at both ends by heating red hot and inserted in slack lime or ashes to cool slowly. Insert the new flue and cut off, allowing one-quarter inch on each end for bead. Copper thimbles between flue and fire-box flue-sheet are used in some of our boilers; drive over end of flue to hold it in place, then expand with roller or sectional expander. Take peen or round end of hammer and drive end of flue over flue-sheet and calk with beading tool down smooth against flue-sheet, then expand again with roller or sectional expander until it is tight and solid in flue-sheet.

Leaky flues may result from one or all of various causes, among which are:

Cold air rushing into and through the flues.—This results from leaving the door open unnecessarily when firing, or leaving it open when there is too much steam pressure, or grates next to flue-sheet open and not covered with fire, allowing cold air to come up through the grates into the flues. The cold air causes violent contraction of flues.

Throwing water into the fire-box to deaden the fire.

Blowing off the boiler under steam pressure.

Letting the water in the boiler freeze.—This often results in serious damage to the fire-box.

Low water.—This causes overheating and expansion of the top row of flues, leakage results, and the water runs down on the other flues, making them leak.

Allowing mud or scale to accumulate in boiler.—This is the most common cause of leaky flues. This results from using bad water

and the failure of the engineer to keep his boiler clean. This accumulates around each flue as well as on the crown-sheet, keeping the water away from the metal, which is thus deprived of its protection while exposed to intense heat, which causes the flues to expand, thus breaking the joint and resulting in leakage.

Alkali water, hard water, stagnant or bad water or oil in the boiler will often cause flues, bolts, seams and rivets to leak.

Too sudden expansion or contraction of flues by heat or cold.

Overcrowding engine, causing extra strain on boiler.

Recollect that if a flue does not leak the first day, it is as perfectly in place as it can be made by human skill. If the engineer does his full duty, and keeps the interior of the boiler free from scale, the flues should remain for a long time in the same condition with good water. In some localities the water is so bad it is necessary to replace the flues often in all steam boilers. Our flues are put in place by the most skilful boiler makers, and are carefully and thoroughly tested by cold water pressure and under working steam pressure, and do not leak when engine leaves factory.

Consequently we are not responsible for leaky flues.

Grates.—The bars to support the burning fuel. They must be kept clean from clinkers and not allowed to clog up so the air cannot get through them to the fire.

Glands.—The cap, to compress and hold the packing in the stuffing boxes.

Gauge-Cocks or Try-Cocks.—Small valves attached to the boiler at different levels, and used to find the height of the water.

Our low try-cock is inserted about two inches above the crown-sheet, and as long as you keep the water up to the lower gauge cocks there can be no danger of dropping or bulging the crown-sheet when the boiler sets level and is clean.

Gib.—Used to take up the lost motion in boxes.

Gearing.—The cogs should be oiled with liquid oil. Axle grease catches too much dust and sand. The boiler castings must be fitted to

boiler so the main shaft, intermediate pin, countershaft and axles are parallel with each other or gearing will run out of line, cut or break.

If the gearing binds or cogs bottom and break, it is generally caused by the countershaft being loose in the box or the babbitt cutting or melting out on top of box and running down and soldering on bottom of box, throwing the cogs of gearing too deeply or too far out of mesh, which makes them run hard and sometimes break. If cogs do not mesh deep enough they are liable to break. There should be 1/8 to 3/16 inch clearance at end of cog. This is corrected by setting the set-screws to gib to counter-shaft box to their proper bearing, or rebabbitting the boxes (use best babbitt). These boxes must be kept properly adjusted all the time, in order to keep the gearing in proper mesh.

The nut or collar on the end of the counter-shaft and the collar on the counter-shaft back of the bracket, must be securely set to hold the gear in proper mesh with pinion in differential gear and to prevent gear from spreading.

If the drive-wheels slip and engine jumps, stop before breaking the gearing or some other part, and put a piece of wood or something under the drive-wheels for a foothold.

Governor.—A machine attached to the steam-pipe to regulate the speed of the engine by the centrifugal force of the balls in or out according to the speed which moves the valve up or down in throttling the steam.

It is very sensitive and must be thoroughly oiled twice a day or more often, as a little friction or gummy oil will make it run irregularly.

If the governor controls the speed when first run empty and under a load it will always do so if properly oiled and adjusted with new parts that may be worn out or bent, and the belt does not slip.

If the governor jumps to let in more or less steam quickly for a quick change from light to heavy load, this does not indicate the speed of the main shaft to engines run irregular.

The Governor is provided with a "speed-regulator," which can

be easily and quickly changed by turning hand-wheel to give from 100 to 300 revolutions of main shaft of engine per minute. 225 revolutions per minute is regular speed of engine.

Always run with the throttle **wide open**, and let the governor control the steam. Do not attempt to control the speed by the throttle-valve.

Balancing Spring should be set strong enough to just lift the valve up off the seat and then give the sprocket to spring a turn to next notch so valve will rise quickly when speed runs down. If too loose, the governor will race. If too tight it will cause extra friction and wear. It may be necessary to change the tension of this spring at times to conditions under which the engine is operated. If governor races it is generally stopped by tightening the balancing or lift spring.

Oil through top nut, drive shafting, gearing, the spindle, sleeve, and stuffing box. If not thoroughly oiled the friction will cause governor to race and wear out parts so governor cannot control speed. A good dose of kerosene oil will cut the gum and free it up. Then apply lubricating oil.

Pack stuffing box with oiled candle wicking. Remove all the old packing before putting in new. Screw down the nut to stuffing box just tight enough to prevent leakage of steam. If stem is too tight in stuffing box, it will cause friction and governor will race.

If there is lost motion in the head up and down, set the collar inside of spring down against the head.

Valve and Stem must be smooth and free from gum, lime, burnt oil, or anything that will cause it to stick in the stuffing box or seat. If stem is bent or worn where it works in stuffing box it cannot be straightened, but must be replaced with a new one. The valve may wear for years and it may soon wear small, depending on the quality of the water. If valve is worn, it should be replaced with a new one. Take the governor belt off and hold the valve way down in the seat by the lever or expanding the balls with steam on full head and the engine should run from 50 to 100 revolutions per minute if valve fits the seat properly.

Belt must be tight enough to prevent slipping and lace pounded down smooth, and free from grease to prevent fluctuation and rac-

ing. Slipping of the main drive belt will also cause racing. The pulley should be lined up so the belt will not rub on flanges.

Guides.—Attached to the cylinder head, between which the cross-head moves back and forth.

Heater.—A chamber in which the feed water is heated, before entering the boiler, by the exhaust steam on its way to the smoke-stack. If the feed-pipe where it enters the boiler is closed with lime, or valve next to check-valve is closed and pump is started, it is liable to burst the pipe in heater, or if water is left in the pipe during cold water it will freeze and burst. This would reduce draft and power and use lots of water and fuel.

Hand-Hole.—Small holes in the boiler, used to remove mud and scale.

Don't allow them to leak, as the rust will eat the boiler plate out thin around the hole and the water running down will wet the ashes in corners under grates and the wet ashes will rust out the boiler plate.

Injector.—A machine for forcing water into the boiler by the direct action of the steam. Its construction consists of jets or tubes with tapers so adjusted that increased speed or velocity of water is obtained similar to water passing through a hose with a reduced taper nozzle. The smaller the nozzle, the greater will be the force and volocity of the water. There are many injectors on the market under different names, but the principle remains the same in all. The lower the steam pressure the hotter it will work the feed water and the greater the lift, but the more steam it takes to start the water. That is, with a four foot lift and water at a temperature of 100 it requires about 60 pounds of steam to start the water, while with water at a temperature of 76 it will start with as low as 40 pounds of steam. The injector possesses many advantages as a boiler feeder: requires no lubrication, occupies but little space, and rarely needs repairs. The steam used in operating it heats the feed water to nearly boiling; and the water supply can be kept up when the engine is not in operation. To insure the perfect working of the injector, all connections and the hose must be air-tight, and the lime cleaned out of injector. Use one part muriatic acid to nine parts of water to clean off lime.

To Start Injector.—Close pump valve and open cock in pump barrel to prevent pumping air into injector. Open valve to return or wetting-down hose to let off back pressure of hot air and water from boiler. Turn on full head of steam and then open valve in suction-pipe with a quick jerk until overflow ceases. If overflow does not stop, you may have suction-valve too far open for the steam pressure and lift of water, and it should be closed again and then opened quickly about one or two turns; keep closing and opening until you find the right opening.

To Stop.—Close angle-valve in steam-pipe and globe-valve in suction-pipe.

To Prevent Freezing.—Open drip-cock in bottom of injector.

To Prevent Heating when not in use, open drip cock in bottom of injector and if pump is not working, open valve to return hose. No injector will work when hot, caused by leaky steam valve or check valve, nor will it work with low steam pressure.

To remove dirt, sediment or scale from the injector, take out the delivery tube and clean it out on the inside. Look through it and be sure it is clean before you replace it. To replace it, insert the lower end in the hollow of the cap, then screw on the cap, and the tube will be in its proper position.

In replacing parts of injector, see that all surfaces are perfectly clean and the steam-jet in top is right side up.

An injector will not work if it leaks air. To test this, fit a wood plug or fusible plug in over-flow; double over end of suction-hose or plug it, and then let on steam and any leaks will show. It will not work if steam pressure is too low, water too hot, suction clogged, overflow-valve or check-valve stuck or clogged. When pump is not used, the injector holds check-valve up and it sometimes limes over and leaks hot water back on injector, or leaky steam valve, making it too hot to work. Dirt in tubes in injector, injector too hot, suction-valve not properly regulated, the pump pumping air into injector, or too much back pressure from boiler or injector, or feed pipe bursted in heater or clogged with lime where it enters boiler. If sand in water cuts out hole in tube too large, injector will not work. New tubes can be furnished

by us.

The suction valve should always be a globe valve placed right end down so the water will flow against the button on valve, not on top of valve.

"Knocking."—An engine on wheels is working under entirely different conditions from a stationary engine. Instead of being placed on a solid foundation, the portable engine is operated on wheels, hence it will make more noise than a stationary engine. Again, there are a number of points about a portable engine, each of which contributes its portion of noise, and the boiler being an excellent conductor of sound, concentrates the separate noises or "knocking," and telephones them to the point where the engineer may be listening, and he is liable to conclude that the "knocking" or "pounding" is located at that precise point, when it is elsewhere.

It is sometimes quite difficult to locate the point where the "knocking" occurs, and engineers are often deceived in its location if they undertake to locate it entirely by sound. Always locate the point where the "knocking" occurs before you try to stop it.

Knocking occurs from lost motion in wrist-pin box, cross-head box, main-shaft box, eccentric-straps, cross-head, link, guide to valve-rod, slide-valve, piston head loose on rod, piston head striking end of cylinder, worn ridges inside cylinder when piston does not travel to counter-bore on one end of ridge on valve-rod, link or valve-seat, eccentric-rods out of line. Main-shaft not a right angle with connecting rod, packing too tight, cylinder, valves, link or other parts running dry. Lack of oil is the most common cause. Loose pins, key in band-wheel or crank loose, water in cylinder, link or some other part striking or rubbing on boiler or against casting. (See directions under these different headings for adjusting these parts.)

Link.—That part which allows the operator to reverse the engine and to hook up the lever so that the valve will cut off the steam at both ports and allow more or less steam to be used.

Use candle wicking in oil pockets to prevent link from throwing off oil.

Use the best cylinder oil on the link. The common thin oil runs

off too quickly. A loose, rattling link is often caused by cylinder and valve or some connection not being properly oiled or kept in proper adjustment.

If the link jumps it is caused by loose bearing in bell crank or pins; too tight a stuffing box; want of oil in cylinder; striking boiler or some other part; a ridge worn on valve seat or link. When sawing lumber or running the engine, only one way, the link and the go-ahead eccentric rod and strap can be removed on our link engine, and a Drew Valve Block can be attached to slide and one of the eccentric rods to save wear on one end of link, which occurs if run any great length of time one way. See eccentric rods for adjusting them so they will not make link jump.

Main Shaft.—To set the main shaft in alignment. Level the engine side way with a spirit level on top of heater on the smooth part that has been planed off. Place a jack-screw under each end of main-shaft and block with wedges or fasten with rope to prevent shaft from moving sideways. Remove caps and jack up shaft out of boxes. Disconnect the connecting rod and eccentric rods from main shaft if necessary.

Remove all the old babbitt from main boxes and anchor holes. Plug with short wood plugs oil the oil holes with the plugs extending through the babbitt.

Place 3/16 inch thick strip of wood between main shaft pinion and intermediate spur wheel cogs to give the proper clearance between bottom of cogs and lower main shaft back in the boxes with gearing in proper mesh. Place 1/4" thick liners under the cap and bolt caps in place.

Jack the opposite end of shaft from the gearing so the shaft is level and has sufficient clearance for the babbitt around the main shaft.

To set the main shaft at right angle with piston rod, tighten up the wrist pin and cross-head boxes ridged on the pins. Push the crank wheel if a single engine up against the main box and be careful to move it backward or forward so the hub has the same bearing around both sides or ends of the main-box. If double engine, the two connecting rods will line up the shaft at a right angle with piston rods with the two bearings on end of main boxes in proper place.

Before pouring the babbitt, see that the boxes are dry and not wet, or babbitt may fly and burn you.

Do not heat the babbitt too hot, as it might spring the shaft when cooling. Heat it just hot enough to brown a pine stick.

To pour the babbitt, remove the cap from boxes and place clay or a rag around each end of box to prevent the babbitt from running out, and pour the lower half of the box. Then place the liners up tight against the shaft the full length of bearing.

There is a hole down on the side of cap below oil hole. Dig the old babbitt out of the hole, replace the cap and pour through this hole.

Remove the caps, jack up main shaft again, remove the plugs and clean out the oil holes and cut a V-shaped groove from 1/2″ from each end of box to all oil holes. File off the edges of the babbitt rounding. Place a piece of thick writing paper in top of each liner and bolt the caps in place. Loosen the connecting rod boxes and turn the main shaft by hand to see that the boxes are not too tight. If too tight, scrape out babbitt to fit the shaft.

Remove rear cylinder head, turn the engine on back center, measure the thickness of offset in inside of cylinder head and add 1/8″ gives the distance the piston head should be from end of cylinder, which allows 1/8″ clearance between piston head and each cylinder head with full stroke of piston.

If piston is not in correct position, screw piston rod in or out of cross head to get the proper clearance and to prevent piston head from striking cylinder head.

Mud or Ice Claws are used on rear drive-wheels when the wheels slip. Often rain will make roads slippery on top, and the claws will cut through to a firm footing, allowing engine to move over muddy and sandy roads. On ice and snow use six on each wheel and run slow; a less number is liable to break something.

Priming.—The passage of water from the boiler to the steam cylinder in the form of spray instead of vapor. Priming can generally be known by the white appearance of the steam, and by a clicking in the cylinder, which is caused by the piston stricking the water against the

cylinder-head at each end of the stroke. Priming is generally caused by carrying too much water in the boiler, thus reducing the capacity of the steam room. One or two inches of water in the glass water gauge is sufficient when boiler sets level. Priming washes the oil from cylinder and valves and kills the power of the engine. Partly close the throttle valve and open the cylinder cocks. Feed all the oil you can into cylinder and run the engine slow until dry steam comes from cylinder-cocks. When boiler primes the water is nearly stationary in glass, when foaming water is wild, that is, up and down in glass. (See foaming.)

Packing.—There are many kinds of packing. We use lead gaskets for hand holes.

Rubber for steam chest, heater heads and glass to water gauge.

Rainbow for throttle union, governor base and cylinder heads.

Hemp, flax, asbestos or special packing for valve rod or pump rod; candlewick for governor and brass valve stems.

Be careful not to screw packing up too tight in stuffing-box or it will make engine pound and run hard. It should be set up only tight enough to prevent leaking.

Piston-Head.—That part of the piston made of one solid casting, and to which the piston-rod is attached, and upon which the packing-rings are placed.

Piston Cylinder Rings.—The rings which make the piston steam-tight.

Should you at any time wish to ascertain if the piston is steam-tight, turn the fly-wheel till the engine is a little past the center, or just far enough to commence taking steam, then block the fly-wheel in that position. Open the cylinder-cock and let on the steam gradually. If the steam issues from both ends of the cylinder, it passes between the packing rings of the piston or the valve or valve seat is cut and allows steam to pass under it. The engine will not develop its power and should be corrected by new rings, or old one adjusted to work steam-tight, or valve and seat scraped down (see valve). If poor oil is used to oil the cylinder, it sometimes gums the rings solid in the grooves in piston-head, and rod should be removed and cleaned with coal oil, so

the rings are free to expand on the head.

Pump.—To start the cross-head pump, **see that the stop-valve, between check-valve and boiler, is open**. This must **never be closed** except when taking apart the pump or check-valve. Close valve to injector and cock to pump barrel, open valve to wetting-down hose to let hot air and back pressure from boiler off, then open valve to suction. Close the angle-valve in the pipe to which the wetting-down hose is attached and the water will be forced through the feed-pipe into the boiler. Open this angle-valve and the surplus of water can pass around through the return-hose back to the tank, or can be used for "wetting-down" around engine. Maintain a **uniform** gauge of water by a steady feed from the pump by adjusting the valve to return hose. A little experience will enable the engineer to do this, and he will not only find it more convenient, but a much safer plan to pursue, as he thus keeps a steady "head" of water, and avoids "flooding" the boiler with water, and, consequently, running down the steam.

Always keep the water over crown-sheet.—The lower gauge-cock and bottom of glass is inserted 2 inches above the crown-sheet, and when you can just see the water in gauge glass there is about 2 inches of water over crown-sheet, and as long as you keep the water up to that point, there can be no danger of bulging the crown-sheet unless the crown-sheet becomes covered with scale or boiler is not level.

The supply pipe, where water enters boiler, sometimes becomes choked with lime, and must be cleaned out or it will shut off the water supply to boiler. When there is no steam on boiler the brass plug in T between check-valve and boiler can be taken out and the lime scraped out with a round file.

The pump will not work if hose, air-chamber, stuffing-box, or any of the connections leak air, or the valves leak or are limed up, or the pipes or valves are clogged, or if pump plunger is cut. If the pump is out of line remove the packing from stuffing-box, place the engine on back center, tighten nuts to pump arm so the plunger is held firmly in place, then turn the engine to front center and watch the plunger to see if it clears the stuffing-box nut on all sides the full length of the plunger. If the plunger rubs on the stuffing-box at either end of stroke, the pump is out of line. The pump arm can be bent to line it up with

the pump rod, or the pump barrel can be raised or lowered, or moved out or in at either end.

Slide Valve.—The sliding plate of metal, working back and forth on its seat in the steam-chest, which admits the steam to cylinder and after being used allows it to pass out of cylinder into exhaust pipe.

The slide valve must fit its seat steam tight to get the full power of engine and not to waste water and fuel. To test the valve, block the main shaft and set the valve to cover both ports so the engine cannot run, then let on the steam and if it blows out of smoke-stack the valve does not seat steam-tight and you are not getting full power of engine. To seat the valve wipe off valve and seat clean. Rub black lead over the seat even and smooth. Place the valve on the seat and move it back and forth in its working position. Remove the valve and the black lead will show where there is no bearing. The high places on the valve or seat can then be scraped down to a bearing. Continue the operation until the valve and seat show an even bearing the full length of the stroke.

SETTING THE SLIDE VALVE

The valves are correctly set at factory, and don't allow anyone to "monkey" with parts **that are all right**. If it becomes necessary to replace some piece of the valve movement with a new part follow these directions.

41. After the valve has been set a cold chisel is placed on eccentric rod close against eccentric strap and hit with hammer. This marks the rod so it can be put back to its original place if the rod should ever slip. The valve rod is also marked or pinned to outside slide.

42. The eccentric hubs are securely fastened to main shaft by three set screws and with a blind set screw through hub into a hole drilled in main shaft or keyed to main shaft and cannot get out of the proper place unless the blind set screw breaks.

43. The front center is when the cross-head and wrist pin are at the extreme end of forward stroke. The back center when cross-head and wrist-pin are at the extreme end of backward stroke towards the back of engine. Care must be taken to get the exact center in the same place every time the main shaft is moved. This can be done with a

tram or pair of dividers, which can be made of iron or a stick with a nail driven in the end of stick with the point of nails 18 7/8 inches apart for old style steel guide engine, 25 15/16 inches apart for new single cylinder Corliss guide engine, or 20 7/8 inches apart for double cylinder engines.

You will find our center punch marks on crank wheel and guide on single engine and on crank counter-balance and top of guide on double engines.

44. Lead about 1/32 in. opening of steam port when piston begins its return stroke. The valve should be set when engine is hot, or eccentric rods lengthened out 1/32 in. if valve was set while engine is cold.

45. To locate notches in quadrant, place the reverse lever backward until there is 13/16 in. clearance between top of link and link block and mark for notch. Throw the reverse lever forward until there is 9/16 in. clearance between lower end of link and bottom of link block, mark and cut out side notches. This cuts off steam at about 3/4 stroke. A center notch should then be cut half way between the outside notches. A notch cut 5/8 in. inside the outside notches allows the link to be hooked up and cut off at about 5/8 stroke.

TO SET VALVE ON SINGLE CYLINDER LINK ENGINES

46. Throw reverse lever in back notch and place engine on front center. (See paragraph 43 for obtaining centers.) Place the swell of go-ahead eccentric hub, which is the left hand one, down on under side of shaft with the back-up eccentric, which is the right hand one, on top of shaft. Paragraph 42 shows how eccentric hubs are fastened to shaft.

47. Turn the go-ahead eccentric hub around the shaft until the valve is at the extreme forward end of travel and drive go-ahead eccentric rod, the one connected to top of link, until valve has a wide open port at back end of steam chest. Tighten set screw on eccentric rod and turn go-ahead eccentric hub forward until lead is obtained **when valve is opening the port** in front end of steam chest.

48. Throw reverse lever forward in front notch and turn back-up eccentric hub to its extreme travel and drive back-up eccentric rod,

the one connected to lower end of link, until you have a wide open port at back end of steam chest. Tighten set screw on eccentric rod and turn eccentric hub backward until lead is obtained **when valve is opening port in front end of steam chest.**

49. Reverse lever forward and backward and compare the leads. If the leads at both forward and backward motion are not the same opening adjust them by moving eccentric hub forward or backward as the case may require until both leads are alike about 1/32 in. opening.

50. Place engine on back center with reverse lever in back notch and see what opening you have for lead. If over 1/32 in. loosen go-ahead eccentric rod and **divide one-half what is over 1/32 in.** If less than 1/32 in. divide one-half of what is lacking to make 1/32 in. lead and tighten set screw on eccentric rod.

51. Throw reverse lever forward and see what opening you have for lead and adjust the lead by driving the back-up eccentric rod the same as in No. 50 paragraph, except reverse lever forward.

52. Turn engine again on front center and adjust leads by turning eccentric hub so both go-ahead and back-up motion will show exactly 1/32 in. opening.

53. Turn engine on back center and see if leads on both go-ahead and back-up motion are exactly alike, about 1/32 in. opening. If leads are all alike, about 1/32 in. opening the valve is set; if not proceed to divide the difference in leads as before in Nos. 50-51 paragraphs until all leads on back and front centers on forward and back-ward motion are alike.

TO SET THE VALVE ON A DOUBLE CYLINDER LINK SIDE-MOUNTED ENGINE

54. Set the valve for one cylinder at a time. Throw reverse lever in back notch and place engine on front center. (See paragraph 43 for obtaining centers.) The two eccentric hubs are made in one casting. Paragraph 42 shows how eccentric hubs are fastened to shaft.

55. Turn the eccentric around the shaft until the valve is at the extreme forward end of travel and drive the go-ahead eccentric rod, the one connected to top of link, until you have a full open port on back end of steam chest, and tighten set screw on eccentric rod.

56. Throw reverse lever forward. Get full valve travel the same as on go-ahead motion and drive back-up eccentric rod, the one connected to bottom of link, until you have a full port opening. While the reverse lever is in forward notch move eccentric hub backward until you have a lead and tighten eccentric hub on shaft.

57. Throw reverse lever in back notch and if you have no lead turn eccentric hub forward until the two leads have equal openings or until valve is in the same position when the reverse lever is thrown in front and rear notch of quadrant. If you have no lead loosen the go-ahead eccentric rod and drive it so the valve has a lead. Then throw reverse lever ahead and drive eccentric rod until you have a lead.

58. Turn engine on back center with reverse lever in back notch. If lead is over 1/32 in loosen go-ahead eccentric rod and divide **one-half** of what is over 1/32 in.; if less than one thirty-second inch, divide one-half of what is lacking to make a lead.

59. Throw lever in forward notch and see what opening you have for lead and adjust the lead by driving the back-up eccentric rod the same as you did in No. 58 paragraph, except reverse lever to forward notch.

60. Turn the engine on front center and make the leads equal by turning eccentric hub on main shaft until both the leads have the same opening.

61. Turn engine on back center and if the leads are the same as on the front center the valve is set. If the leads are not the same go over this operation again in No. 58-59 paragraphs until all four leads are equal with the same sized opening.

62. Our double engines have both eccentrics cast on one hub, the leads cannot be increased nor decreased but can be made equal so they will be all alike with the same opening. Our engines cut off exhaust steam and hold it in cylinder for cushion to piston head at end of stroke so it does not make much difference if there is little more than 1/32 lead, just so they are equal.

Set the valve on the opposite cylinder in same manner as above, commencing with paragraph No. 54.

TO SET THE VALVES ON OUR DOUBLE CYLINDER REAR MOUNT ENGINE

63. Turn the main shaft around to the back center. Place your finger around the valve rod against the steam chest stuffing box gland. Then reverse the reverse lever and if valve rod does not move endways the engine is on dead center. If it does move, continue to turn the main shaft forward or backward and throw reverse lever until you find the right place where valve rod does not move when reversed and you have the dead center.

64. Move the slide valve rod to a lead about 1/32 in. on the back port.

65. Turn the main shaft to the front center the same as 63rd paragraph, and if the lead is the same the valve is set on one cylinder.

66. If the leads are not the same, move the slide valve on the valve rod **1/2 the difference between the two leads**. Continue to go over this until the leads are equal and all the same. The leads cannot be increased or decreased but can be set with equal openings.

67. Set the valve on the opposite cylinder in the same manner, commencing with paragraph number 63.

68. The eccentric hubs are fastened to the main shaft with three set screws, and after the valves are set at factory a hole is drilled through the hub and into main shaft and a blind set screw inserted, making the hub solid to main shaft. If necessary to replace the eccentric hub, set the engine on the back dead center, which can be obtained by a tram made of iron or a stick with a nail in each end, the points 21" apart. You will find our center punch mark on the front end of guide to cross head and on counter balance to main shaft. Then turn the belly of eccentric hub up on top of shaft. Reverse, and if the valve rod does not move endways the eccentric hub is in its true position. If valve rod does move, turn the eccentric hub a little forward or backward on the shaft until you find the right place when reversing does not move valve rod endways.

Smoke Box.—The space at the end of the boiler, and immediately under the smoke-stack, into which the smoke passes from the flues. Keep it cleaned out, and also the little hole in bottom, so the water

from exhaust nozzle can run out, or it will rust out.

Stuffing-Box.—The recess of small chamber in the casting through which the piston, pump-rod or valve-rod passes, and in which the packing is placed.

Steam Pipe.—The pipe conveying the steam from the dome to the cylinder or to injector.

Steam-Gauge.—An instrument for indicating the pressure of steam in the boiler, which is shown by a dial and hand. Steam-gauges sometimes get weak by the heat drawing the temper of the bourdon spring or the hand slips so they indicate more or less pressure than you have in the boiler. They can be reset and tested at our factory or any of our branch houses when not worn out.

Do not permit a weakened steam-gauge to make you think that your safety-valve is out of order.

Safety-Valve.—A valve fitted to the boiler, which opens when pressure rises to a certain height and allows the surplus steam to escape.

Always be sure that the safety-valve works free and easy, and that it **will** "blow off" at the number of pounds at which it is set. This valve is set on our new engines to "pop" and relieve the pressure of steam at 150 pounds on single and 165 pounds on double engines, and should not be tampered with or taken apart. The lever should be moved every day to be certain that the valve has not stuck fast. If the steam-gauge indicates more or less than what the pop is set to blow off at, don't change the pop until you find the steam-gauge is correct, for sometimes the steam-gauge hand gets loose and indicates more or less than the correct pressure. Steam-gauges and safety-valves can be tested and set correctly by us, if they are not worn out.

Supply Pipe.—The pipe leading from the pump or injector through the heater, and entering the boiler just below the front end of the heater.

The end of this supply-pipe where it enters the boiler, sometimes becomes choked with lime and sediment. When there is no steam in the boiler, take out the brass plug in T, between the stop-cock and the boiler, and if there is any lime or sediment in the pipe, it must

be cleaned out or you are liable to burst the air-chamber to pump, the pipes, or some other part. If pipe is bursted or leaks inside of heater the engine will use more water and fuel than necessary and reduce the power.

Solvents.—Soft water is the best preventive of scale. Use all you can, and if compelled to use hard water through the week, still it will be of great benefit to fill the boiler with soft water once a week and let it stand as long as possible. Boiler compounds are sometimes used with good results, but the trouble is to find the right compound for the kind of water you are using and a compound that will not injure the plate.

Solvents simply aid in loosening and removing scale, and in precipitating impurities. If the loosened scale and sediment are permitted to remain in the boiler, they will spread over the crown-sheet and tubes. Therefore it is of the first importance that the boiler should be frequently and thoroughly cleaned out. Do not use kerosene or oil to cut the scale, as it leaves a film on the plate which prevents the water from reaching the plate, and if enough is used will bulge the crown-sheet.

Steam-Chest.—The box-shaped chamber on the side of the cylinder for the slide-valve.

Throttle-Valve.—A valve placed in the steam pipe, by which the supply of steam may be stopped or turned on. The packing to throttle-stem should be kept just tight enough to prevent the steam from blowing open the valve. Use rainbow packing in union on throttle to steam-pipe. Rubber will not hold steam tight in this place. A drain-cock will be noticed in the throttle-valve, which should be opened in cold weather, when shutting down for the night, to allow the water which may condense from the steam to escape. Otherwise freezing may result, and the body bulged so the valves do not seat to shut off the steam.

Water Gauge.—A small glass tube attached to boiler by brass valves, and used for the same purpose as the gauge-cocks, to show amount of water in boiler. When you can see any water in the glass, there is about two inches of water over crown-sheet when the boiler is level if valve is not clogged. Blow out the glass often by opening cock, and examine water-gauge often to see that it is in no way stopped up.

Otherwise the gauge may become stopped at connection and show water in glass higher than it really is in the boiler, or when there is none in the boiler.

Water Supply is of great importance, and if neglected, disastrous results are likely to follow. The pump and injector should always be kept in running order. One or two inches of water in glass is sufficient when engine stands level. Maintain a **uniform** gauge of water by a steady feed. A little experience will enable the engineer to do this with the pump, and he will not only find it more convenient but a much safer plan to pursue, as he thus keeps a steady "head" of water, and also avoids "flooding" the boiler with water, and, consequently, running down the steam. Never shut down the engine with less than two inches water in the glass, as the water will fall one-half inch when the engine is stopped.

If the water is so low in the boiler that you cannot tell where it is, pull the fire immediately or cover the fire with ashes or dirt, and let the engine run until the steam has run down. Don't attempt to fill boiler with water until it is cool.

Wheels with end play should have washers placed on axle, or engine will shake when running and gear rin in and out.

Wrist Pin on crank-wheel. To replace it with a new one on single engines, cut off the part riveted over on back side of crank wheel and drive it out with a sledge, holding a heavy weight against outside of crank wheel near the pin.

To put in a new pin, file it down all the way around, even to a driving fit, and drive in place with a heavy hammer, holding a heavy weight against the back side of crank wheel. It must be a good, tight, driving fit. If the old pin was loose in the crank wheel, the hole is not true and even if the pin does drive in tight the cross head end of connecting rod will run in and out, as it is not at a right angle with the connecting rod at both ends of stroke.

This is liable to cause wrist pin box to heat. In a case of this kind it is best to ship the main shaft with crank wheel to the factory or some machinist who understands boring out the hole in crank wheel and putting the pin in alignment.

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