THE

LOCOMOTIVE ENGINEER'S

"TORCH."

BY

FRANK C. SMITH, M. E., B. L. E.
(V. HOOK.)

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TO

ROBERT BLEE, Esq.,

One of "Nature's Noblemen," as a tribute to his preeminence as a railroad man, and as a mark of admiration and respect, this book is respectfully dedicated by the author. F. C. S.

PREFACE.

This book is not written for locomotive engine builders, nor does it profess to be an exhaustive treatise on the art of locomotive running. Its province is, simply to discuss such points of interest to the locomotive engineer as the writer happens to be acquainted with.

The writer has no apology to make in offering this book to the knights of the throttle lever, for the same will not enhance its merits (if it has any), nor make its errors less apparent.

F. C. S.

DELAWARE, O., July 1st, 1880.

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FIRING UP.

An engine, after standing in the house for several days, becoming completely cold, is liable to smoke around the fire-door on being fired up, until the dampness in the flues, etc., is expelled. If a light fire of shavings is started in the front end, or smoke arch, and kept burning until the stack is warmed up, it will greatly facilitate the draft through the fire-box and flues, and in a great measure do away with a smoky cab while the fire is getting under way.

CYLINDER PACKING.

Without doubt, the old-fashioned packing (rings and springs) is superior to any steam or self-setting packing. With steam packing, the rings are forced out against the cylinder in proportion to the pressure in the cylinder. Thus, with the reverse lever in the six-inch notch the rings press the cylinder at a pressure due nearly that of the boiler pressure for six inches of the stroke, and as the cylinder pressure is reduced by expansion, the pressure under the rings is reduced proportionally, reducing the friction and consequent wear. The natural result is that the cylinder has hardly any two portions of the same diameter, after running awhile. Absolute truth in a cylinder is something to be aimed at, and, when approximated, the old-fashioned rings tend to maintain it in that condition much longer than the steam packing. Steam packing requires less attention than "rings and springs." The writer is cognizant of a set running four years without special attention, at the end of which time, however, one-quarter of an inch was bored out of the cylinder to true it up again. The "rings and springs" packing should be set out just as lightly as will maintain a tight piston. The rings should be, theoretically, in actual contact with the cylinder, but exert no outward pressure on it. The beauty of the solid piston is, that it fulfills these conditions more nearly than any other form of piston. The want of any means of adjustment, however, precludes its use. Setting any ring packing requires good judgment and delicacy, and doing it right can only be acquired by long practice. The frequency with which the rings should be set out depends on so many different conditions, that to set any stated intervals at which this should be packing requires setting out it should be attended to. Evidently the extent of service of the engine, the harmoniousness with which the rings and cylinder wear on each other, and their care, alone determine this. An average of once in two months, as engines are ordinarily run, will cover the case. Packing blows either because it is not in contact with the piston, the cylinder or follower. The remedy is to re-set it, or re-grind the rings, piston (or spider) and follower together. It is too frequently the practice to neglect turning the rings when setting them out. This should be done to bring the extra wear due to the weight of the piston on to different portions of the rings, and thus increase their life. As a general thing, the blow on the piston is during the entire stroke, but from the nature of the case it is greater at the beginning, and is far more apt to be distinguished there, as the cylinder pressure is greater at the ends, the pressure being nearer that of the boiler pressure up to the point of the cut-off, than after. The side on which the blow occurs can be ascertained by opening the front end and placing a light chip over each nozzle and noticing which is blown off—the engine, of course, standing still, on the quarter on the side being tried, the wheels blocked, and a little steam given. The packing should be tried at the ends and centre of the cylinder. The blow proceding from the packing is heavier and stronger than that from the valve. The difference is only learned by actual experience, listening carefully with the fire-door open, when the engine is pulling heavy and running slow. A blow in the packing is more frequcnt than one in the valve, and in ninety-nine cases out of a hundred when a blow occurs that was not noticed the day before, it is in the packing. The valve may be tried for a blow by placing it over the centre of the seat (covering both steam ports). The valve is in this position when the valve stem and the rocker arm are at right angles to each other, that is, just before the crank pin reaches the centre. The wheels may be blocked and a little stcam given, when the amount of steam issuing from the cylinder cocks will indicate the tightness of the valve, *at that point.* In link-motion engines, as the valve travels different distances (dependant on the point of cut-off), it is obvious that the seat will be worn more in the middle of its length than at the ends, as the ordinary engine is run hooked back more than at full stroke, and therefore the valve may be and is generally tighter at one point (when traveling short) than when traveling full stroke. To determine the position of a blow understandingly involves a knowledge of valve motion. Blows sometimes occur that no ordinary test will place. The writer remembers one of this character. An engine, after running for some time, began to blow badly. It was evident, from the heaviness of the blow, that it was not in the valve. The engine was reported as having the rings down on the right hand side. An examination showed that such was not the case. The cylinder-head and chest cover were removed, and the opening of the port into the cylinder closed nicely with a piece of pine. The valve being removed, the port from the steam-chest was filled with water. It was evident that as the wood was water-tight and did not leak, and as the level of the water in the port soon lowered, that there was a leak somewhere. Examination showed a sand hole from the steam to the exhaust port. False seats will get loose and cause blows. Cylinder packing should be set out when the engine is hot. The best lubricant for valves and cylinders is plumbago and tallow.

PUMPS.

Locomotive pumps are generally driven direct from the cross-head; although in certain classes of engines the pump is bolted to the footboard and is driven generally by an overhanging crank from the back pin. Others are hung beneath the boiler and driven from an eccentric on the main shaft. The lift of pump-valves depends altogether on their diameter—larger valves requiring a decreased lift to give the required area of opening. In any case the lift of the valve ought to give an area for water passage, at least equal to end area of plunger. This is not always the case, however. A valve with large water passages, will make an easy working pump. Generally the lift of the bottom valve varies from 1-8 to 3-16, the middle valve from 3-16 to 5-16 and the check from 3-8 to 1-2 inch. The lift is, or should be, entirely dependent on the diameter of valve. In some pumps the joints are extremely difficult to keep tight. This is due to contracted water passages, somewhere, it may be, in the middle valve or check; but when this occurs in a pump that had not before given any bother in this respect, the trouble will be found in the liming up of the hole from the check casting to the boiler. When a pump refuses to work and it is not from a "stuck" or "cocked" check, the trouble will generally be found in the bottom-valve—a chip or something under it. A "stuck" check-valve will generally reseat from a few taps of a hammer. This failing, the tank-valve may be opened, allowing the feed-pipe to fill with water, when the lazy cock may be shut off and the heater-cock opened. The pump will generally go to work then; if not, repeat the operation. The philosophy of this is, that when the check is "stuck" the hot water from the boiler descends to the top valve of the pump, heating it up to such a degree as to form a partial vapor from the water left in the pump barrel. This vapor fills the vacuum due to the action of the plunger and prevents the water in the feed-pipe from entering the pump barrel. Filling the feed-pipe with water from the tank, and then applying the heater, forces the water forward of the heater-pipe in the feed-pipe, into the pump barrel, which is then forced by the plunger up to the check-valve, cooling and cleaning it, and allowing it to reseat. It is a good plan to use the left-hand pump daily a little, to keep its packing soft, so that it may be ready when needed. A good pump is a valuable acquisition.

A pump should not be alternately pulled on wide open, and, when three gauges show up, be shut clear off. A pump should be gauged to supply the amount of water evaporated by the boiler. This regularity of pumping will cause less fuel to be burned, will keep the flues tighter longer, and an engine that will steam at all will do so with regular pumping. The alternate pulling on and shutting off of the pump causes the temperature in the boiler to be continually varying, keeps the metal of the boiler constantly expanding and braced boilers, in a fracture and probable explosion. All engines will steam better when full of water, the reason being that the larger quantity of water contains more heat and is less affected by the incoming feed-water from the pump. The pump should be shut off when the engine is not using steam, as the draught through the flues from the exhaust is then wanting, and as no large amount of heat is passing into the water the feed from the pump cools the boiler too suddenly. Forcing water into the boiler when the engine is not making steam, unless it be in very small quantities, acts like the alternate pulling on and shutting off of the pump, and a set of tight flues may be a set of leaky flues by the operation. Sudden changes of any kind in a boiler are detrimental. Every engineer ought to know the distance from the bottom gauge to the crown-sheet; one gauge of water in one boiler is frequently altogether another thing from the same expression applied to another boiler. This distance can be found by measuring with a stick from the inside of the fire-box door to the crown-sheet, and then repeating the operation from the outside of the door on the boiler-head, adding the thickness of the crown-sheet. It is sometimes necessary to favor an engine on a hill by shutting off the pump entirely; this, of course, interferes should be paid to the pumps. It should not be taken for granted that because a heater keeps a pump from freezing at the beginning of a trip, that it will continue to do so throughout. It should be examined frequently, to see that steam is issuing from the pet cock. It is not generally necessary to put the heater on to the right-hand pump when taking water at a station; this, of course, depends on the weather, and the exposed condition of the engine. In case an engine is to be left cold out in the weather in winter, the joints of the pumps should be broken to prevent any water that may leak into the pumps from freezing in a confined space. It is a trite saying among engineers who have had experience in the matter, that "hard" water will burst the best pump. A frozen pump may be thawed out by burning greasy waste on it. A pump should not be packed too tight; it will do better service if some elasticity is left in the packing.

MAIN RODS.

The keying-up of the rods of an engine is a subject not generally understood, and requires considerable judgment. When an engine comes out of the shop, the length of the main rod should be such as to give equal clearance at each end of the cylinder. When this is the case, the cross-head will travel equally past the travel slots in the guides, if correctly located. Assuming that this is the case, the engineer should keep the rod as near that length as possible. If, however, he has neglected to do so, or is given charge of an engine in which the former engineer had neglected it, the proper course for him to pursue is as follows: The travel slots in the guides should be so located that when the rod is of the proper length, the cross-head will travel an equal distance past each (usually one-half the width of the slot). If there is any doubt as to the proper location of these slots, the main rod may be taken down and the cross-head pinched clear ahead, till the piston strikes the cylinder-head. A mark should now be made on the guides even with the forward end of cross-head. The same operation should be repeated for the back end. If these marks are each equally distant from the travel slots, they are correctly situated and can henceforth be used as guides to key the length of the rod to. If they are not, it is clearly evident that the man who located them had no idea of their use. It may not be out of place here to state their use. These slots perform the same office for the cross-head that the counter-bore in the cylinder does for the length, the end of the cross-head will just travel past the edge of each slot; hence, no shoulder can be formed by wear on the guide for the cross-head to strike against. A great many engineers will tell you, that these slots are to lead off the oil forced to the ends of the guides by the cross-head.

After ascertaining that the travel slots are in the right position, alter the length of the rod so as to allow the cross-head to pass each equally. As most main rods have but two keys, and both inside, the driving of either will lengthen the rod. Having ascertained that the main rod needs keying-up, take it down, having first placed the engine on the centre on that side. Now caliper the pin, and if much out of true, have it corrected with a file. Pins wear smaller across the horizontal diameter when the pin is on either quarter, as the force transmitted by the piston is greatest at that point; for this reason the rod should be keyed-up on the centre, or across the greatest diameter, as, if keyed on the smaller diameter, they would evidently bind on the greater. Having calipered the pin across the greatest diameter, take this distance in a pair of inside calipers, and having removed the brasses from the straps, place them together, "brass and brass." Now by calipering them with the inside calipers, the amount to be filed off will be indicated by the distance the inside calipers lack of equaling the crank-pin hole in brasses, remembering that half the difference, as indicated by the inside calipers, comes off of each brass. The edges of each brass, as shown in fig. 1, at *a*, *a*

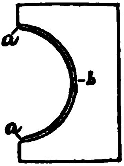

Fig 1

and *b*, should be rounded or backed off with the file for about ¼ of an inch. If left square the edges are ragged, and these projections will cause excessive heat and friction. Having filed almost as much off of the brasses, to let them together, as is indicated by the calipers, place them in the strap and on the pin, not using the rod at all, driving the key till they are "brass and brass," and if found loose enough then to revolve easily by hand, they may be called finished; if not, a trifle more will have to come off of their edges. When the boxes are just right, the key may be slacked back till the joint line of the brasses stands even with the centre of the oil hole in the strap. If the rod is correctly made, its length will be just right then to give the cross-head correct travel as regards the travel slots in the guides

The key should be marked even with the strap. Now, by loosening up the key, the boxes may be shifted toward the open end of the strap and a piece of stiff putty, as big as the end of a man's finger, placed on the crown of the strap inside, and the key again driven down to the mark on it. This will bring the brasses "brass and brass," and the thickness of the liners necessary to be put in will be indicated by the thickness of the putty. The forward end of the rod may be adjusted similarly, and the rod then put up. Now by pinching the engine past the centres, the rod should be of the right length; that is, the cross-head should pass the travel slots equally. If it does not, the rod will have to be lengthened or shortened by taking out or putting in liners, till the proper length of the rod is obtained. The rod can be maintained of this length by always dividing the wear on the one side by a liner and on the other by the key. Brasses should never be filed apart; that is, when properly adjusted on the pin, there should be no space between them. They should be filed only enough to bear properly on the pin, and still be "brass and brass," at their joint line. This involves the taking down of the rod when it is necessary to key it up; but brasses will not wear as fast nor heat as quick when "brass and brass," and have, moreover, all

Draw-strap rods, that is those rods in which the driving of the key draws the strap on to the stub end of rod, and in which the bolts fastening strap to stub end must be loosened first, require no special remarks, excepting that in driving the key the rod is shortened, instead of lengthened as in the ordinary rod. In keying-up these rods it is best to insert lines between stub end of rod and brasses for half the wear, and drive the key for the other half. This will keep the rod of one length. The engine should be hot when keying rods or making any other adjustment effected by the expansion of the engine.

SIDE-RODS.

The office of side or parallel rods is evidently to transmit a portion of the piston force to the back drivers, in order that the rail may not suffer from the excessive weight of engine, as it would if thrown on a single pair of drivers. If the back drivers are not in line with the front drivers, or if there is a difference in the size of the driving-wheels, it is evident that the side-rods will suffer therefrom. Therefore, if either of the above faults exist it is making a bad matter worse to key-up the rods, as the very looseness of the rods will accommodate, to an extent, these faults. Theoretically, perfection in side-rods assumes that the rotation of each pin is in the same plane; in other words, that the drivers are square with each other, that the centres of rotation are always in direct line with each other; that is, that there is no spot on the rail, out of line vertically, with another spot the length of the centres of the drivers apart, as it is evident that if one driver lowers or raises, it changes the distance between the wheel centres, and therefore on a rough road the side-rods should be rather loose to accommodate inequalities in the rail; and, lastly, that there is no lost motion in driving-boxes; hence, before keying-up the side-rods, it is evident that the wedges should be up snug. After setting up the wedges and tramming the wheel centres, which should be equalized, the tram may be placed on the pin centres. Now, if the rods were very loose, the back pins will be later or behind in their position, as compared with the forward ones by what lost motion there is in the side-rods; hence, the back drivers will have to be slipped till the pin centres tram. This can best be effected by taking the weight off of the drivers with a pair of jacks under the foot-board. The side on which the keying-up is done should be on the centre, for the same reason as given for the main rod. The side-rods being down, the engine may be trammed; the brasses of each end should be filed so as to be a proper fit on the pin and "brass and brass" when keyed-up, as explained for the main rod brasses. The forward strap should then be put up on to the pin and the joint line of the boxes made to coincide with oil hole in strap as for the main rod, liners being put in forward of the box, and the key driven for the back box to effect this. The key should be marked next the strap and the rod put up, and the back end of rod adjusted so that the rod can be shifted sidewise by hand.

The rod being loose enough to move sidewise proves that neither key has a tendency to wedge apart or draw together the pins, and the boxes having been tried on the pins in the straps, and being "brass and brass," does away with any question as to their tightness. Briefly, the operation is this: The pins being corrected by the tram, are the right distance apart, because they equal the distance between the wheel centres. The forward end of the rod being put up, it alone remains to shift the back boxes in their strap with the keys till they coincide with the pin, or practically, till the rod can be shaken slightly with both hands.

When, as is seldom the case, the rod has four keys, the keying-up is the same—the forward key of the forward end of the rod taking the place of the liners. There is another plan much in use on rods with three keys. The keys in the back end of the rod are slacked back, and the key to the front end is driven, forcing the box it bears on up to the pin, and then the entire rod back. This draws the front box of the forward end up to the pin, and also forces the front box of the back end to the pin (providing it has worn equally with the forward boxes). The front boxes being keyed, it alone remains to adjust the back brass. In this plan, the back key of the back end goes down twice as fast as the others, as it has not only the wear of its brass to take up, but that also of the forward end, which is thrown on to it when the entire rod shifts back. This plan is not specially objectionable when the brasses are left "brass and brass;" if they are left apart, hot pins will be the result generally. The brasses, in all cases, should be "brass and brass," as they will run longer and be more satisfactory in all respects. The writer remembers a case, in which the engineer, adhering rigidly to the "brass and brass" plan, found it necessary to key his rods once only in from twenty to twenty-four months.

Ten-wheel engines should be keyed as the ordinary eight-wheel engine; that is, they should be first trammed, the wedges being right, and then each side-rod keyed as already described, commencing with the forward side-rod and working back. Ten-wheelers, when doing yard service, radius, will need looser side-rods than otherwise, to accommodate the long-wheel base.

WEDGES.

The wedges of an engine are probably as ticklish a thing as the average engineer cares to handle. Where engines have wedges forward and back of each box, a very little unskilled handling will leave an engine pretty thoroughly mixed up. In such engines the engineer should never touch the front wedges. Loose wedges are indicated by the heavy thumps when the engine is running, and can be located by getting under the engine, which may be on the quarter, giving a little steam and having the reverse lever worked from end to end of quadrant, which will alternately transfer the pressure from one end of the piston to the other. This will cause the box to move to the extent of the lost motion, which can be either seen or felt. The tender brake should be set during the preceding test for the wedges. With those wedges in which a T-headed adjusting screw slips into a slot in the bottom of the wedge, screwing through the pedestal, it is customary to force the wedge up pretty snug with a ten or twelve inch wrench, and then slack it off a turn or two, as in the squareness of the drivers with the frames is determined by the wedges, it may not be out of place to discuss that point here. It is a common plan to find a point on either the back side of the centre-pin plate or bed-plate of the engine, midway between the cylinder centres; and placing one point of a stick with a tram point in one end in this point, bring the other end to the edge of shoe on forward side of forward jaw, mark it, and repeat the operation on the opposite side, comparing the point where it touches this shoe with the mark made from the first shoe. This plan assumes that each cylinder centre is exactly the same distance removed from the inside face of shoe. Evidently this may or may not be the case. The plan illustrated in Fig. 2 will be found better, I think.

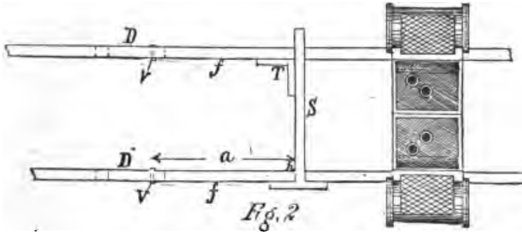

Fig. 2

Measure any convenient distance, as *a*, from the face of forward shoe toward front end on frame, and make a mark as at *h*. Repeat the operation the inside of frame to the top, and with a T square of known truth place as shown at *S*. If the same edge of T square blade coincides with the marks on both frames the jaws are square with each other. In place of the T square a line or straight-edge may be used and a try-square placed inside of frame and tried with the straight-edge or line. In Fig. 2, *f*, *f*, are the frames, *D*, *D*, jaws, and *v*, *v*, shoes. This plan assumes that the frames are planed and are true. If they were not, that is, were sprung out of truth, it would be a job for the gang boss, and not the engineer. Fig. 3 is intended to illustrate

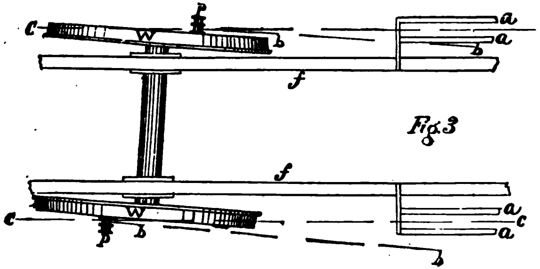

Fig. 3

a short-hand method of trying the squareness of the driving-wheels with the frames. Disconnect the forward end of main rod and key the back end up so as to leave no lost motion. Now place the boxes in the forward end of strap and replace the strap on the rod end. Having the cross-head at one end of stroke, lower the rod end on to the cross-head and see if the sides of the strap and boxes are true with the cross-head, that is, would drop squarely on to the cross-head wrist. Now, if the jaws were out of square it would throw the drivers *W* as shown in Fig. 3. The sketch is greatly exaggerated in order to show the idea clearly. If the rod fails to "lead" correctly to the cross-head, as shown in Fig. 4, something is out of square. It

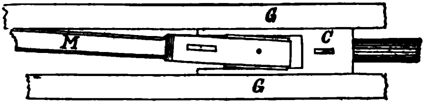

Fig. 4

could be the jaws, as shown in Fig. 3 the line *b*, *b*, representing the centre line of rod *a*, *a*, *a*, *a*, the guides, showing where it would lead as compared with centre line of cylinder *c*, *c*, and also comparing with cross-head, as in Fig. 4. The pin might be bent as shown in Fig. 7. Whether it was a bent pin or a want of squareness in the frames, would be indicated by the fact, that if a bent pin, the forward end of main rod would alternately pass from side to side of the centre line of cylinder, as in Fig. 7. On one centre the rod would lead toward the outside of cross-head, on the other toward the inside. If it were the jaws, the rod would *constantly* lead to one side of cylinder centre either in or

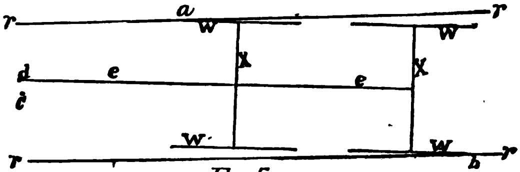

Fig. 5

out, depending on which side of the engine was being tried. Fig. 5 shows the effect of the centre-pin being out of line with the centre line

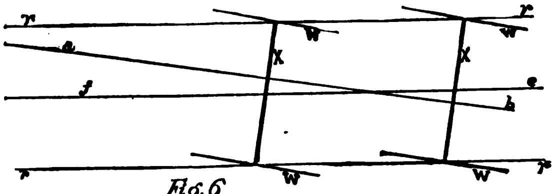

Fig. 6

of engine, *e e ; c* being the correct position of pin and *d* the incorrect position. This condition of affairs evidently throws the forward driver flange against the rail *r* at *a*, and the back driver flange against the rail at *b*; *W W* being the driver flanges and *X* the axle. An engine with centre-pin out of true will indicate it by wearing the forward driver flange on one side, and the back driver flange on the other side. The remedy would be to throw the truck to the side the front driver cuts on, or the head of the engine away from that side. Fig. 6 shows a condition of affairs that frequently puzzles engineers.

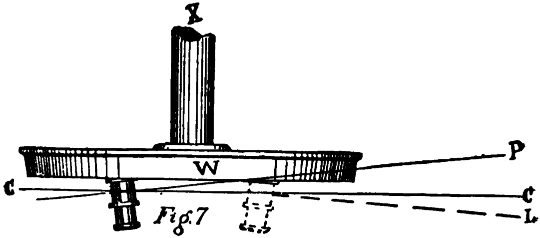

Fig. 7

The jaws are out of square, or, in other words, one side of the engine is further ahead than the other. This would be indicated by both driving flanges cutting or wearing altogether on one side. *W W* are the driver flanges, *r r* the rail, *f e* centre line of engine, and *a b* direction wheels intend to roll in. The wheels being skewed under the engine, they tend to roll to one side, that is to mount the rail continually, and consequently cut

SETTING VALVES.

Although the setting of a locomotive's valves, is not, strictly speaking within the province of the engineer's duties, it will do him no harm to know how. It is first necessary to get the engine on the dead centre. This is usually accomplished as follows: Pinch the engine till the cross-head is within two or three inches of the end of its travel, then with a short tram (seven or eight inches in length), one leg of which is placed in a prick punch mark in the wheel-guard, make a mark with the other leg on the side of the tire of the forward driving-wheel. Now pinch the engine till the cross-head reaches the centre, of which it was within two or three inches, and passes it on the return stroke, to an exactly equal distance (two or three inches) as when the first mark was made on the tire. With the leg of the tram in the centrepunch mark on the wheel guard as before, make another mark with the other leg on the tire as before. Find the centre between the two marks on the tire and mark it lightly with a prick punch. Now pinch the engine till the leg of the tram falls into this centre mark and the engine is on the centre at that end. Repeat the operation on the other end of guides, and also on the other side of engine. A much the engine with the cross-head within a few inches of the end of its travel, then with a lamp or candle smoke the piston-rod for a short distance. Hold a scriber firmly on the guides, the end bearing on the smoked portion of the rod. Now by pinching the engine till the cross-head reaches and passes the centre, a line will be drawn by the scriber in the soot on the piston-rod. If we now pinch the engine back till the scriber just reaches the end of the line in the soot the engine is on the centre for all practical purposes. We may now ascertain the correct length of the valve-stem. This may be done by placing the valve exactly over the centre of the ports and then lengthen or shorten the valve-stem till the upper arm of the rocker-shaft is at right angles with the valve-stem. We have now to ascertain the length of the eccentric-rods. This may be done by fastening the eccentrics (regardless of their position) and pinching the engine (the reverse lever being in full motion, depending on which eccentric-rod is being corrected) till it is ascertained whether one port is opened wider than the other. If so, lengthen or shorten the eccentric-rod till the valve opens each port about equal. This approximaces the correct length of the rod. The engine may now be placed on either centre. It will be necessary to state here that engines with rocker-shafts, the belly of the go-ahead eccentric, is nearly at right-angles with the crank-pin, and is behind it, or in other words, *follows* the crank-pin when the engine is going ahead. The back-up eccentric similarly, is nearly at right-angles with the crank-pin and *follows* it when the engine is backing up Now, having the approximate length of the eccentric-rod and the engine on the centre, and assuming that it is the go-ahead eccentric that we are setting, we shift the eccentric till the proper amount of lead appears and again fasten the eccentric, noting that the full part of the belly of the eccentric is in such a position as to follow the pin; that is, if the engine was on the forward centre (the lever being in the go-ahead motion) the full part of the eccentric would be *up* and slightly inclined to the pin. Pinch the engine on to the other centre and note the lead, lengthen or shorten the eccentric-rod *half* the difference of the lead, and when the lead is equal on each end fasten the eccentric, unless there should be too much or too little lead, in which case shift the eccentric till the required amount of lead is obtained. That is, shift the eccentric *to* the pin for more lead and *from* it for less lead. Briefly, this plan ascertains the correct length of the valve-stem at once, and leaves all changes to be made in approximately squaring the valve to the lengthening or shortening of the eccentric-rod. When the valve opens each port equally, the engine is placed on the centre, the eccentric shifted into position to give the required amount of lead, and the inequality of the lead, or the difference which it varies on one end from the other, adjusted by lengthening or shortening the eccentric-rod. It is frequently the practice, and a good plan, too, after getting the correct length of the valve-stem, to pull the valve to one end, having placed a piece of thin tin in the port, the valve just touching it. Then with a tram about six inches in length, one leg on the stuffing-box (not the gland), make a mark with the other on the valve-stem. Insert the tin in the other port and push the valve up to it, and make another mark on the valve-stem with the tram. The chest cover can now be put on, as the relative position of the valve and the edges of the ports have now been transferred to the stem outside, and the subsequent adjustment can be made by use of the tram. That is, in squaring the valve by the eccentric-rod, it would be necessary to see that the marks on the valve-stem passed the point of the tram equally, etc. Having set one eccentric, the other may be set. The first eccentric set should then be run over again, as it will probably be changed somewhat. The valve-stem being of the right length for one motion, is the right length for the other, and in setting the second eccentric the valve-stem's length should not be changed, the changes being made entirely in the eccentric-rod. The preceding may be performed while the engine is cold; but when the engine is hot, the valve points should be run over again (by means of the tram), as the expansion will have affected the former adjustment. There are other points, such as seeing that the links lift alike, the length of the reach-rod, marking the quadrant, etc., etc., that the engineer has nothing to do with, and hence they are not treated of here.

TIRES.

There is little to be said about tires, save that a difference in size will cause pounding, hot pins and cut flanges. Tires wear out of size from difference in hardness. Steel tires are frequently run down to $1\frac{1}{4}$ or $1\frac{1}{2}$ inches in thickness before being removed, when they become difficult to keep tight and should be removed.

COUNTER-BALANCING.

An engine not properly counter-balanced will indicate it by surging and rough riding; also, by the jerking between the tender and engine, if the buffer-spring is slack. The correction of this is not properly a part of the engineer's business. The subject is scientifically treated in D. K. Clark's "Railway Machinery," which will be found re-printed in Forney's work on the Locomotive. The following mode will be found to give satisfactory results: Ascertain the weight of the side-rod, main rod, cross-head and piston of one side, placing two-thirds of this on the forward driver and one-third on the back driver. To do this the wheels should be from under the engine. Two pieces of wrought iron, planed true, about 1 in. square and two or three feet long, should be bolted to the top of two wooden horses. These should be placed so as to allow of the journals of the driver bearing on them; they should also be leveled. The wheels being placed on the horses which are high enough to keep the wheels clear of the floor, weights equal to 2-3 of side and main rod cross-head and piston of one side are hung on to the crank-pin (assuming that it is the forward wheels which are being balanced). Now cut from a thin piece of wood a template of the shape of the permanent counter-balance (wedge shape to fit between the spokes), and hang it by a string from one corner; where this string (which should be allowed to hang down past one side of the template with a nut on the end to keep it taut) crosses a central line drawn lengthwise of the template, dividing it into two equal portions, is the centre of gravity, which should be marked. The template should now be placed in between the spokes, in the position it is to occupy, and the centre of gravity marked on the spokes. Trial-weights should then be hung by a chain from this centre of gravity on the spoke till the weight on the crank-pin is balanced. The weight of these trial-weights is the weight of the permanent counter-balance. If two permanent counter-balances are used, they will both represent one-half of the trial-weights, and if three, they will each be one-third of the trial-weights. If it is desired to use three weights (between different spokes), and in casting them solid they would be too heavy, the pattern should be hollowed out on the inside to make their combined weight equal to the trial-weights. If the trial-weights are cast-iron, the cubic inches in them can easily be obtained by placing them in a square box of water, noting the height of the water before and after they are put into it. Then by multiplying the length by the breadth of the box (inside) by the amount the water has been raised by the weights, the product will equal the cubic inches. By making the thickness of the permanent weights such as to equal in cubic inches that of the trial-weights, they will be right. The same plan applies to the back drivers, save but one-third of the side, main rod, etc., is hung to the crank-pin. Each side of the engine should, of course, be counter-balanced, using the weight as found for one side for the weight of the counter-balance for the other

NOZZLES AND PETTICOAT PIPE.

Double nozzles will give better satisfaction than a single nozzle. The indicator shows that the single nozzle has a tendency to increase the back pressure, the reaction of the exhaust from one cylinder causing a portion of it to shoot over into the exhaust-pipe of the other cylinder. Exhaust-nozzles should be worked as large as possible, as decreasing their size increases the back pressure.

The object of the petticoat pipe is to equalize the effect of the exhaust through the flues; that is, to cause each flue to conduct its portion of the heat and flame. If the petticoat pipe is too high, the exhaust affects the draft through the lower flues to a greater extent than the upper; that is, it is a shorter cut for the gases through the bottom of the petticoat pipe than the upper part, and therefore the bulk of the gases passes through the bottom flues, the top ones becoming the receptacle for fine ashes, the result being that the engine fails to steam freely for want of a proper the petticoat pipe be too low, the top flues do the work, the bottom ones becoming filled with ashes, etc. When it is properly set, the flame will divide itself evenly through each flue, as can be seen by opening the fire-box door, and after a short run by opening the front end and looking through the flues, the fire-box door being open, or a lamp held in the fire-box, noticing if each flue is clean, or some partially filled with ashes. If the flues keep clean the petticoat pipe is right, and if the engine fails to steam the fault is somewhere else, as the cleanness of the flues proves that the petticoat pipe has fulfilled its office perfectly. When an engine tears up the fire, carrying large pieces through the flues, the nozzles are too small, and by readjusting the petticoat pipe so as to get each flue to do its portion of the work, the nozzles can be enlarged, relieving the engine of much back pressure and effecting economy in the fuel account of the engine. It is not infrequent to see engines with sufficient heating and grate surface, throwing fire and large chunks of unburned fuel from the stack; the fault lying first with the master mechanic, who probably has no idea of the use of the petticoat pipe, and has therefore had the pipe adjusted by guess, or as some other engine that did well, notwithstanding that the conditions were run and fails to steam. The master mechanic says the petticoat pipe is right because it is like the one in the other engine that *is* all right; so the nozzles are decreased, and half the fuel thrown into the fire-box is pulled through a few flues, unburnt, by the sharp exhaust. She steams, but at what an expense? An engine with sufficient heating-surface, petticoat pipe right, nozzles as large as possible, and a large grate, so that the combustion may be slower, and therefore, more perfect, will make the best showing.

THE SMOKE-STACK.

The stack is generally made equal in diameter to the cylinder and of different heights. The exhaust fills the stack, acting like a plunger in a pump, which as it ascends through the stack, creates a vacuum behind it in the smoke-box, the atmosphere having only access then to it through the ash-pan, fire-box and flues, rushes through them to fill the vacauum thus creating a forced draft and combustion. When stacks are seen contracted or smaller at half their height, it may be set down as a fact that the petticoat pipe, heating or grate surface, or valve motion, is badly proportioned. Such devices are the outgrowth of ignorance and are mistakes to correct mistakes.

cessively, or the stack at all, there has been a mistake made somewhere else.

With large grate-surface, correct petticoat pipe and good valve-motion, large nozzles and small cones in stacks can be used. Engines smoke around the fire-box door when the cone is too large, set too low, the netting too fine, or the stack too small in diameter. In a great many cases these faults grow out of a faulty petticoat pipe. That is, when only a portion of the flues are doing the work the nozzles are decreased to increase the draft; the engine then throws fire, a larger cone is put in, or the old one lowered to correct the fire-throwing propensity; the result is that the draft is choked and the gases seek to escape the shortest possible way, which is around and at the door. It is important that the door in the front end, as well as the entire smoke-box, be as tight as possible so as not to injure the vacuum produced by the exhaust.

LUBRICATION.

Friction is the result of the interlocking of minute projections on the bearings. Under the microscope a cambric needle looks like a rusty crowbar. The finest finished bearing is composed of depressions and elevations on the surface. The interlocking, for instance, of the projections on a driving-axle with the depressions in the driving-box and *vice versa* is friction. Oiling a bearing floats the surfaces apart, so that the projections pass each other without touching materially. When a bearing runs dry, there is nothing to prevent the surfaces interlocking like a pair of gears; the tearing off of the minute teeth is known as "cutting."

A very small quantity of oil is necessary to properly lubricate a journal, if fed to it continuously. The occasional oiling from an oil-can wastes one-half the oil.

Hot bearings are an annoyance of considerable magnitude to the engineer, and it requires good judgment to get along with them. One of the chief causes of hot bearings is dirt. Engineers will frequently fool away hours of time with a hot bearing, alternately running a few miles and stopping to pour water over it, when, if they would (if possible) disconnect the bearing so as to clean it thoroughly, they could put an end to the matter. The boxes should be slacked off if too tight, but not too slack, as a very loose bearing will heat as quickly almost as a tight one. If side or main rods heat from being out of line, it is better to disconnect them, as they will continue to heat till lined up.

One of the best, in fact, the best remedy, for a hot bearing is plumbago. The writer has seen bearings that ran hot continuously and others which were so bad that it was impossible to run them at all with ordinary lubricators, go off as cool as could be wished for when lubricated with oil and plumbago. It will pay any engineer who is bothered with hot pins, etc., to carry a small quantity at his own expense, if the master mechanic will not furnish it. It is necessary to use the pure article, and the writer is aware of only one concern where it can be obtained—The Dixon Crucible Company, Jersey City, N. J. Fed to a cylinder occasionally causes it to resemble a looking-glass in smoothness and brightness, and a new engine or new pins, etc., if lubricated with it run as cool as bearings which have run long enough to get down to a "bearing." Once used, and the engineer will wonder how he ever railroaded without it.

SLIPPING.

An engine chronically affected with slipping causes even religious engineers to indulge in mild profanity. A dirty rail will make any engine slip; but those engines which slip for the fun of the thing will generally be found with chilled cast-iron tires, very hard steel tires, short driving wheel base, or too much cylinder. Tires that have been run so long as to have the tread worn hollowing, so as to fit the top of the rail, are apt to slip. The reason being that the rail at all times is covered with a light coating of dirt, etc.; the tire fitting the rail has too much surface on it, the weight on the wheel being insufficient to crush the coating of dirt out from under it; sand being used to grind the face of the rail clean, which allows the metal of the tire to come into direct contact with the rail, the projections on it taking hold of those on the rail, like gears, when the engine ceases to slip. With new tires, the bearing on the rail is smaller, and the weight being concentrated on a small space crushes the dirt away, and the tire comes into direct contact with the rail.

When the rail gets into a condition that an engine not given to slipping slips almost continuously, it can be mitigated to a great extent by dropping the reverse-lever down a notch or two, and easing off the throttle. The pressure in the cylinder will then be more nearly equal throughout the stroke, the piston not being subjected to such an extensive varying pressure as when the links are "hooked" up, and the engine cutting off short.

RUNNING AN ENGINE ECONOMICALLY.

The principal points to be looked to on the part of the engineer for an economical performance on the part of his engine, is a high water-line, high steam pressure and short cut-off. As the correct manner of firing engines is pretty thoroughly understood—a heavy fire with anthracite coal, a light open fire frequently supplied with soft, or bituminous coal, air being supplied either through hollow stay-bolts or the door, in quantities sufficient to keep down the heavy black smoke that is to burn it before the gases fall to the temperature of visible smoke, and a fire even with the door with wood—it will not be discussed here.

A high water-line is economical, because a boiler full of water contains more heat, hence it does not feel the incoming feed from the pump ; the steam pressure will not drop as quick, because there is a greater mass of water which must change its temperature before this can occur, and evidently a large quantity of water will loose its heat slower than a smaller quantity. A high steam pressure is economical, because the amount of heat and water does not increase in the same ratio as the pressure. That is, steam at a pressure of 100 lbs., does not contain twice as much heat and water as steam at 50 lbs., but proportionately less, hence the higher pressure is best, because, though we have doubled the effective force (by increasing its pressure from 50 lbs. to 100 lbs.) we have not used twice the amount of water nor heat to accomplished the result. The high pressure also gives a greater degree of expansive force. Theoretically the higher pressure steam enters a cylinder and the lower it leaves it gives the greatest amount of work performed for the quantity of live steam used. This is, of course, accomplished by cutting it off as close and at as high a pressure as possible. There is, however, a point beyond which it is not economy to go in point of cut-off, owing to the rapid cooling of the steam entering by the cylinder, which had been cooled below the temperature of the incoming steam, by the loss of heat due to the expansion of the steam of the previous stroke. This point varies from 1-4 to 1-6 of the stroke dependent on the steam pressure. In link-motion engines the closest point of cut-off is also limited at about 1-4 of the stroke by wire drawing, etc., of the steam from the limited port opening. The engineer who wants to make a good showing for his engine will run with the throttle as wide open as possible, controlling the speed as far as possible by the reverse-lever and changing the throttle only when absolutely necessary. There is no doubt on this point, although it has been stated on what ought to be good authority that the speed of the train should be controlled by the throttle. Closing the throttle wire-draws the steam; that is, allowed to pass, and it has been repeatedly proved on the best automatic cut-off stationary engines in the United States that any thing having a tendency to wire-draw the steam detracted from the economy of the engine. In fact, the wonderfully economical stationary engines—Buckeye, Corliss, etc.—owe their superiority to the fact that their speed is automatically regulated by the point of cut-off and not by the common throttling governor. What is true, therefore, so far as the principle of expansion is concerned, in the stationary engine is also true in the locomotive. This point has also been determined by an actual trial on the locomotive.

Another point to be looked after is not to allow an engine to be "blowed out" while hot. This will leave the boiler and flues as hot as the water blowed out. The result being that any soft lime or scale that may be on the flues or boiler is baked on as hard as stone by the heat of the flues, etc. The better plan is to blow a gauge of water out while on the road if possible and bring her into the house with three gauges, which may also be blown out under steam pressure. Any scale that would be removed by blowing would now be removed. The boiler should then be allowed to stand over night, if possible, when the remaining water (all but the three gauges leave the scale and mud soft, when it can be washed out by the hose and water pressure. An engine's fuel account will soon increase if the mud and scale is baked on every time she is washed out.

MISCELLANEOUS ITEMS.

Engineers notice that the link engine when "hooked up" will be clear of a pound, which is very plain if the engine is dropped down full stroke. This is due to the great compression resulting from hooking the link up. That is, the exhaust is closed so early in the stroke that there is a greater amount of steam pressure in between the piston and cylinder-head with no means of escape, than when the engine is running full stroke. This steam is compressed or squeezed between the advancing piston, which acts as a cushion, taking up gradually the lost motion and reducing the pound.

In reversing an engine, when from any cause the shortest possible stop is necessary to be made, the engine is holding back with the greatest effect when the drivers are just ready to slip, but still revolve in the direction the engine is going. When slipping, the minute projections on tire and rail are torn off. Any one who has ever overloaded, has probably been astonished at the short time it requires to strip the teeth when it has once begun. The reason is that as soon as a single tooth is stripped, the driving-gear gathers momentum through the space which the broken tooth occupied, and strikes the next tooth with a blow which generally breaks it, and so on with the balance of the teeth. The same is true of the driving-wheel; when it slips it strips the projections spoken of and fails to be as effective in resisting the momentum of the engine.

This is also illustrated in chipping. When the chisel is struck by the hammer, the force or work in the hammer is applied instantaneously, and, owing to its speed, the effect is seen in the chisel cutting the metal. If the same force was applied with less speed, that is, if a person were to push on the chisel with the same force as the hammer struck it, it is evident that no chips would be cut off, owing to the effect of the push having time to diffuse itself over greater space. It is not all applied at one point, as is the result of the hammer. So with the driving-wheels when revolving with the speed of the engine; the tire obtains a bite or grip on the rail, which is effective in offering resistance; if the wheel slips, the force is applied too quick, and the face of the rail is stripped, like the chips from the chisel.

The foaming of a boiler is the result of some foreign substance in the water, such as grease, etc. A boiler with too small a steam space will raise her water, sometimes a gauge and a half to two gauges, but this is not foaming. Pumping and blowing will change the water in the boiler; however, if the trouble is in the water in the tank, the engineer must "grin and bear it." The true level of the water can be found by shutting the engine off entirely and pulling the safety-valve lever down, so as to shut off all escape of steam, and the water will at once settle down to its natural level, which may be ascertained by the gauge cocks or glass gauge. An engine may continue to foam slightly, even after every escape for steam is shut off, if the fire is very intense. When this is the case, the damper should be dropped for a minute or two before shutting off, to try the water.

If the exhaust fails to clean the front end of cinders, the petticoat pipe should be dropped a little; not too much, however, as it may throw the flame and smoke through the top flues. When the petticoat pipe is made right to suit the engine (generally with two skirts), and set so as to equalize the draft through the flues, the front end will keep clean.

When a crack or leak appears in any part of the boiler not in direct contact with the fire, it is a sign of distress, and should be examined at once

It means that a stay-bolt is broken, a brace wasted away, the sheet corroded to a dangerous thinness, etc. Like the rattle of a rattlesnake, a warning is given to those who know enough to heed it. A leak is a symptom of disease, of a weakness, and when this occurs in the outside fire-box sheet, it should be attended to at once, as a blow-out will certainly follow in time.

The pounding of side and main rods has been treated of under the heading of "Side Rods" etc. Side rods, if *very* loose, will pound by throwing themselves on the pins when passing the centres. An engine may pound for want of lead or compression, when running at full stroke or nearly so. As stated before, hooking a link engine up, takes the "pound" out of them. The piston may be loose on the rod, or the piston-rod loose on the cross-head; the main rod may be too long or too short, and the piston-head strike the cylinder-heads. The cylinder itself may be loose on the frame, or the frame, if a splice frame, loose at the splice. If the pins are bent, the wheels out of tram, or the rods out of line, the result will be a pound. An engine, after being off the track, will frequently pound from a sprung axle, rod or frame.

ACCIDENTS ON THE ROAD.

If an engine gets off of the track, it is necessary to pull her fire at once if the crown-sheet or flues are uncovered. Shoveling green sod or earth into the fire-box will smother out the fire. If the engine cannot be replaced without the help of another engine, the side and main rods should be disconnected to prevent their being sprung, etc. As a general thing an engine will go back on to the track more easily the way she came off.

In case of a broken side-rod, disconnect the broken rod and the opposite rod also. This is all that is necessary. The necessity for taking down the opposite rod is this : if only the broken rod were removed, and the pin on that side was on either quarter, the pin on the opposite side being on the centre could not start the back drivers through its side-rod, in case the front wheel slipped slightly on the start. The result being that the back drivers not being compelled to slip with the front ones would remain nearly stationary; the front pins would pass the centre, and the back one remaining nearly in its original position, would either break or bend the side-rod. If a main rod breaks, disconnect it, block the cross-head at the back end, disconnect the valve-stem, tie it to the hand-rail and go ahead. It would be as well in connection with the above to pull the valve clear back so as to open the front hanging the valve stem to the hand-rail, jamming the gland on the stem by screwing up one side only. Covering both ports with the valve (after blocking the cross-head) is the plan most generally used. The plan adopted by many engineers after disconnecting the main rod, is to place the piston at the back end of the cylinder and open the front port, jamming the gland on to the steam. This plan is a fraud, as the valve *may* shift and then a bad cylinder-head is the result. Always block a piston or cross-head at the back end, as, if it should get loose, the front head alone, which is less costly than the back head, will suffer. A better plan than carrying blocking for the cross-head is to have the blacksmith make a hook out of a piece of inch and a half round iron, also a piece about fifteen inches long by one and a half thick and four inches wide, with a hole through the centre for the shank of the hook to pass through. This shank is threaded for a nut. Now, when it is necessary to block a piston, get it to the back end, pass the hook around the wrist of the cross-head, and the other end through the straight piece which bears against the yoke supporting the back end of the guides; run up a nut on the shank of the hook, hard against the cross-piece, and the piston is secured. Two nuts will be better than one, jamming the outside hard against the other forming a check-nut.

If a leading wrist-pin break, the main and side rod on that side, and the side rod on the other side must come down the piston blocked, and the valve-stem disconnected. In case of a back pin being broken, both side rods must come down. If a valve-stem breaks take it down, also the main rod on that side, blocking the piston. If the stem is broken outside of the chest let the piece remain in the stuffing-box, if inside, fit a piece of wood into the stuffing-box, fill in some packing, and screw up the gland. If the back-up eccentric-rod breaks, take both of them down; if it is the go-ahead rod, it alone may come down with the straps, also the main rod and valve stem on that side. The main rod and valve stem should also be disconnected in case the back-up eccentric-rod breaks, and, in either case—a broken go-ahead or back-up eccentric-rod—the link should be disconnected from the tumbling-shaft by disconnecting the hanger. If the lifter tumbling-shaft or arms, saddle-pin or reach-rod break, a piece of wood may be fitted, and tied in over the block, for the link to rest on; the piece may be long enough to raise the link to where it is desired to run her—in case of the broken reach-rod or tumbling-shaft, both links will have to be blocked up as described.

As the engine will then have to be held entirely

For broken eccentric straps, or eccentric, proceed as for broken eccentric-rods. For a slipped eccentric, assuming that it is a link engine, and the eccentric the go-ahead one, put the engine on the centre, on the side of the slipped eccentric, pull the reverse-lever into the full back-up notch, mark the valve-stem flush with the gland with a knife blade, throw the reverse-lever in the go-ahead notch, turn the slipped eccentric till the mark on the stem reappears in the same position as when marked, notice that the slipped eccentric is not in the same position as the back-up eccentric, but the full part or belly of the eccentric opposite, nearly to the back eccentric, fasten the eccentric and go ahead. A broken spring-hanger requires that the broken spring be removed unless an extra hanger or a good strong chain is carried, when the break is easily repaired by jacking up the back end of the engine under the foot-board, when the extra hanger can be inserted, or the end of the spring chained down. If neither the chain nor hanger are at hand, slip a block of wood or rubber under the end of the equalizer thick enough to raise the equalizer about level, the weight being removed by jacks under the foot-board. If the engine has far to go and a train to pull, it will be best to put a block of frame, over the wheel where the hanger is broken, to ease the other spring, in addition to above. If jacks are not at hand, the driver may be run on to a stick of wood about four or six inches thick under the forward wheel, to take the weight from the back wheel, and *vice versa.* A broken spring should be treated the same as a broken spring hanger. A broken equalizer requires that it be removed if it is in danger of getting into the wheels, also the springs and wooden pieces fitted over the driving-boxes to keep the frame up. A broken tire, if clear off, requires that the wheel centre be kept from the rail, by either running the wheel on to a block of wood or by placing a jack under the wrist-pin and fitting a block of wood between the pedestal brace and oil cellar. The two side rods should come down if the tire is a back one, also if it is a forward one, as should the main rod on that side also.

It will not be out of place here to remark, that whenever the main rod is disconnected, the piston should be blocked and the valve-stem disconnected. A broken front truck, wheel or axle, can generally be chained up so as to get on to a side track. The engine should be run very slow. An unshipped throttle requires that the steam pressure be reduced, pulling the valve-lever into the block the driving-wheels with sticks of wood when the tender is in right position. A bursted flue can be plugged with wooden plugs, or, better still, with iron ones.

If a driving-axle breaks, so as to leave the wheels in position, the engine may generally be run alone to a side track. Also, if a back axle breaks the engine can be got on to a side track where another pair of drivers should be sent for.

A broken cylinder-head requires the main rod on that side to come down, the ports covered by the valve and the valve-stem disconnected.

If the steam-chest cover or branch pipe in front end breaks, the engine can be got in by bolting a piece of two-inch oak plank with a rubber gasket between it and the end of the steam-pipe in the front end, the branch pipe being removed. The main rod, etc., should be disconnected on that side. If the steam-pipe breaks inside the boiler it can be got along with as if the throttle had unshipped. If a flange on a truck wheel break, the engine by being run *very* slow may be got in, taking especial care when going over frogs, etc. If a tender axle or wheel break, that end of the truck may be chained to a tie placed on the flange of the tender, both ends of the tie being chained, and blocking put between the tie and top of tank to take weight off from the tender flange.

A PLEA FOR THE ENGINEER.

Engineers are frequently blamed for what is in no way their fault. There is a certain class of master mechanics (?) whose *forte* it is to shift on to some one else's shoulders the fault for which their ignorance alone is responsible. To this class of master mechanics (so-called), belong those very practical men who can produce a "dead true" surface with a file and get "dead-loads" of work from a lathe; who have learned the machinist's trade thoroughly; who can do good work on the floor, and who, through the length of time they have been around a railroad machine shop, are at last made master mechanics, to fill a vacancy. These men, as a general thing, have only a very limited education. They can do things as they have seen them done before, but their lack of education has left them sadly ignorant of the only thing they need to make them jewels in the line of master mechanics, and that is *theory*. They need a knowledge of the natural laws of physics and chemistry. The very practical man never uses the steam-engine indicator; he sneers when the theory of combustion, etc., is broached, and if his want of knowledge affected only himself no harm would be done; but the stockholders of his road and the engineers suffer by it. He talks about the lap and lead of valves, etc., when it is the point of cut-off, compression, back-pressure, etc., which should and would engage his attention if his acquirements allowed of it. The lap, etc., is of secondary consideration, and it really does not matter whether, of itself considered, it is three-fourths of an inch or two inches. The *effect* and not the cause, is the point to be looked after. To produce the most economical effect, the steam must act after reaching the cylinder in accordance with well recognized laws; how it gets there, how it is cut off, is in comparison of no consequence. Still it is a fact that the very practical man gets no further than the mere lineal dimensions of the valve, and don't care or don't know anything about the action of the steam when in the cylinder. More than one road has been bankrupted by such men. The writer knew of just such a man who lowered the chest cover of an engine to decrease the pressure on the valve. His argument was this: "Steam has a given pressure on a square inch. Now the first inch of steam bears down on the valve with 120 lbs., the next one on the back of that bears on that first inch with another pressure of 120; if I lower the chest-cover, so that there will be only one-fourth of an inch between it and the valve, there will be a pressure of only one-fourth of 120 lbs. on each square inch of the valve." Another Master Mechanic of the same stripe got his pumps up with very large air-chambers to make them work easy, and then screwed his pet cock into the top of the air-chamber without running a pipe down from the pet cock on the inside of the air-chamber. But worse than this type of master mechanic is the man who accidentally gets into the berth of master mechanic and who absolutely knows nothing, not even how to handle a chipping hammer. Such an instance the writer is acquainted with. The man got employment in the round-house, slushing tender-boxes, etc., and staid there till, through his wife's influence, he got employment as time-keeper (he being originally a shoemaker, and a fiddler for dances) in another shop. The master mechanic soon wished to rid himself of him, and so recommended him as a division master mechanic notwithstanding that the man's entire railroad experience consisted of slushing or doping tender-boxes. Through the resignation of the general master mechanic the directors put this man in, they, of course, not knowing a machinist from a shoemaker. He had got along fairly while a division master mechanic by employing an experienced foreman, but once in the general master mechanic's seat, his presumption showed itself, as he tried to do without a good man under him. The road which had before been famous for good enstoves" as they were aptly called. The new master mechanic decided that all that was previously known about valve-motion, was wrong, his ignorant foreman concurred with him, and between them were soon produced some of the most astonishing pieces of machinery on record. Passenger engines of the new build were considered economical that made a hundred miles on sixteen tons of coal, standing at every water station for forty minutes for steam, and not infrequently going on to the side track to be towed in for want of steam. The thing was kept for a time even from the directors' eyes, by charging about half the coal used and repairs on the new engines to the account of those engines built by the former master mechanic which, according to the new master mechanic, were all in very bad condition very suddenly. At last, by partially copying from the former master mechanic's engines, the new engines managed to get over the road without stopping more than ten minutes at water stations for steam. The road soon ceased paying dividends, then it got into the hands of a general manager and is expected to be soon run by a receiver. There is no doubt but that the new master mechanic is the cause of the road's failure. When engines are built with 16-inch cylinders, and won't steam with a 50-inch boiler, there is certainly something wrong somewhere. The valve of the new master mechanic exhausted at full stroke at *fourteen* inches, making it necessary for the piston to travel the balance of the stroke (8 inches) with no steam behind it. This is the class of master mechanics, who make it hard for the engineers, by laying the blame of the failure of their engines on to the hard-working engineers. When an engineer has his engine fired properly, runs her full of water, and with a high steam pressure and short point of cut-off, he has done all he can for the engine, and if she won't steam then, his master mechanic probably learned the shoemaker's trade before attempting the master mechanicship of a railroad.