FIG. 2.—LEAVES AND FRUIT OF THE MILK TREE. (HALF SIZE.)

A chemical analysis made by M. Boussingault reveals the presence of four groups of constituents, namely: a greasy substance, something like beeswax, which melts at 50°; a nitrogenous substance resembling vegetable fibrine; a saccharine substance; and finally, salts of potash, soda, and magnesia, chiefly in the form of phosphates.

At the French Exhibition of 1878 several flasks containing vegetable milk were exhibited, sent by the government of Venezuela.

M. Boussingault believes that the tree might be acclimated in Cuba, and that its cultivation there would have the advantages of a humidity not to be attained everywhere. In the opinion of this naturalist its introduction would be a valuable acquisition, not so much on account of the milk which the tree yields, which in reality does not compete with or equal that of animals as a popular food supply, but because of the enormous quantity of wax which may be extracted from the jui e which it yields.

SIGNS OF THE QUALITY OF TIMBER OF CONIFEROUS TREES.

DR. SCHUBERT, of Bonn, gives the following tests for the quality of the timber of coniferous trees. Trees, especially pine, grown upon elevated locations, are superior to those from low and swampy grounds, as they are harder and more solid, and also have less tendency to rot. A clear sound emitted when a tree is struck with a hammer on a portion of the south side from which the bark has been removed, is indicative of soundness; and a hollow, dead sound, of a sickly tree. Gray elevations and reddish depressions in the bark are also marks of a sound tree; and whitish elevations and gray depressions, of the reverse. In the felled log excellence is manifested by reddish annual-rings, with pale interstices, whilst grayish rings with white, soft, crooked interstices, show that the tree was dead. The most reliable test of the quality of a log, however, is its ability to propagate sound; when the ear is placed upon one end, light taps on the other end should be distinctly heard.

DESTRUCTION OF GRASS, WEEDS, ETC.

ADLUNG recommends, as the cheapest and most effective agent for destroying grass, the so-called earth lye, a troublesome, worthless waste product of the potash industry at Stassfurt. It is essentially a saturated solution of magnesium chloride, containing a small amount of potassium chloride, magnesium sulphate, and common salt. The magnesium chloride is very poisonous to the roots of plants, and yet, on account of its ready solubility, it sinks so rapidly into the subsoil that by careful employment of it the adjoining vegetation remains unaffected. Tin cans can be used with it, and a single repetition suffices to eradicate the grass. A concentrated solution of kieserit, an impure magnesium sulphate, is almost as effective. This is also an abundant waste product at Stassfurt, and is brought into the market in rectangular blocks, at a low price. It requires warm water for its solution, which takes place slowly.

HARVESTING CARROTS.

THE season is now approaching for harvesting the carrot crop in many portions of the country, and we give the following simple mode for performing the work in a systematic manner for moderate plantations:

Take a good steel spade and loosen the roots along the first

FIG. 1.—MODE OF DRYING IN THE SUN AT HARVESTING—ROOTS UP, TOPS DOWN.

row, and grasping the tops in one hand throw them about three feet back from the row with the tops toward you, shaking the roots well. Proceed in the same way with the next row, placing the roots on the top of the previous row (Fig. 1). Proceed in this way until as many are thrown out as can be secured the same day. The tops on which each row rests keep them from the ground and they dry rapidly;

the earth is easily removed and the tops readily cut. This mode of drying is adapted to harvesting with the plow.

For preservation in winter, if there is no cellar, dig a shallow trench of any desired length, about three feet wide and eight or ten inches deep, where there is a perfect under-drainage. Place the roots here, heaping them up evenly like a two-sided steep roof. Cover them thickly with straw, so that when packed it may be nine inches to a foot thick, according to the latitude and winters. Cover this with three or four inches of earth beaten smooth (Fig. 2). The carrots will keep much better with plenty of straw and but little earth than under more earth and less straw. Make air-holes with a crowbar for each four or five feet of length, and when winter comes plug these with straw wisps.

A cellar is more convenient, accessible in winter, and attended with less labor. A house cellar is usually too warm, and if kept as neat as every good farmer wishes, ought not to be encumbered with cattle feed. Every barn should have a cellar under it; the sills will be more durable, and the only cost is excavation and walls. A cellar large enough to hold five thousand bushels need not cost over \$200 to dig and build walls—or at the rate of four cents per bushel once for all time. Filled with roots, it would supply sixty cattle for five months with a peck each night and morning. Such a supply, in connection with dry fodder, would contribute

FIG. 2.—CROSS SECTION OF CARROT HEAP.

greatly to their health and thrift. The bottom should be paved and covered with water-lime cement, so that the earth which drops from the roots may be easily and neatly swept out. A root cellar should be kept in perfect order, and no filth or decaying vegetables ever allowed in it a day. It should have windows on opposite sides, and free ventilation allowed whenever the weather will admit. If the thermometer is not much below freezing, let the wind blow through, and lessen the current as the frost increases. The more uniformly cool the roots are kept the better and fresher will be their condition. Many would be surprised at the amount of air which might be admitted with safety. If the tight plank floor above is insufficient to exclude frost during the severest weather, a foot of straw over the tops of the roots will be an additional protection.

When barn cellars are large and hold many thousand bushels of roots, the ventilation will be imperfect unless a sparred floor is made a few inches above the cement bottom. It may be made of scantling of any convenient size, with inch spaces between. The passages between the bins for receiving the roots should be in the direction of the prevailing winds, so as to effect a free circulation—the wind being made to blow under the sparred floor. Without free ventilation both the roots and the timbers of the barn will decay. —Country Gentleman.

PREVENTION OF ROTTING OF POTATOES.—Drs. Nohl and Van Hees state that potatoes are not liable to rot in keeping, if immersed for half an hour, sound and unsound together, in a 1 per cent. solution of chloride of lime, and on removal from it in a 1 per cent. solution of soda, and then rinsed in pure water, and dried in the air. For 250 pounds of potatoes but ½ a pound of chloride of lime, and a like amount of soda would be required.

UTILIZATION OF FROZEN POTATOES.—It is stated, as a result of experience, that a meal may be formed from frozen, or even spoiled potatoes, that will keep as well as that from grain; and that the inhabitants of the more elevated and colder regions of Peru allow potatoes to freeze, and separate the meal formed from the skins by treading, and after placing it in nets or bags for several days, in spring water, they dry it by exposure to air and sunshine, thus producing a meal which is used by them for all kinds of food.

PRACTICAL NOTES ON LOCOMOTIVE ENGINE DRIVING.*

By MICHAEL REYNOLDS.

THERE is no royal road to the lever of a locomotive engine. Promotion is really and of necessity a matter of toil. Before a man can take charge of a locomotive engine, to work a train and keep time, it is imperative that he should have more than a knowledge of his engine.

The foot-plate is the only place where that knowledge can be acquired, for there only can a man learn the ways in which it is possible for an engine and train to go wrong. Every failure is a deviation from what should have been perfect success, and whatever contributes to lessen the probability of a failure must have a beneficial advantage. So engine men were at the beginning, and are now, as a rule, reared with the locomotive. It is found necessary that they should enter upon this branch of instruction young, whilst the mind is elastic and capable of receiving the most durable impressions.

A man may be a first-rate mechanic, he may have built engines, and have read all the published books on locomotive engines, and yet he is not capable of taking charge of a locomotive under steam, moving at the rate of 88 feet a second. Whilst an engine is under steam with a train keeping time, everything seen, heard, felt, and smelt, in connection with it and the train, is capable of conveying ideas to the driver. On the foot-plate the eye is taught or rather trained to distinguish colors at a distance; the ear learns to detect the slightest variation in the four beats of the two cylinders. It in time learns to detect the daily wear of a piston ring or a slide valve, and not only that, the mind is trained to look for the results of such wear and tear. As the ring or the valve loses its true and full value, there is an increase of blowing through of the steam, which acts upon the fuel, and increases the quantity and the size of the ashes in the smoke box. On the foot-plate the human frame learns to decide what oscillations and pitchings of the engine are due to a defective spring, and what are due to a defective permanent way. The nose becomes, from experience acquired under all kinds of circumstances, very sensitive, so that it can distinguish the rising of fire from waste carelessly left by the cleaner about the engine, from a fire originating from friction.

It is only under steam at high speed with a train that a locomotive engine man has the advantage of a stationary engine man.

On railways there are "coral reefs" and sandbanks. There are traps of all kinds; trap points, trap sidings, and gulleys. These are put in for the public safety, and intended to trap a train—man, engine, and carriages. Should the engine and train come along in charge of an engine man who imperfectly knows the road, he is safe to be trapped.

Sometimes this trapping is very serious as regards expense. Many railway companies could show the public some very expensive trapping of engine and trains. I do not refer to trains containing passengers. The drivers in charge of passengers have been in many instances in some ugly traps in their earlier days, but having served some years on the goods trains, they become wise and precautionary, which qualifies them for taking charge of the more responsible part of the traffic.

The rank and value of every locomotive engine man is exactly in proportion to the labor and study he has bestowed on railway traps.

These are everywhere, even in the coal, in the tender, in the tube, and in the smoke box. When a man is trapped, no matter how, when, or where, he asks himself at once the question if anybody else has been served the same. If he satisfies himself his is an exceptional case, the man is not so much to be blamed; but if an engine man goes and does what others have done before him, and been fined for or discharged, he is, strictly speaking, to blame.

Well then, the rank and value of a locomotive engine man depends upon his acquaintance with matters purely incidental to railway working. Has he the hidden rocks upon his chart?

Does he know what has wrecked engines and trains? If he does not he drives by chance. Of all places in the world, chance has no locality upon a railway.

Locomotive driving when of first class quality is good to-day, to-morrow, and next day, and all the year round, that is, it is constantly good—true.

And why? Because it is based upon certain rules and principles.

A driver who keeps his eyes rolling and his mind active, seeks out the cause of every failure, and comparing them with his own experience, soon finds out how to obtain a salutary lesson. Now there are certain rules and principles about locomotive driving which, if they are observed, enable an engine man to keep time without cutting too deeply into the coal heap. Without such rules and principles all is uncertain. The hand trembles upon the regulator, the eye watches with painful anxiety the needle of the pressure gauge, and the driver, through looking into a white fire, is for a moment struck with color blindness. Nothing of this occurs with first class engine driving.

The rules and principles to which I am about to refer have proved themselves correct a thousand times over, and they have the property of relieving the mind of the driver from painful anxiety. Moreover, and beyond, they give the same results under all possible circumstances. They are not right to-day, and wrong the next day; not right with Derbyshire coal, and upside down with Welsh coal. Not right with one class of engine, and all astray with another. Not right with ten coaches, and wrong with twenty. In a word, when recognized and acted upon they enable an engine man to keep time, to travel with perfect ease, and to finish with success.

As soon as an engine man arrives on duty he examines his engine; there are few men but what do so; but hundreds of men have failed soon after the examination, from causes too numerous to mention, and which showed that the subsequent examination proved nothing.

Let us see how an engine should be examined properly before joining the train.

The driver arrives on duty and steps up on to the foot-plate, where he is generally supposed to be at least three-quarters of an hour before train time. The first thing he should do is to know what water there is in the boiler. Many drivers rest satisfied by looking at the gauge glass and not by actual fact.

* A paper recently read before the London Association. The President, Mr. Joseph Newton, introduced Mr. Michael Reynolds as one of the best authorities upon matters connected with locomotives. The gentleman had passed his whole life amongst engines, and as a practical man he had gone through every stage of locomotive engineering, and might, therefore, be considered a fit person to instruct others on the subject.—*Foreman Engineer and Draughtsman.*

It is only by actually opening the gauge cocks that a man can be positive as to what water is in the boiler. He should try all the gauge cocks on the boiler, and satisfy himself that they are all in working order; this is very important.

I have in my mind's eye a case in which two men's lives and two very valuable hunters, were lost *instantly* through a gauge glass cock not working—not having been worked daily, which it should be.

The driver in the case I am about to refer to was about to sight the distant signal of a station, but before he could see the signal light the gauge glass broke, and the steam and water required to be shut off. He attempted to do so and shut the water off, but the steam he could not, for the plug was fast; meanwhile he was going probably 88 feet per second, and being so much engaged with the water gauge, both he and his fireman missed the signals which were against them, and in all probability they were trying to shut a plug—only a small thing—when they were dashed into two horse boxes and some wagons. Two valuable lives sacrificed by not thinking what great disasters can arise from very *simple* accidents! The next thing for a driver to notice after the water, is the steam in the boiler when he takes possession of the engine. There have been engine men who came on duty three-quarters of an hour before train time, who at starting time found the engine would not move for want of steam. This was for want of a proper systematical method of overhauling an engine. If things are done by chance at haphazard, the result must be unsatisfactory. If a man chooses to examine loosely, or by halves, or anyhow, the penalty is astonishing to a man, but if he thinks seriously about the matter it is not.

When examining an engine it is a good rule to remember where others have failed and come to grief—what gave way. It is astonishing what little failures have done in the way of upsetting the ordinary working of a large traffic, not to mention the inconvenience suffered by passengers. More engines have failed through split pins and cotteners working out than anything else in the motion. It is, therefore, requisite to act with caution *where* most men have failed, and to examine all things, on the principle that what is liable to fail is worth being overhauled thoroughly.

Now how should we examine an engine before she leaves the shed? The engine should be fixed with both big ends below the center of shaft or crank axle, so that each part can be properly examined without moving the engine. The examination should be conducted systematically all round and underneath the engine, until the engine man arrives at the point where he commenced. He should commence on his own side of the engine at the trailing axle box and spring of engine, and examine all the spring and spring pins, until having gone round the engine he again reaches his own side of the engine. Whilst this examination is going on it is wise, I think, to remember *where* others have failed and *what* has brought them to grief, because an engine man's fame depends upon how closely he has inspected his engine before joining his train.

This examination I have just referred to is very important, and more so after the engine man has booked repairs to his engine. It has occurred and there is no reason why it should not occur again, that fitters have left their calipers in the feed pipe, left the right or left hand pump ram down after examining the piston of an engine cottened to a cross-head; they have left files in the steam chest after the cylinder faces have been faced up. This shows examination over the pit is not sufficient to secure successful driving, and it proves examination over a shed pit is only a part of a good beginning. Many an engine man has examined well—without examining on a system—who has failed on a train through a pump not working, either the suction, pump, or the top clack having been omitted by the fitter when examining the pump. Between the shed and the train a first class engine man puts his engine through certain performances, calculated to detect in time any deficiency in its action; for it is far better to find your engine defective between the shed and the train than to find it out on the road. When an engine has been undergoing repairs between trips particular inspection is necessary. Chapters could be written to prove that many things have been found out over a pit which had they escaped notice must have led to a vexatious failure.

The old saying, "that a good beginning insures a good finish," is indeed particularly applicable to preparing a locomotive engine for its trip, but doubly so as regards the fire. After the driver has found the true level of the water in the boiler, and the pressure of steam on his arrival, he should examine the fire. Firemen, as a rule, arrive before the drivers, and make up the fire in some instances before the engine man arrives; it is, therefore, very necessary for engine men coming on duty after the fireman has made up the fire to examine such fires. Unless the fire is properly constructed and well burnt through at the commencement of the trip, however clever an engine man may be, he will have a hard matter to keep time, especially if he should have a side wind and a heavy train. The fire at the start *must* be right. On some of the English express trains the average speed is 50 miles an hour, and in order to keep time the engines must run at some parts of the road 70 to 80 miles an hour. I have traveled at 82 miles an hour, and then arrived only to time. On long trips, say over 100 miles without stopping, the fireman should make up the fire, with Welsh coal, 1½ to 2 hours before train time. With Shipley or Derbyshire coal, it should be broken up into pieces the size of a brick, say, an inch watered well. But before the coal is put into the fire box there is a most important point in a fireman's duties to be observed, and that is, the fire bars should be protected either by chalk or sand, or fire bricks, from the effects of the fire, which will burn them if left totally exposed; moreover, a few broken fire bricks scattered fore and aft of the grate bars of a locomotive engine will probably prevent the coals falling out, and exclude the cold air from coming in. In making up a Welsh coal fire—and Welsh is chiefly used on this side of the Tweed—after the grate has received a coating of fire brick or chalk, the coals should be placed round the fire box, and not placed in a haphazard manner anywhere. Some firemen shovel the coals—that is all. And when you have said that, you have described their system. When the coals are placed round the fire box close against the heating surface, they must have the most effective effect. The heating substance is close to the requirements. The best of the coals should be placed in the fire box in making up a starting fire. There is nothing like having a good foundation. When a fire is made up of Welsh coal—good lumps placed round the box—it expands very much by the heat, and reminds an observer of a cauliflower plant. Hard coal or what is known as Shipley, Langley Mill, or Booth coal, does not swell so much, but it requires very nice treatment. Hard coal, such as I have mentioned (Shipley, Langley Mill, or Booth), has been put

into the fire boxes or bank engines and remained there for fires until it was coked, and such engines have been after waiting for hours attached to pilot trains, and then at the finish of the trip the coals remaining have had all the appearance of coke. On this account many engine men using hard coal with tight dampers prefer to get it into the fire box in good time before starting—an hour before train time.

So much for the fire. The oiling is generally done by the driver on the outside of the engine, and the fireman does what is necessary underneath. The siphons which contain plug trimmings can be filled up at any time, as the swing of the machinery is necessary to cause the oil to lubricate. With tail trimmings it is different. The worsted ends being in the oil, they lubricate either stationary or in motion. The causes of heating when it leads to a failure is upon all railways a matter for serious investigating. No one on a railway likes to see good time keeping better than a general manager. He is, of course, responsible for all that takes place either in the locomotive or traffic department. The causes of heating are many. For instance, the worsted may be too tight in the first place, and it may become too tight through glutinous matter, such as resin or India-rubber, which is dissolved in some oils. The cotton may be too slack, siphoning all the oil away before the supply can be renewed. The cotton may be choked with tallow, which blocks up the tubes of the cotton, and this latter cause is more often the source of the mischief than anything else, and would not occur for obvious reasons if each driver was properly acquainted with capillary attraction.

If we look over the list of engine failures we shall find more engines hooking off their trains through having hot bearings than from any other cause, and apart from siphoning there are causes which produce the effect. If a keep to an axle box is bearing on the journal it will produce friction underneath the journal, and being deprived of lubrication, very soon causes a journal to fire. Then some brasses may be too light endwise, and not having sufficient lateral play to allow of a film of oil to separate the metals. And again, a bearing may have too much weight upon it; and lastly, a bearing may have too much bearing.

The history of locomotive failures is very instructive, for at least two-thirds of them occur through preventable causes which should have been prevented, and would have been prevented had the engine men systematically and thoroughly examined their engines over and off the pit before joining the train. In the charge of one driver an engine will run its daily trips and give the best of satisfaction, but when it is placed in the hands of another engine man she is always in trouble, not leaving the rails, but warming either in the motion or the axles, or by split pins coming out, or a big end siphon top slacking back, and thereby losing the oil which was intended for lubrication.

Examination before leaving the shed, and after doing so before joining the train, is very essential; but the constant cause of successful driving is close observation.

A philosopher hath said, A frequent similar effect argueth a constant cause. What, then, is the constant cause of successful locomotive driving, in so far as it applies to the engine under steam attached to a train?

The great and most important question to a driver is, Can I obtain steam? If I can I can run. Now, to obtain steam for a long run without putting any extra strain on the driver's mind is to make up a fire not too deep or too thick for the load on the piston. The shape of a fire that will make steam when all others fail will be concave; and besides making steam, with a little attention it will not clinker. The greatest evil is having too deep a fire. The exhaust steam from the cylinder has then not sufficient power to bring the air out of the ash pan through the grate openings into the furnace, and the dross in the fuel runs through the coals into the bars, whereas if the blast could have penetrated the fire its temperature would have been raised, and the dross literally consumed.

When the fire is concave it is much thinner in the center, and the body of the coals rests against the walls of the fire box, which is the superior portion of the heating surface. A fire made on this principle is true, and never deceived either driver or fireman. A few vigorous beats, and there are signs of a fire being all right, provided it does not hang together, which Welsh coal very often does. But if the engine is shy of steam and does answer the "thrashing," with regulator wide open and lever full over for a minute, then the best thing is, in the first place, to get a shovelful of small coals and scatter them over the top of the "stupid" fire; but chiefly along the sides, back, and front of the box, and the effect will be that some portion of the small coals will fall into the holes through which the fire box is drawing air. When the shovel of small coals has no effect the dart should be thrust into the center of the fire to open it if close, or to close it if burnt hollow, but on short trips, provided an engine man could see his way clear to keep time and keep his boiler safe, he may run for miles with a saving of fuel, for in time the action of the blast and the vibration of the engine will bring the fire round.

We are now under steam with a train, say. With a proper fire not too deep for the load on the piston a few puffs of steam will set incandescent coals into a fierce flame, and steam will be maintained. On our fast express trains running long distances without stopping the needle of the pressure gauge must point to a full boiler of steam exactly, nothing more or less; if the steam is allowed to waste at the safety valve it will tell upon the fuel, and if the steam is allowed to drop it will tell against the time sheet. Scarcely any locomotives in England have any great margin of reserved power. We have locomotives of the very best build and design, but they frequently have their work so cut out that an engine man requires to superintend them with great caution or they will surely round on him. It is only under certain conditions that they will stand "thrashing" to their work, and when that becomes a necessity the mode of firing becomes a great feature—a most important feature. To fire properly on fast expresses the fireman should command his work without fatigue, turning on his heels from tender to fire box and from fire box to tender. The shovel should be handled as though it were too hot to hold; every shovelful of coal should have its billet, and be delivered as clean as shot. The shovel should not enter the fire box, but stop dead on the fire door ring. There is, however, one shovelful required under the door, and the shovel *must* enter the box to land the coals against the back plate of the fire box.

The first shovelful—just what will lie on the shovel nicely—should be put in the left-hand corner. When the knees and the body follow the shovel about the foot plate firing becomes fatiguing; it should be done by the muscles acting through the arms. The second shovelful should be put in the right-hand corner of fire box, the third shovelful in the right-hand back corner, the fourth in the left-hand back

corner, the fifth under the brick arch close to the tube plate, the sixth under the door. It is seen that such a fire is made close to the plates, and in actual contact with the heating surface, and that the center is self-feeding, the blast and the shocks of the road causing the lumps to fall from the sides into it. By this means the center is composed of the finest quality of the coals, free from dirt, and open so that the air can enter without interruption in the center, and mingling with the burning coals becomes heated and enters the tube at a very high temperature, doing them no harm. Further, the fire box is cold air proof. So long as air can be obtained through the grate in the center no clinkers will form, as the abundant supply of air is capable of consuming all the earthy matter contained in coal.

Similar coals have been delivered to two different drivers having the same class of engines, working the same day over the same metals with equal average loads, and the results have been very different; while one complained that they made clinkers, and was half afraid they would "suck some one in," the other pronounced them to be of fair average quality. The one driver put the coals in the center of the grate, but the other fired round the box after the manner already explained. It is a fact that some drivers run for weeks and never need to clean a fire. At the termination of the trip what clinkers they have they rake back under the door.

Next to the question of how to fire follows one of equal importance, viz., *when to fire*. On long trips, to effect a saving of fuel, the sooner the first round of coals is put on after starting the better, as it will prevent the fire, which is generally well burnt through, from passing away into the tube and raising steam too rapidly.

The best and the most favorable moment for opening the fire door to get some coals in is just as the steam is lifting the safety valves; by doing so the steam is slightly checked, which saves both water and fuel. Some drivers run twenty or even thirty miles before they start firing.

The interval between the start and each round of firing is regulated by the weight of the train, the state of the weather, and the time allowed to run the train, together with the quality of the coal; but however much these may vary, one thing will remain constant and certain, and that is, the fire, to maintain its efficiency, must retain its concave shape throughout the trip. The coals require to be put into the very place they are intended for when picked up by the shovel, and they should not be dropped in at the door and allowed to "wander."

The secret how to obtain and hold a respectable position on the coal saving list is, fire with few coals, and often round the box.

Notwithstanding the different plans which have been invented to effect the perfect combustion of smoke, the best plan is to employ a willing and persevering fireman, who puts both heart and soul into the work. The shovel is seldom out of his hands after he has commenced to fire until he finds he has sufficient in the box to finish the trip with. The practice, however, is in many cases to fire heavily, and by so doing the temperature of the furnace is suddenly reduced, and then leaking takes place. When to fire: Locomotive firing should be done with the steam on.

What an unsightly thing it is to see an engine entering a station with the driver at the break, the blower hissing loud, and the fireman shoveling coals on the fire! Undoubtedly this is not in accordance with first-class practice. In preference to the above, when firing is required it should be done away from stations and signals, and some two or three miles before the regulator is going to be closed, so that air can have an opportunity of getting through the fresh coals, and thereby assisting to keep down the smoke without much use of the jet.

When firing is done with the steam on the driver can give his eye for a moment to the fireman's actions, and see that every lump of coal finds its proper billet, and when the train enters the station both are attending to their respective duties. When the firing is done with the steam on the coals do not choke up the grate through which the iron steel draws his breath, the foot plate is kept free from smoke and sulphur, and the blower can also be dispensed with. When firing on long runs the most favorable spots and gradients for working the shovel should be selected and habitually used. The grand aim of first-class firemen is to keep the boiler at an even temperature from the start to the finish, up hill and down dale. To do this—and it is accomplished every day—the opportunity for opening the fire door should be seized. For instance, it should be opened the moment steam commences to waste from the safety valves; and this occurs frequently where little notice is taken of it, and that is when ascending an incline, when the fire door can be opened just to check the steam. The fire door should never be opened to check the steam, as it is best controlled by the dampers. When the wind is blowing hard advantage is taken of the cuttings and places where the line is well protected by the trees to prevent the coals being carried off the shovel. To avoid a choked fire—that is, one so thick as to prevent air entering the fire box through the grate openings—two things should be kept in mind. The back corners should be well filled up, and the fire should taper toward the tube plate. Firing, when done by the shovel alone, is one of the strongest evidences we can find in connection with a fireman's duties, of a man working his mind as well as his muscles, and whether on goods or passenger engines, the value and rank of every man will be in proportion to the mental labor exerted with each manual task.

While the engine is running the train the regulator should never be shut to pull the link up. The practice, especially an engine having a worn motion and play in the driving journal, is liable to break an engine down. It also inflicts a severe tensile strain upon the couplings, and is apt, when the steam is suddenly put on, to part the train.

It is a remarkable fact that engine men who habitually close the regulator to notch their engines up come to grief nine times out of ten while in the act of doing so. The answer to the question, "Where did this occur?" has been answered again and again by different men with the same reply. Just starting away from the station their piston rods have snapped off from solid material; piston heads have, even of brass, been bent by suddenly turning the steam into them.

The distance traversed from the station before commencing to expand steam depends upon the load, gradient, weather, and time allowed to run the trip in; but although circumstances will alter cases, yet there is one thing in connection with part of a locomotive engine man's duties that will remain constant, no matter what engine he has, and that is, after the train has attained a pretty good speed, the reversing lever should be used to notch up by degrees, and not pulled up almost out of gear at once. A few clear beats at the start not only prove whether the fitter has lined the

big end brasses up so that the piston head strikes the cylinder cover, but they prove also whether the fireman has put the coals on so that the fire box is air tight. To get away well without lifting the water out of the boiler into the cylinder is a very desirable attainment, because half a pint of boiling water will as effectually wash the lubrication off the face of the valves and cylinder as it will the grease off plates and dishes.

Priming in most instances is either due to the fault of the driver or fireman; but to avoid priming it is necessary to carry the water at one particular height which experience decides is the best.

Engines are worked by engine men three different ways: one driver, indifferent to the elasticity of the steam as a power, does not insist on the fireman keeping the steam up to the full boiler pressure, which is, say, 140 lb. to the square inch; he gets along and keeps time with the regulator open and the reversing lever in the third or fourth notch, allowing the steam to follow the piston some considerable part of the stroke. Driver B likes a boiler full of steam, 140 lb., but works his engine chiefly with the regulator—that is, wire draws the steam. Another driver works his engine with the regulator open, and expands the steam by cutting it off as early as possible, and sometimes, with a moderate load, the steam is released very little above the atmospheric pressure.

To run swift and important trains three things must be thoroughly combined in the experience of the engine man, and they are, knowledge of the signals, knowledge of the gradients, and knowledge of the traffic.

The greater part of every driver's time upon the footplate is occupied in attending to the signals, and until he is familiar with their relative position to the gradients, junctions, and stations over and through which he has to run, he cannot approach them voluntarily and at sufficient speed to keep time. Many of our express engines are only equal to a certain number of coaches, and when an engine is just loaded, if a minute or two is lost it cannot be fetched up again; therefore when an engine man has to "dig into" it is very necessary for him to know the road thoroughly. The weather in all instances has to be studied. In misty weather the rails are slippery, and the engine requires very close attention. In foggy weather the signals require close attention. Some signals, owing to their position, cannot be sighted well, but such signals can frequently be seen across country. While one engine man is running timidly into a curve and ready to act with caution should the signal be on, another has caught it in his eye a couple of miles off, and dashes into the curve at full speed.

Knowledge of the engine signals and gradients is worthy of every attention, but there is a different kind of knowledge necessary, and that is a knowledge of the traffic.

A few years ago a goods train with two engines attached was proceeding south at midnight. After it had passed the driver of a fast express going north a thought struck him that for two engines the roll or sound of the train going by him was unusually short. He stepped over to the fireman's side of the footplate to see if there were tail lights on the last vehicle, but owing to the curve and speed he could not see. He, however, knowing what goods they were, said to his fireman, "It strikes me that the whole train is not there, mate." He shut off steam and had reduced the speed of his train considerably, and was proceeding cautiously, when they saw in the distance a red light waved violently. They pulled up at once, and that easily, when they found the red light belonged to the rearguard of the goods train, and as he held his bull's-eye light full in their face he informed them that a wagon axle belonging to his train had broken and thrown ten trucks across their road. The guard got on to the step of the engine, which was then moved close to the scene, when both driver and fireman saw sufficient to convince them that something else besides driving and firing are required to make good railway men.

Every engine failure is the result of one of two things: it is either a deviation from what the builder intended, or it is a deviation from perfect enginemanship, and we cannot tell what the deviation—the something wrong—is, until we know what the thing deviated from—the prior something right—was.

Things appertaining to the foot plate generally find their place in men's experience and little in books.

I have dwelt on the start (we have been under steam), we have noticed how to treat the engine with the lever; how and when to fire; we noticed that something more than locomotive knowledge is necessary upon a railway—namely, a thorough acquaintance with the signals, with the gradients, and the traffic; we will now briefly review the last part of a trip. From the start the fire should be kept up well round the fire box until experience cries—hold! This may happen 60 miles from the terminus, or it may be only 30 miles; all depends upon the weather, the load, and the gradients.

But when the last portion of the trip is entered the small coals should be used. Get in sight of home, so to speak, before the small coal is put on.

It should be put into the two back corners with the shovel, as the vibration of the road will carry it into the center.

Experience teaches a driver how much coal his fire box holds, and say he is 50 miles from the terminus, he looks and sees he has got about 10 cwt., and that is 22 lb. per mile if it took him right home. Locomotive engines, working heavy express trains, do well if they keep time with about 28 lb. per mile of hard coal, and 24 lb. per mile of Welsh coal. We are in this last portion of the trip; there is, say, 10 cwt. of coal in the fire box as the engine moves along on her journey; in time all the smoke has been consumed out of the coals, and nothing but pure carbon remains, and every facility is then given for the fuel uniting chemically with the oxygen of the air, and the result is perfect combustion. But perfect combustion has never gone on before in this trip until now, and the tubes and smoke box are coated with soot or unburnt carbon; and carbonic acid being formed, attacks the unburnt carbon in the tubes, and it peels off the tubes. Hence, when running in with a pure fire, it very often happens that the engine is very free of steam, simply because the soot is a non-conducting substance in the tubes which has been displaced, and the bare skin of the tube is exposed to the heat.

Some fires require more attention than others, and they do not burn down level all round, which is owing to the air spaces between the bars being uneven, or if some tubes are stopped up, the fire underneath them is not forced so strongly as the portion lying directly in the way of the blast drawn through a clean tube.

So if the fire is uneven when finishing, it is well to carefully level it with a fire iron, and at the same time crack the clinker if there is one when the oxygen of the air will destroy it gradually.

After the engine has arrived at the end of its trip, it should be immediately examined all round, because if this performance is left until the engine reaches the shed, which may be an hour or two, what was hot on the shed will be either cold or only warm, thereby very much deceiving a man. The engine should be thoroughly overhauled, and the valves and pistons tested, and the smoke box examined.

From the start to the finish everything demands close attention, and there is not a body of men in England who try to give satisfaction like our brave engine men of the iron horse.

IRON RAILWAY SLEEPERS.

THE Prussian Minister of Trade, Dr. Achenbach, has lately issued a formal notice to the various state railways, enjoining them, in consequence of the favorable results of experiments with iron sleepers—especially those of the Hilf system, to give these a more extended use upon their roads. Already the number of German railways, which to a greater or less extent are laid on iron, is considerable. The Hilf sleeper has been some time in use on the railroads of Nassau and other lines, is being extensively tried by the Belgian Government, and has lately been definitely adopted as the sleeper for the great strategic railway which is being made from Berlin to Coblenz, Treves, and Thiacville, connecting the German capital with its newly acquired possessions on the frontier of France. Altogether not less than 1,000 miles of track are now laid with this single system. In Belgium, 10,000 Vautherin iron sleepers were laid down, as long ago as in 1869, on the Grand Central Railway, and although these have been in some measure condemned, yet the use of iron has been continually extended in that country, under the superintendence of its leading engineers. In France several of the great lines, notably the Chemin de fer de l'Est, have experimented on various forms of iron sleepers, and have them still in use with more or less favorable results. We will not dwell on such countries as India and South America, where iron is rapidly supplanting timber in all directions, because it may be agreed that the conditions of climate in those regions make them useless as a guide for English practice. But the case of Germany is especially to be remarked, because the railway timber is there entirely of home growth, being produced by the enormous forests of that country, and forming an important constituent of her in-

base is provided with openings, A, A, for inserting ballast to pack the interior. The width of gauge and the level of the sleeper are alike maintained by the cross-tie B, which consists of a bar of flat iron set edgewise, run through openings in both the corresponding sleepers, and secured to each by a cotter, C, and pin, D. The Greavesleeper, originally tried in 1847, on the Lancashire and Yorkshire Railway, was selected by Robert Stephenson, as early as 1851, for the railway across the Isthmus of Suez, as being the form best suited to the conditions of climate and to the nature of the ballast, which consisted partly of sand and partly of alluvial soil from the Nile. The wisdom of the choice has been confirmed by the reports of the engineers in 1862 and 1865; but it must be added that complaints from travelers as to the roughness of the road have not been wanting. Greave sleepers were subsequently adopted by the Madras and Calcutta Railways, and on the Mooltan Railway in the Punjab, where they were reported on as forming an exceptionally good road. They have also been used extensively in Brazil and in the Argentine Republic, where they replaced the Barlow rails originally employed. On the other hand, Mr. Sibley, the engineer of the East Indian Railway, decided against them after considerable expense, and replaced them by a wrought iron system of his own, which we shall describe hereafter. The "pot" or "bowl" sleeper has received modifications and improvements at the hands of several inventors. On these we shall only touch briefly. The chief variation attempted was to make the base of the chair a mere flat plate, strengthened by ribs underneath, thus doing away with all difficulties as to packing the ballast. Of this character were the sleepers of Mr. Samuel, of Mr. Peter Barlow, laid down on the South-Eastern Railway in 1849, and afterwards tried on the Midland and Eastern Counties Railways, and of M. Henry, tried on two of the railways in France. None of these obtained any lasting favor, in consequence, it would appear, of their liability to fracture and their small hold on the ballast. Quite recently the same type has been revived by M. Mounier, of the East India Railway. His sleeper is a broad flat plate turned over at the two ends to grip the ballast, and having across its middle a trough-shaped depression, which is filled with a half round block of hard wood. On this the rail, which is double-headed, rests, and is secured by a cast iron jaw on each side, bolted to the top of the sleeper. A rib runs longitudinally under the sleeper from the middle to each end to stiffen it; or in some cases the sleeper is hollowed into a

FIG. 1

FIG. 2

GREAVE'S POT SLEEPER.

FIG. 1A

FIG. 2A.

GRIFFIN'S SLEEPER.

ternal trade. On the other hand, in England, almost every sleeper is an imported article, brought long distances across the ocean, at a cost which, of course, goes mainly into the pocket of the foreign grower, whilst, as at the present moment, our own iron forges and furnaces may be languishing for lack of employment. Looking at the present disastrous state of things in the iron trade, it can hardly be denied that he would deserve well of his country who should point out how an imported article in timber could be replaced by a home-made one in iron, provided it was at an equal, or even a slightly greater, first cost.

We need not say more to show that the question we ask is not superfluous; and it is scarcely needful to remark that it is far from being unimportant. In this connection we may, perhaps, repeat some rather startling statements for which the journal of the *Verein Deutschen Eisenbahn-Verwaltungen* is responsible. Here it is assumed that an iron sleeper weighs 35 kilogrammes, and that 100 sleepers require to be renewed annually for each kilometer of railway. The yearly weight of iron required for each kilometer will thus be $3\frac{1}{2}$ tonnes, and as Europe possesses about 112,800 kilometers of permanent way, it follows that the yearly consumption of iron thus attained would be 401,800 tonnes—or say, in round numbers, 400,000 English tons. We think this estimate considerably too high, but it must be remembered that this applies to the renewals on existing lines only, and allows nothing for new lines, fresh sidings, etc. At the present low rates—say, £6 per ton—the estimate represents an annual money value of about £2,400,000, which is certainly sufficient to give the question of this substitution an undoubted commercial importance.

It is to be noticed that cast iron has found most favor with English engineers, and has been extensively used by them, not indeed in England, but in India, South America, and other countries; while wrought iron has been everywhere preferred on the Continent, and all the developments going on now are in that direction.

Cast Iron Sleepers.—One of the earliest and at the same time one of the most successful forms of cast iron sleeper is the "pot" sleeper of Mr. Greave. The principle of his design is to use the ordinary cast iron chair for the actual support of the rail, and simply to extend the base of this into a large bowl-shaped surface, which is sunk in the ballast and carefully packed in the inside. This sleeper is shown in elevation and plan in Figs. 1 and 2.* It will be seen that the jaws of the chair are strengthened by ribs, and hold the rail with a wooden key in the ordinary manner. The hollow

similar depression along its center, through which the tie, which is a round bar, passes. We are not aware whether this design has been tried in practice. The Griffin sleeper, on the other hand, has been widely used in South America, but is in essentials the same as the Greave. The chief differences are, as shown in Figs. 1A and 2A, that the outline of the bowl is oval, or oblong, instead of round, that it has a flat lip round the edge, and that the surface is cast in corrugations radiating from the major axis, so as to increase the strength. A recess runs along the whole length of the top, having a section much like the jaws of a chair. In this the rail rests, and is secured by a strip of teak, on the outside, and by an iron key on the inner side, or where two rails meet, a single fish plate takes the place of the latter. The tie bar is of wrought iron, not passing right through the rail, but inserted in a recess in its side, and simply wedged up with a common taper key. But the bowl sleeper has been now brought to what is probably its fullest development in the hands of Mr. James Livesey, of Westminster. In Figs. 3 and 4 are given a plan and elevation of Mr. Livesey's cast iron sleeper for a double-headed rail in its most improved form; in Fig. 5 is a perspective sketch of a similar sleeper arranged for a Vignoles, or flat bottomed rail. It will be seen that the bowl in this sleeper is decidedly shallower than in Greave's, and has a flat lip round the outer edge, which tends to prevent the sleeper from rising. The openings in the bowl for packing are also done away with; these were found to do more harm than good, as the ballast had a tendency to work up through them, under the action of the trains. The comparative shallowness of the bowl makes the task of packing more easy, while it still retains ample holding power in the ground. As a matter of fact no trouble is found with the packing, which is done in one of two ways. In the first the sleeper is laid on its back close to the spot where it is to rest, carefully filled with ballast, and then turned suddenly over into its proper position. In the other a small heap of ballast is first formed at the proper spot, then the sleeper is dropped over the top of this, and finally the packing is completed by ramming it under the edges. The shape of the bowl itself is oval, and the jaws of which two, A, A, are close to the ends of the major axis, and one, B, opposite to them in the middle, the rail is laid in place and then fixed against the faces of jaws, A, A, by a cast iron wedge-shaped key inserted between the web of the rail and the face of the central jaw. The arrangement of this key is simple and ingenious. Its outer side is formed into a series of shallow parallel corrugations, and a set of precisely similar corrugations is cast on the face of the jaw. The key, C,

* Von Waldegg, Atlas to Vol. 1, plate 14, Figs. 1 and 2.