THE

LOCOMOTIVE ENGINE

POPULARLY EXPLAINED.

R. SMITH AND CO., PRINTERS, LORD-STREET, LIVERPOOL.

THE LOCOMOTIVE ENGINE POPULARLY EXPLAINED,

AND ILLUSTRATED BY

LITHOGRAPHIC DESIGNS;

TO WHICH ARE ADDED,

RULES AND TABLES

FOR

ASCERTAINING ITS AMOUNT OF USEFUL EFFECT,
RESISTANCE, &c.

ALSO,

INTERESTING STATISTICAL PARTICULARS

CONNECTED WITH

RAILWAYS,

FOR GENERAL INFORMATION.

BY WILLIAM TEMPLETON,

AUTHOR OF "THE MILLWRIGHT AND ENGINEER'S POCKET COMPANION,"
"ENGINEER'S COMMON-PLACE BOOK," &c.

LONDON:

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1841.

EGERTON SMITH AND CO., PRINTERS, LORD-STREET, LIVERPOOL.

PREFACE.

It is a curious fact that, up to the date of this work, only one previous attempt at a popular description of the locomotive steam-engine has come before the public in the English language, and that by Mr. Stephenson, its celebrated improver. Unfortunately, however, that work has been published at an expense which renders it quite out of the reach of many who, probably, are the most anxious to acquire such information, and who might, by their mechanical skill and speculative minds, be the means of adding useful improvements to the machine, so that it should approximate nearer to a state of perfection, and be rendered essentially serviceable to the purposes for which it is required.

With a view to the partial removal of this defect, by rendering such information accessible to all classes of society, the present work is now offered to the public, being the result of several years practice on a line of railway in the locomotive department, on which I had a constant opportunity of testing the merits and defects of the engines, and also the practical working of the line, so far as the engines were related.

In the selection of an engine whereby to make a design for illustration, I have found a most difficult task, engines having of late become so numerous, and each laying higher claim to public approbation than its predecessor. Having, however, had considerable practice with some made by Messrs. Kirtley and Co., of Warrington, which have given much satisfaction, I at last determined to select one of them, introducing various of Stephenson's late improvements, which I considered might be adopted with advantage.

The work also contains general information connected with railways, which, it is hoped, will be found, not only interesting, but extremely useful, it being the author's sincere desire to create, in the public mind, a feeling of investigation towards railways, so as to render that mode of conveyance ultimately both speedy and secure.

W. T.

Leeds, January, 1841.

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A

POPULAR AND SCIENTIFIC DESCRIPTION

OF A

LOCOMOTIVE ENGINE.

LOCOMOTIVE ENGINES are machines chiefly employed upon railways, for the purpose of conveying carriages with goods and passengers, by the propelling power of steam,—steam being water combined with caloric, or the matter of heat.

WATER: ITS BOILING POINT.

Water, under common circumstances of pressure, will imbibe caloric until it attains a temperature of 212° Fahrenheit, at which point ebullition and evaporation take place. The water is changed from a fluid to an aeriform state, or steam, equal to the pressure of the atmosphere, namely, 14.7 lbs. per square inch.

EFFECTS OF PRESSURE.

If the water be inclosed in a proper vessel or boiler, and the pressure augmented by any artificial means, such as a safety valve, &c., ebullition will not take place at 212° Faht., but somewhere above that point, proportionate to the pressure on the valve; and, as the temperature of the water is elevated, so is the density of the vapour increased, but in a very superior ratio. Hence, to produce steam of double or triple the pressure, double or triple the temperature is not required, but by experiment is found to be as exhibited in the following table :—

TABLE OF THE PROPERTIES OF STEAM, EXPRESSED IN VARIOUS TERMS.

Lbs. per square inch above the atmosphere.	Temperature in degrees of Farenheit.	Volume of Steam, water being 1.	Cubic inches of water in a cubic foot of steam.	Elastic force in inches of mercury.	Lbs. per square inch above the atmosphere.	Temperature in degrees of Farenheit.	Volume of steam, water being 1.	Cubic inches of water in a cubic foot of steam.	Elastic force in inches of mercury.
2.5	220°	1496	1.14	5.15	30	275°	609	2.81	61.8
3	222	1453	1.18	6.18	35	282	553	3.09	72.1
4	225	1366	1.25	8.24	40	288	506	3.38	82.4
5	228	1282	1.33	10.3	45	294	468	3.66	92.7
10	240	1044	1.64	20.6	50	299	435	3.93	103.0
15	251	883	1.93	30.9	55	304	407	4.20	113.3
29	260	767	2.23	41.2	60	309	382	4.48	123.6
25	268	678	2.52	51.5					

USEFUL EFFECTS OF STEAM.

It is chiefly owing to the preceding properties of steam that locomotives are rendered so effectively useful on railways. It is also owing to those properties that steam vessels have, of late, been enabled to traverse thousands of miles on the trackless ocean to visit other countries, the accomplishment of which was, a few years back, but rarely anticipated.

APPLICATION OF STEAM, AND ITS PRODUCTION IN LOCOMOTIVES.

Steam is made available for the production of motive power in two different ways; first, by force or pressure, and secondly, by condensation. But, in the high-pressure, or locomotive application, force is the entire principle. The machine is so constructed that motion is produced by the propelling force of the steam, which is afterwards allowed to escape into the atmosphere by the chimney: its superior force expels the air, and causes an artificial current of heated air to pass through the water in the boiler by means of a number of brass tubes, which thereby render the boiler sufficiently competent for generating the required quantity of steam.

LOCOMOTIVE BOILER AS DIVIDED.

The boiler is the most extensive portion of a locomotive engine, and consists of three separate compartments or distinct divisions; namely, the fire-box end, or back end A, in which the body of fire is contained; the middle or cylindrical part B, in which the tubes are contained; and the smoke box, or front end C, in which the cylinders, valves, and blast pipe are contained, and also on which the chimney D is placed.

EXTERNAL SHELL OF THE BOILER.

The external shell of the boiler is of wrought iron plates $\frac{5}{16}$ths of an inch in thickness, and rivetted together, the rivets are $\frac{5}{8}$ths of an inch diameter, and about $1\frac{5}{8}$ inches from centre to centre of each; the corners, or angles, are united by angle iron, $2\frac{1}{2}$ inches in breadth, and rivetted together in a similar manner.

THE FIRE BOX.

The fire-box end is composed of a double casing, the internal of which is properly designated the fire box, and is of copper plates, $\frac{3}{8}$ths of an inch in thickness, except that part of the front or tube plate in which the tubes are inserted, which is from $\frac{3}{4}$ths to $\frac{7}{8}$ths.

WATER SPACES.

Surrounding the fire box, and inclosed by the external shell, are water spaces, W W W W, of which those on the sides and back are about 3 inches in width; the space on the front side requires to be a little wider, say about $3\frac{1}{2}$, on account of the blast pipe causing the action of the fire to be greatest on that side.

GAUGE OF RAILS, &c.: WIDTH OF FIRE BOX.

In engines of 4 feet $8\frac{1}{2}$ inches gauge, being the usual gauge of rails in this country, the external shell of the fire box cannot well exceed 4 feet 3 inches in width across the engine, and for any other gauge of rails the same in proportion, consequently 4 feet 3 inches, minus the thickness of plates and width of water spaces, equal about 3 feet $7\frac{1}{2}$ inches for the width of the fire box.

HEATING SURFACE OF FIRE BOX.

To proportion for the quantity of heating surface in the fire box:

RULE.—Multiply the cubic contents of one cylinder in inches by .027, the product is the extent in square feet. Hence, divide that surface, minus the area of front and back plates, by twice the height, plus the width of the fire box, and the quotient is the length in the direction of the boiler.

Example.—Suppose cylinders of 12 inches diameter, strokes 18, width of fire box 3 feet 7½ inches, and height 3 feet 8 inches, required the whole extent of area in the fire box, and its length in the direction of the boiler.

$12^2 \times .7854 \times 18 \times .027 = 54.96$ square feet of surface.

3 ft. 8 in. × 3 ft. 7½ in. × 2 = 26.5 square feet in front and back plates.

And 3 ft. 8 in. × 2 + 3 ft. 7½ in. = 10 feet 11½ inches, or 10,958 feet, length of sides and top included.

Hence, $\frac{54.96 - 26.5}{10.958} = 2.59$ feet, or about 2 feet 7 inches in the direction of the boiler.

THE STAYS.

The stays, *s s s s*, *&c.* are generally of ¾ths round copper, about 5 inches asunder, which pass through the water spaces, screwed into each plate, and rivetted, being for the purpose of rendering the flat surfaces of the fire box capable of withstanding the force of the steam. For the same purpose, the bars, *b b*, *&c.* are rivetted to the top of the fire box, resting upon rings about one inch in depth, so as to allow a free circulation of the water between each bar and the plate.

FIRE GRATE, AND DROP BARS IN FIRE GRATE.

The bottom of the fire box is about 20 inches from the top of the rails, and made up with wrought iron bars, 6 inches higher up, *a a a, &c.*, which are laid in the direction of the boiler, and constitute the fire grate; they are about 2½ inches in depth, the top edge 1 inch in thickness, bottom edge ½ an inch, and about 1 inch asunder. Four bars in the middle ought to be united together at each end, which rest upon the catch *c*, so that when the fire requires to be speedily removed the catch is withdrawn, and the four bars instantly drop, and along with them a great portion of the fire; otherwise, if the removal of a bar or bars is to be effected by the fire door, and especially when an indifferent quality of coke has been in for some length of time, it becomes clinkered together, and before it is possible to get one bar out, the whole of the water may be evaporated from off the top of the fire box, the leaden plug become melted, and perhaps two or three rows of tubes destroyed.

LEADEN OR FUSEABLE PLUG.

To render a leaden or fuseable plug of any essential service in such emergencies, it ought to be inserted into a tube attached to the top of the fire box, at least 1½ inches in height above the plate, because the plug will not melt until the water is entirely evaporated from around it; and very probably before it is melted the tubes are burned. And again, I have seen in such a case the steam so highly rarified, previous to the plugs being melted, as to ignite the moment it came in contact with the fire, to the great danger of those who were near to the engine at the time, besides setting on fire and destroying the casing of the boiler.

Fuseable plugs for locomotive boilers ought to be composed of two parts lead and three parts tin, which melt at a temperature of 334° Faht.

THE FIRE DOOR AND DOORWAY.

The door, or doorway *e*, is an opening into the fire box, through the back end of the boiler; its length across the engine is about 13 inches, width 9, and 8½ inches above the foot plate; semicircular at each end, and closed by a door of a similar form, attached to the boiler by hinges. The door is composed of two iron plates, about 1 inch apart, and rivetted together, so as to prevent the external plate becoming red hot by the action of the fire. This opening to the fire box is indispensably necessary,—1st, For the admission of coke in supplying the fire; 2ndly, For the introduction of a rod, to extract small pieces of coke which frequently stick fast in the ends of the tubes; and, 3rdly, For the insertion of plugs into the ends of the tubes, when they at any time become leaky, or chance to burst.

THE GLASS GAUGE.

The glass gauge G is an indicator generally attached to the back of the fire box, for the purpose of ascertaining, as nearly as possible, the height of the water in the boiler, and consists of two small cocks, with proper receptacles for a glass tube; the tube is about 12 inches long and ⅝ths diameter; 10 inches of its length is exposed to view, and so situated on the boiler that the bottom of the glass is level with the top of the fire box. Particular attention requires to be paid to the glass gauge, for various reasons: namely, the openings through the cocks to the boiler may get stopped up; the water in the tube sometimes becomes frothy, and no solid water indicated; also, if the regulator be suddenly opened in starting the engine, the water will rush up the tube, and remain quite full for some considerable length of time; and the only real test or prevention in such cases is to partially shut the cocks from the boiler, renew the water in the tube, or partially open the fire door for a short space of time.

GAUGE COCKS.

Gauge cocks, as they are commonly termed, are two, sometimes three, small cocks inserted on one side of the fire box at *c c*, and used as a check to the glass gauge. They are frequently screwed into the boiler, the bottom cock being about 1 inch above the top of the fire box. When only two are inserted they are placed 4 inches apart; if three, 3 inches apart.

THE BLOW OFF COCKS.

The blow off cocks *k k* are 1½ inches bore, and situated at the bottom of the water space in the back end of the boiler, for the purpose of emptying the boiler of water by the force of the steam, through which it is violently ejected, carrying along with it foreign matter held in solution, and other light substances that may be deposited at the bottom of the fire box. They are sometimes placed on the sides of the fire box, and immediately over the rails, but on account of the almost impossibility of keeping them tight, a constant dropping of water upon the rails is the consequence, thereby rendering it of frequent inconvenience to engines following, by causing them to lose their adhesion, and slip upon the rails.

THE MUD HOLES, AND HOW MADE UP.

The mud holes *m m* are circular openings, about 1½ inches in diameter, at the bottom of the water spaces into each corner of the fire box, and made up either by circular covers, held to their places by T heated bolts, or the plate tapped and screw plugs inserted. These holes are for the purpose of removing the sediment and scale that constantly accumulate at the bottom of the water spaces, and also for the purpose of introducing a jet of water, so as to prevent any accumulation of dirt or scale among the stays, which, if not frequently attended to, soon becomes in such a state as not to be easily removed.

THE FRONT TUBE PLATE.

The front tube plate P, or that into which the tubes are inserted in the fore end of the boiler, is of rolled iron, about $\frac{5}{8}$ths of an inch in thickness; this plate forms the fore end of the cylindrical part of the boiler, also the back of the smoke box, and attached to each by $2\frac{1}{2}$ inch angle iron.

THE HOLES FOR THE TUBES.

The holes for the tubes are bored out perfectly round, and as nearly as possible their outside diameter; the distance between each hole is from $\frac{5}{8}$ths to $\frac{3}{4}$ths of an inch, and the top of the highest tube not exceeding the centre of the boiler.

DIMENSIONS AND QUALITY OF THE TUBES.

Tubes vary in size in common use, from $1\frac{5}{8}$ to 2 inches outside diameter, the smaller being most applicable to engines for passenger trains, or engines where a great quantity of heating surface is required, and the larger for luggage engines that have to transmit a greater load at a less velocity: they also vary in length from $7\frac{1}{2}$ to $8\frac{1}{2}$ feet, for similar reasons.

THE USE AND INSERTION OF THE TUBES.

The tubes are for the purpose of communication between the fire box and the chimney, and also for the distribution of caloric to the water in which they are immersed. The best tubes are of rolled brass, No. 13 wire gauge, well soldered, drawn perfectly true from end to end, and tested to at least 150 lbs. per square inch. After they are fitted to their proper places in the boiler, they are rivetted or turned over the plates a little at each end, so as to prevent the hoops, when in the action of being driven, taking the tubes along with them.

THE HOOPS AND THEIR DIMENSIONS.

The hoops are $1\frac{1}{4}$ inches in breadth and $\frac{1}{8}$th in thickness, having their external diameter turned slightly conical, and a little larger than the internal diameter of the tubes, so that when they are driven into the tubes they may cause them to expand so as to bring their external diameter so closely in contact with the internal diameters of the holes as to render them water tight.

QUALITY OF HOOPS.

The hoops for the fire-box end are of steel, and for the smoke-box end of iron, steel being found in practice to withstand the action of the coke much better than iron, and nearly in the same proportion as brass tubes to copper tubes—namely, brass in preference to copper nearly as 6 to 1.

HEATING SURFACE IN THE TUBES.

The proportion of heating surface in the tubes is about seven times the quantity in the fire box; hence, when the quantity of heating surface is known, and the diameter and length of tubes determined, the number is easily ascertained.

EXAMPLE.—Suppose the heating surface in the fire box 50.85 square feet, the length of the tubes 8 feet, and internal diameter $1\frac{1}{2}$ inches, required the number.

$1\frac{1}{2} \times 3.1416 = 4.71$ inches, circumference of each tube.

$50.85 \times 7 = 355.95 \div 8 = 44.49 \times 12 = 533.88$ inches, the whole circumference of the tubes. And $533.88 \div 4.71 = 113$ tubes.

LONGITUDINAL STAYS.

The stays S S are three or more round iron bars, about $1\frac{1}{8}$ inches diameter, and extending from the back extremity of the boiler, through the front tube plate inside the smoke box; they are screwed into each plate so as to render them completely tight, and are for the sole purpose of support to the ends of the boiler against the force of the steam.

THE DOME.

The steam dome M is a cylinder of wrought iron, about 14 inches diameter, 2 feet in height, and placed in some engines immediately behind the chimney, on the body part of the boiler; it is for the purpose of admitting the steam to the cylinders at a greater height above the surface of the water in the boiler; it is also, when so placed, a means of ready admission to the regulator, being the only article generally that requires the interior of the boiler to be exposed.

STEAM PIPES, &c.

The steam pipe N is 4 or $4\frac{1}{2}$ inches diameter, made of copper one-sixteenth of an inch in thickness. The steam is conducted to the regulator by this pipe, and thence to outside the front tube plate and interior of the smoke box, where it diverges, and $3\frac{1}{2}$ inch pipes attached, by which the steam is conducted to the valve boxes, B B. The top of the pipe in the dome is in form of a funnel, in order to prevent, as much as possible, any particles of water arising with the steam getting into the steam pipe, and thereby passing into the cylinders, generally known by the term priming, and is not only very unpleasant, but extremely detrimental to the engine. Priming is much less liable to take place when pure soft water can be obtained, and by keeping the boiler properly clean.

THE REGULATOR.

The regulator R might be conceived to be an obstruction in the steam pipe, and consists of two flat circular disks *d d*, ground face to face until they are rendered perfectly steam tight. Into each plate are two or three openings exactly opposite to each other, so that, by one disk remaining stationary, and the other being moved a fourth or sixth of a circle, the openings are brought opposite to each other, or otherwise, as required; consequently, by this means the steam can be completely shut off, or partially shut off, and the velocity of the engine easily regulated at pleasure.

MEANS BY WHICH THE REGULATOR IS MOVED.

Connected with the regulator, and for the sake of convenience, the rod *r* is continued from the back of the moveable disk *d* to the back of the fire box, on which is fixed the lever L, and by which the change of the regulator is effected. The stationary disk is usually of cast iron, the moveable of brass, and each about 10 inches diameter.

SAFETY VALVES.

To regulate the density, and also to protect the boiler against unnecessary accumulation of steam, two safety valves are attached of 2½ inches diameter each at the narrowest part; one is placed upon the dome M, and the other any where convenient to the engineer, so that he may have it in his power to lessen the regular pressure, namely, 50 lbs. per square inch, at any time the engine is about to be lessened in effect; and it should always be attended to when the engine is stopped for any length of time.

EFFECTS OF THE LEVER AND SPRING BALANCE ON THE SAFETY VALVE.

Upon each valve is placed a lever *l l*, and at the end of each lever a spring balance *t t*, fixed to the boiler. Hence, in calculating the effect or pressure on the valve, the action of the lever and spring balance must be taken into account, which is easily ascertained by the following simple means:—Disengage the spring balance from the boiler, and attach another to the lever immediately above the centre of the safety valve, which will indicate the number of pounds to be distributed on each square inch of the valve.

DIVISIONS OF THE LEVER.

Sometimes, for the sake of ready calculation, the valve levers are so divided that the distance from the fulcrum to the valve equals the diameter of the valve, and the distance from the fulcrum to the spring balance as many times the diameter of the valve as there are square inches in its area, consequently the pressure upon the valve per square inch is always indicated by the spring balance, plus the action of the lever.

CALCULATIONS CONNECTED WITH THE SAFETY VALVE.

When levers so applied are not thus proportioned, the effect of the lever requires also to be taken into account;—For example, suppose a lever 30 inches in length, distance from the fulcrum to the valve $2\frac{1}{2}$ inches, area of the valve 4.9 inches, and the action of the lever and spring balance equal 16 lbs upon the valve, what will the spring balance indicate when steam is at a pressure of 50 lbs per square inch above the pressure of the atmosphere?

$\frac{30}{2.5} = 12$, or the effect of the lever; and

4.9 = the area of the valve in square inches.
$\times$ 50 lbs. pressure per square inch.

245 = the whole pressure upon the valve.
— 16 lbs. action of the lever and spring balance.

12) 229(19.08 lbs. indicated by the spring balance.

THE AREA OF THE VALVE.

To find the area, or number of square inches in a valve.

Rule.—Multiply the square of the diameter by .7854 and the product is the area,—thus, $2.5^2 = 6.25 \times .7854 = 4.9087$ the area.

THE SMOKE BOX.

The shell of the smoke box is of wrought iron plates, $\frac{1}{4}$th of an inch in thickness, unless the front plate, which is generally $\frac{3}{16}$ths; the angle iron for uniting the corners 2 inches in breadth; the rivets $\frac{1}{2}$ inch diameter, and $1\frac{1}{2}$ from centre to centre of each. Some makers attach the front plate to the angle iron by $\frac{5}{8}$ths bolts, for the purpose of being more easily removed, and prevent shaking to pieces any other part of the smoke box, in case of general repair, &c.

DOORS OF THE SMOKE BOX.

In the front of the smoke box is a door-way, just sufficient in size to clear the ends of all the tubes, so that a rod may easily be introduced to clean the tubes, or the tubes easily replaced when required. The opening is made up by a door or doors, and attached to the front plate by hinges, so as to admit of ready access, and also to render the smoke box as tight as possible, so that the tubes may be completely inclosed and the current of heated air be allowed to pass unobstructed from the fire to the chimney.

THE CYLINDERS.

The cylinders *g g*, are situated at the bottom of the smoke box, and attached to the front tube plate P by five bolts $\frac{7}{8}$ths of an inch in diameter, the centre of each cylinder being placed in a direct line with the centre of the crank axle, and parallel to each other at a distance of about 31 inches from centre to centre, for engines of 4 feet $8\frac{1}{2}$ inches gauge.

THE PISTONS.

The cylinders are of cast iron from $\frac{3}{4}$ths to $\frac{7}{8}$ths of an inch in thickness, and bored out truly circular and parallel from end to end, into which the pistons *p p* are fitted steam tight, and to the sides of which the steam is admitted alternately, so as to give a reciprocating motion to each, which is communicated to the crank axle by the piston rods *r r* and connecting rods *e e*, and a circular motion obtained.

SUPPORT OF THE CYLINDERS.

For the mutual support of the cylinders a flange is sometimes cast upon the lower external diameter of each, in the direction of their length, by which they are bolted together, to prevent, as much as possible, any twisting of the tube plate taking place by the action of the engine.

THE STEAM WAYS.

The openings or steam ways *o o*, through which the steam is conducted to and from each side of the pistons alternately, are cast upon the cylinders, and to which they bear the following proportions:—Width across the cylinder, about $\frac{2}{3}$rds of its diameter; area, $\frac{1}{16}$th of the square of its diameter. The openings *u u*, through which the steam makes its escape to the atmosphere, are the same in length, but about double the width of the others.

THE VALVES.

The valves *v v*, by which the steam ways are covered, and by which the quantity of steam to each cylinder is regulated, are sometimes made of brass, but more generally of cast iron, and in the form of an inverted rectangular box, the internal length being equal to the length of the steam openings; width, their distance between, and depth about equal to one of the openings.

LAP OF THE VALVES.

The external width of each box, or face of the valve, is augmented by flanges of about ½ inch more than is sufficient to cover all the openings, and designated the lap of the valve. This augmentation is for the purpose of cutting off the communication with the boiler, previous to the pistons reaching the ends of the cylinders or return of the strokes, and thereby causing the diminished velocity of the pistons to be continued to the end of the stroke by the expansive force of the steam.

MOTION OF THE VALVES.

The motion of the valves is obtained from the crank axle, by means of the eccentrics *x x x x*, and communicated by the eccentric rods *r r r r*, and levers *i i*, *&c.* Two eccentrics, rods, &c., are adapted to each piston, so as to cause an easy and certain change of motion to take place when required. The two outer eccentrics cause a forward motion, and the two inner a backward motion of the engine, which are set to suit accordingly.

THE LEAD OF THE VALVE.

The lead of the valve is a certain advance in the extent of its movement to the movement of the piston, but generally understood the quantity of opening for admitting the steam to the opposite side of the piston at its return of the stroke, for the purpose of obtaining the steam at a greater density for a first impulse to the piston. And, train engines, or engines running about thirty miles per hour, require more lead than luggage engines with heavy loads which run at about half that velocity, the ratio of advantage derived from the lead of the valve being nearly as follows :—

Suppose the lead = 0, the velocity = 1.
„ „ = $\frac{1}{8}$ „ „ = 1.016.
„ „ = $\frac{3}{8}$ „ „ = 1.048.
„ „ = $\frac{5}{8}$ „ „ = 1.103.

THE BLAST PIPE.

The blast pipe *y* is a copper conical tube, the bottom end of which is attached to each cylinder, and a direct communication formed from the middle openings or thoroughfares under the valves, to the bottom of the chimney, for the purpose of allowing the steam to escape, after performing its duty in propelling the pistons, and also to render it available for the production of steam,—for, by its superior density, the air is expelled from out of the chimney, and thereby causes an excess of heated air to pass through the tubes. The bottom end of the blast pipe is about equal in area to the two middle openings on the cylinders, its height about an inch into the chimney, and its orifice one-fourth of the cylinder's diameter.

THE CHIMNEY.

The chimney D is of rolled iron plates $\frac{1}{8}$th of an inch in thickness, its diameter $\frac{7}{6}$ths of the cylinder's diameter, and extreme height 13 feet 6 inches above the rails. The top is sometimes made in the form of a funnel, and extended to nearly twice the bottom diameter, and covered with No. 12 wire-work about $\frac{3}{16}$ths asunder. Others have the wire-work at the bottom of the chimney, and directly above the ends of the tubes; in either case it is intended to prevent, as much as possible, any danger or annoyance from small pieces of hot coke which are carried from the fire through the tubes, by the action of the blast pipe.

The preceding are chiefly of what the boiler is composed, and a few parts of the engine, which it incloses. Hence, the following are external parts required to constitute the whole machine, and render its effects complete.

THE EXTERNAL FRAME.

The frame F F which surrounds the boiler is of oak or ash timber, about 7 inches by 3, and covered on each side with rolled iron plates $\frac{1}{4}$th of an inch in thickness, except the front or buffer board, which is not covered with iron, but is of considerably greater dimensions, say about 13 inches in breadth and $5\frac{1}{2}$ or 6 inches in thickness, in order that it may be enabled to withstand the sudden shocks it is constantly liable to receive.

THE KNEES.

The knees *n n n*, *&c.*, by which the boiler is supported and attached to the frame, are of wrought iron, 4 inches broad and $\frac{3}{4}$ths or $\frac{7}{8}$ths of an inch in thickness. The front and middle knees are each riveted to the boiler; those on the back end are attached by screws, so as to be easily removed when the copper fire box requires to be renewed.

THE GUARD PLATES.

The guard plates *g g g*, *&c.*, are of wrought iron, $\frac{3}{8}$ths of an inch in thickness, and attached to the frame in pairs at the ends of each axle, for the purpose of keeping the axle boxes in their proper situations; the openings in the plates are made exactly parallel, and also fixed to the frame parallel to each other, so as to allow the axle boxes to move easily but accurately up and down, by which means the shaking motion of the engine is rendered comparatively little, through the action of the springs.

THE SPRINGS.

The springs are generally composed of $\frac{1}{4}$th or $\frac{5}{16}$ths steel plates from 3 to 4 inches in breadth, and containing from ten to fifteen plates, varying in quantity and form with the weight of the engine and judgment of the maker; a proper tension of the springs being of very essential consequence to the benefit of the working parts and safety of the engine, as the shaking or tremulous motion through them may be considerably lessened; and I have found, from practice, that wheels and tires last much longer on engines where the springs are of a proper elasticity.

THE AXLE BOXES.

The axle boxes *q q q*, *&c.*, are sometimes made of brass, but more generally of cast iron, into which is fitted a lining or receptacle for the ends of the axles, composed entirely of copper and tin, so as to reduce the liability of the bearings becoming heated by the weight of the engine and velocity of the wheels.

Into the upper part of each axle box is formed a cavity, for the purpose of retaining a portion of oil or other lubricating matter, which is distributed by degrees, through small holes upon the bearings, and renewed occasionally, as required.

THE AXLES.

The axles *z z z*, on which the wheels are fastened, require to be of the best wrought iron, fagoted and welded together, generally termed fagoted iron, the ends or bearings being made all of the same length and diameter, and to suit the receptacles in the axle boxes, viz., 5½ inches in length, and about 3¼ in diameter; those parts on the front and back axles, on which the wheels are fixed, are about 4½ inches diameter, and the remainder, or middle part, from 3¾ to 4 inches. Some makers contend that diminishing the diameters of the axles towards the centre considerably reduces the liability of breaking where any inequality of the road takes place, but having seen only few in use of that description, I am not yet prepared to contend for, or attribute any particular merit to, the design.

The cranked or middle axle is that on which the driving wheels are fixed, the power communicated, and the motion of the engine obtained; it is composed of one solid mass of wrought iron, the cranked parts being set at right angles to each other, and cut out after the axle is forged, the bearings of the cranks, to which the connecting rods are fitted, being about 5 inches in diameter, and 3½ in length, the middle or stay bearings 4¾ inches diameter, and 2¾ in length, and the parts on which the wheels are fixed 6 inches diameter.

After the axles are turned and finished, the end bearings are properly case hardened, so as to render the surface of a close compact texture, approximating the nature of steel, which is found to be essentially necessary, on account of the whole weight of the engine resting upon those small bearings. When this precaution is not adopted, and very superior brasses applied, the bearings become heated by friction, lubricration is destroyed, the surfaces of the axles become unavoidably rough, and afterwards no means whatever will prevent their heating, by which the velocity of the engine is retarded, the machinery destroyed, and an unnecessary quantity of fuel expended.

Exceedingly great attention on the part of engine-men require to be paid to those outer bearings, as they are generally termed, by seeing each axle box properly cleaned and lubricated at each end of the journey, and also when a moment of opportunity occurs at any stopping place on the road, the same examined by the touch of the hand, such attention being most required with a new engine, or any engine after receiving a general repair; but if the materials are good and properly manufactured, they soon become humoured to their proper bearings, and still keeping in mind cleanliness, less of other attention is required.

THE WHEELS.

The wheels are chiefly made of wrought iron, with cast iron naves, so as to combine the arms together, and form the means by which they may be firmly fixed upon their axles. Wheels are of very different constructions, varying, of course, with the opinions of the makers, but in all cases the arms and rim welded together. In some the arms are of flat iron, in others round, but each forming a plane surface to the centre. Another, and I believe the best form of wrought iron wheels, is round arms strutting from the rim to the nave in a zig-zag form, and in place of the arms forming a plane surface with the centre they form a double cone, and thereby considerably augment the stability of the wheel, and diminish the tendency to the oscillating motion of the engine.

Wheels of wrought iron are very expensive to make, and unless made of considerable strength and superior workmanship, are apt to vibrate from the centre, by which it is not unfrequent to start the arms from the rim, and thereby render the wheels unsafe. To avoid, as much as possible, each of those inconveniences, cast iron wheels have been introduced of late, which seem to answer very well; they have round arms, cast hollow, like pipes, so as to render the cooling, and, consequently, the contraction of the metal, nearly equal.

In each description of wheels the arms are commonly set about one foot apart on the rim, the cast iron arms being hollow, cause their diameter to be greater, and, consequently, their number less. In six feet wheels, with round arms of wrought iron, they are about 2⅛th inches diameter at the rim, and contain 18 arms; cast iron wheels of the same diameter have arms about 3 inches diameter at the rim, and contain 16 arms. In either case the arms increase in diameter towards the centre about ⅛th of an inch for each foot in length, and the naves of each are about 18 inches diameter. Hence, from the above dimensions, wheels of any diameter may easily be proportioned.

THE TIRES.

The outer rims or tires are of the best rolled iron, from 1½ to 1¾ inches in thickness, and from 5 to 6 inches in breadth; the broader the tire, the less is it liable to become elongated by the weight and action of the engine upon the rails.

As a means of preventing the tires becoming loose upon the wheels, the external diameter of the wheels and internal diameter of the tires are turned to a plain even surface, leaving the tires of smaller diameter, so that, when heated, they may expand to a sufficient size, to go easily on to the wheel, and so, by the contracting power of the metal in cooling, may bind the two surfaces compactly together. The tires are afterwards turned to the dimensions and proper form required, the inner side of the wheel being made about 1/7th of the breadth of the tire larger in diameter than the outer side, and thus renders the tire in form of a cone.

The diameters of wheels for locomotives are proportioned in the following manner:—

5 feet driving wheels, and	3 ft.	6 in. small wheels.		
5¼	,,	3	7½	,,
5½	,,	3	9	,,
6	,,	4	0	,,
6½	,,	4	6	,,
7	,,	5	0	,,

the tires of which require to be nearly of the following lengths when in their unbent state:—

Wheels 3 ft.	6 in.	diam.	tires 11 ft.	8 in.	in length.
3	7½	,,	11	9	,,
3	9	,,	12	4	,,
4	0	,,	13	2	,,
4	6	,,	14	9	,,
5	0	,,	16	6	,,
5	3	,,	17	4	,,
5	6	,,	18	2	,,
6	0	,,	19	10	,,
6	6	,,	21	5	,,
7	0	,,	23	1	,,

ADHESION OF THE WHEELS.

The adhesion of the driving wheels is fouud to be about $\frac{1}{5}$th of the weight bearing upon them when the rails are clean, but vary with their dirty condition to about $\frac{1}{10}$th, consequently, for the purposes of calculation, generally reckoned at $\frac{1}{6}$th.

PISTON RODS.

The piston rods *r r* are the means by which the power of the steam is conveyed outside the cylinders. Each rod being inserted properly into its respective piston *p p*, is made to pass through the stuffing boxes *n n*, which are filled with hemp or soft rope yarn, and compressed upon the rods sufficiently to prevent any escape of steam.

Piston rods for locomotive engines ought invariably to be of steel; being of a more compact texture than iron, it is of course stronger, less liable to corrode, and not so easily scratched or grooved, by which qualities unnecessary friction is avoided, and the packing requires to be less frequently renewed.

The diameters of piston rods may be proportionate to their cylinders, as follows:—

Cylinders	10	in. diam.	piston rods	1.43	in. diam.
	11	,,	,,	1.57	,,
	12	,,	,,	1.71	,,
	13	,,	,,	1.86	,,
	14	,,	,,	2.0	,,
	16	,,	,,	2.3	,,

THE CONNECTING RODS.

The links *e e*, by which the power is communicated from the piston rods to the cranks, are of wrought iron, and designated connecting rods, to each end of which is attached, by a wrought iron strap, a pair of semicircular brasses, one pair being suited to the diameter of the cross head *h*, and the other to the diameter of the crank bearings; these brasses are brought together upon their bearings by means of wedges or cotters, consequently, a considerable degree of care is required in tightening these cotters, so that the brasses may neither be too tight, nor have any tendency to jump or shake upon their bearings at the return of the stroke, for in either case it causes a considerable liability to heating, and by which the cranks may ultimately be prevented in a great measure from revolving in their brasses, and thus cause an unnecessary degree of friction, and, probably, disarrangements to a serious extent, which might easily have been avoided.

THE SLIDES, BLOCKS, &c.

As the connecting rods in their motion are unavoidably thrown out of a direct line with the piston rods, by the revolution of the cranks, and being attached to the piston rods, it is necessary their union be protected in a direct line with the cylinders; and in order to effect this, each is attached to a spindle, or cross head *h h*, on either end of which is a block of brass or cast iron *m m*, &c., guided between slides of cast iron or steel, which are attached to each inside frame in a direct line with the cylinders. These blocks are about 6 inches in length, 2½ to 3 inches in breadth, and 2 inches in thickness, and, until lately, consisted of either brass or steel, but now are more frequently of cast iron, and found to wear extremely well.

The slides are attached together in pairs, by a stud at each end, and kept in their proper situations by the inside frames.

THE ECCENTRICS.

As a continued circular motion is obtained from the reciprocating motion of the pistons, by means of the cranks, so is an alternate motion obtained from continued circular motion of the crank shaft, by means of the eccentrics.

The eccentrics *x x*, &c., are cast iron wheels or pulleys, about 9 inches in diameter and 2 inches in thickness, which are fixed upon the crank shaft, each having its centre of motion as far from the centre by which it is described as half the travel of the valve, unless the levers by which the motion is communicated be of unequal lengths, and if so, the case becomes involved into arithmetical proportion ; hence the following simple rules become applicable to the demand, in which let all the dimensions be in the same terms :—

1. The travel of the valves and length of levers being given to find the required throw of eccentrics :

Rule.—Multiply the travel of the valves by the length of the levers to which the eccentric rods are attached, and divide the product by the length of the levers which more immediately communicates the motion to the valves, the quotient is the required throw of eccentrics.

Ex.—Suppose an engine, the travel of whose valves are each $3\frac{1}{2}$ inches, the length of the levers to which the eccentric rods are attached $6\frac{1}{4}$ inches, and the length of the levers more immediately attached to the valves $5\frac{3}{4}$ inches, required the throw of eccentrics:

$3.5 \times 6.25 = 21.875 \div 5.75 = 3.8$ inches throw of eccentrics, or $3.8 \div 2 = 1.9$ inches between their centre of motion and centre by which they are described.

2. The travel of the valves, the length of the levers to which the eccentric rods are attached, and throw of eccentrics being given, to find the length of the levers immediately giving motion to the valves:

Rule.—Multiply the travel of the valves by the length of the levers to which the eccentric rods are attached, and divide by the throw of the eccentrics; the quotient is the length of the levers immediately connected with the valves.

Suppose, as in the preceding example,

Then, $3.5 \times 6.25 \div 3.8 = 5.75$ length of levers.

3. The length of the levers immediately attached to the valves, the throw of eccentrics and travel of the valves being given, to find the length of the levers to which the eccentric rods are attached:

Rule.—Multiply the throw of the eccentrics by the length of the levers attached to the valves, and divide by the travel of the valves: the quotient is the length of the levers to which the eccentric rods are attached.

Thus, as before, $3.8 \times 5.75 \div 3.5 = 6.25$ length of levers.

4. The throw of the eccentrics and the length of the levers being given to find the travel of the valves :

Rule.—Multiply the throw of the eccentrics by the length of the levers immediately connected with the valves, and divide by the length of the levers to which the eccentric rods are attached, and the quotient is the travel of the valves.

$$3.8 \times 5.75 \div 6.25 = 3.5 \text{ travel of the valves.}$$

Surrounding the eccentrics are hoops of brass, to which the rods are attached; the rods *r r*, &c., are of wrought iron, the stud ends of which are in the form of a V, which are allowed to drop clear of the studs, but only so far as to be still kept within their range, and, by a combination of levers, which is communicated to the back end of the boiler, can be lifted at any moment by the engine-man with certainty, so that the motion of the engine may be changed as required.

THE PUMPS.

The pumps *p p*, are of brass, and fixed to the inside frames, for the purpose of supplying the boiler with water against the force of the steam; the strokes of the pumps are equal to the strokes of the pistons, being attached, and worked from the cross heads; the rams, by which the water is displaced in the pumps, are of wrought iron, and about $\frac{1}{7}$th of the cylinder's diameter. The water is conducted from the tender to the pumps by copper pipes, into each of which is placed a valve, for the purpose of preventing the water returning to the tender by the action of the pumps, consequently, what is displaced by the rams is forced into the boiler. It

SAFETY COCKS.

Into each cylinder cover is screwed a cock, for the purpose of allowing an escape of water which frequently accumulates in the cylinders while the engine is standing, and the same precaution ought to be taken in introducing cocks into each valve box, as water also accumulates there in a similar manner, when all the apertures are covered by the valves, for I have seen instances of this kind where great violence was required before the valves could be removed, causing extreme danger to the working parts, and sometimes considerable delay.

THE FOOT BOARD.

The foot board, as it is generally termed, is a wrought iron plate at the back end of the boiler, and fixed to the top of the frame, in a line with the bottom of the tender, which serves as a platform for the men in their active duties upon the engine: it is also a support to the pin of the drag link, by which the tender is attached to the engine.

Having, in the preceding remarks, described the most prominent parts of a railway locomotive engine, it is only necessary to add the tender, and the machine is complete.

THE TENDER: WEIGHT OF ENGINE, &c.

The tender consists of a wrought iron tank, placed upon a strong frame-work of timber, which is supported and conveyed upon 4 or 6 wheels, as may be required, according to its weight. The axles, axle boxes, guard plates, springs, &c., being similar to those upon the engine, it is quite necessary, for the sake of safety, to

have them of a proper tension. Tenders are generally made sufficient to contain from 700 to 800 gallons of water, and from 10 to 12 cwt. of coke, this being about the necessary expenditure for a 30 mile trip of an engine containing 12 inch cylinders and 18 inch strokes. An engine of this description, when fully equipped with coke and water, is about 12 tons in weight, and the tender similarly situated is about $6\frac{1}{2}$. The weight of the engine upon the driving wheels is about $6\frac{1}{2}$ to 7 tons.

PRELIMINARIES

TO THE

CALCULATION OF USEFUL EFFECT

IN

LOCOMOTIVE ENGINES.

In order to determine the useful effect of a locomotive engine, it is necessary to observe that 6 lbs. per ton of its own weight is expended in overcoming the friction of its parts; 9 lbs. per ton of gross load for horizontal traction and additional friction which is caused to the engine by the load; and 14.7 lbs. per square inch, the pressure of the atmosphere. These being premised, the following calculations are easily determined:

1. The weight of an engine, tender, and load, being given, also the dimensions of cylinders and diameter of driving wheels, to find the force of steam required to overcome that resistance:

Rule.—To the gross load of the train in tons, multiplied by 9, add the friction of the engine,—multiply that sum by the diameter of the driving wheels in inches, divide the product by the capacity of the cylinder, and the quotient, plus 14.7, equal the pressure of the steam in lbs. per square inch.

EXAMPLE.—Suppose a train of 80 tons, engine 12, and tender $6\frac{1}{2}$, driving wheels $5\frac{1}{2}$ feet or 66 inches diameter, cylinders 12 inches diameter and 18 inches strokes, required the pressure of steam per square inch:

$80 + 12 + 6\frac{1}{2} = 98.5$ tons gross load $\times 9 = 886.5$ lbs. traction.
Friction of engine $12 \times 6 = 72$

958.5
Diameter of wheels........... 66

Cylinders $12^2 \times 18 = 259)63261(24.4 + 14.7 = 38.11$ lbs. per square inch.

To ascertain the pressure of steam necessary, supposing the engine be required to ascend an incline with the same load, under similar circumstances, and at an equal velocity:

RULE 1. Divide 2240, or the number of lbs. in a ton, by the inclination of the plane to 1 or unity, to the quotient of which add 9, and divide the sum by 9, the result is the effect of gravity upon the plane.

2. Multiply the pressure of steam required upon the horizontal line, minus 14.7, by the effect of gravity upon the plane, and the product, plus 14.7, is the force of steam required per square inch.

Suppose the terms as in the last example, and the engine has to ascend an incline of 1 in 160.

$$\frac{2240}{160} = \overline{\frac{14 + 9}{9}} = 2.55,$$ effect of gravity to 1 of horizontal traction.

And $38.11 - 14.7 \times 2.55 = 62.2 + 14.7 = 76.92$ lbs. per square inch, before the engine can ascend the plane at an equal velocity.

To determine the diameter of the driving wheels of an engine for a given load, when the effective capacity of the cylinders and force of the steam are given:

Rule.—Multiply the capacity of the cylinder in inches by the effective force of the steam in pounds per square inch, and divide the product by the amount of traction, plus the friction of the engine, the quotient is the diameter of the wheels in inches.

Example.—Required the diameter of the driving wheels for an engine with 12 inch cylinders and 18 inch strokes, the effective force of the steam being 50 lbs. per square inch, and the weight of the train 200 tons, engine 12, and tender 6.

$$200 + 12 + 6 = 218 \text{ tons gross load.}$$

And $\overline{218 \times 9} + \overline{12 \times 6} = 2034$ lbs. force of traction and friction of the engine. $12^2 \times 18 \times 50 = 129600$ lbs. effective force produced by the steam. Hence,

$$\frac{129600}{2034} = 63.7 \text{ inches, diameter of wheels.}$$

Again, how much must this load be reduced, so as to enable the engine, under the same circumstances of pressure, &c. to ascend an incline of 1 in 140?

$$\frac{2240}{140} = \frac{\overline{16 + 9}}{9} = 2.77. \quad \text{And } \frac{200}{2.77} = 72.2$$

consequently, $200 - 72.2 = 127.8$ tons, the train must be reduced.

OF THE EFFECT OF A LOCOMOTIVE ENGINE IN HORSES' POWER.

3. To determine the effect of a locomotive engine in horses' power:

Rule.—Multiply the total resistance in pounds by the velocity in miles per hour, and by the constant number 2.66, cut off five figures from the right hand of the product for decimals, the remainder is the effect of the engine expressed in the term horses' power.

Example.—Required the number of horses' power an engine is equal to when the force of the steam will overcome a load of 221 tons, the engine being 12 tons, and tender 7, or gross load 240 tons, at the rate of 14 miles per hour.

$\overline{240 \times 9} + \overline{12 \times 6} = 2232$ lbs. resistance and friction of the engine and train.

Then, $2232 \times 14 \times 2.66 = 83.11968$ horses power.

If the number of horses' power thus obtained be multiplied by the constant number 375, the product will be a constant number whereby to obtain the velocity of any other load by the same amount of power.

Thus, suppose the horses' power the same as above, but the total resistance only 1800 lbs., required the velocity:

$$\frac{83.11968 \times 375}{1800} = 17.2 \text{ miles per hour.}$$

TIME AND DISTANCE TABLE.

A Table by which to ascertain the Rate of Travelling on a Railway per hour.

¼ of a mile in	75	seconds or 1 mile in	5	minutes	= 12	miles per hour.
¼	69	or 1	4	36″	= 13	
¼	64	or 1	4	16″	= 14	
¼	60	or 1	4		= 15	
¼	56	or 1	3	44″	= 16	
¼	53	or 1	3	32″	= 17	
¼	50	or 1	3	20″	= 18	
¼	47	or 1	3	8″	= 19	
¼	45	or 1	3		= 20	
¼	43	or 1	2	54″	= 21	
¼	41	or 1	2	44″	= 22	
¼	39	or 1	2	36″	= 23	
¼	37	or 1	2	28″	= 24	
¼	36	or 1	2	24″	= 25	
¼	34	or 1	2	16″	= 26	
¼	33	or 1	2	12″	= 27	
¼	32	or 1	2	8″	= 28	
¼	31	or 1	2	4″	= 29	
¼	30	or 1	2		= 30	
¼	29	or 1	1	56″	= 31	
¼	28	or 1	1	52″	= 32	
¼	27	or 1	1	48″	= 33	
¼	26	or 1	1	46″	= 34	
¼	25	or 1	1	40″	= 36	
¼	24	or 1	1	35″	= 38	
¼	22	or 1	1	30″	= 40	
¼	20	or 1	1	20″	= 45	
¼	18	or 1	1	12″	= 50	
¼	16	or 1	1	5″	= 55	
¼	15	or 1	1		= 60	

A TABLE

Whereby to ascertain the Total Resistance of Loads arising from Gravity and Friction on Inclined Planes, taken at $\frac{1}{240}$th of the weight.

	INCLINATION OF THE PLANE = TO 1 IN									
	0	100	200	300	400	500	600	700	800	900
0	.004167	.0141667	.0091667	.0075	.0066667	.0061667	.0058333	.0055953	.0054167	.0052778
10	.0041667	.0132575	.0089285	.0073925	.0066057	.0061275	.005806	.0055752	.0054013	.0052656
20	.054167	.0125	.008712	.0072917	.0065477	.0060898	.0057796	.0055555	.0053862	.0052537
30	.0375	.01213	.0085144	.007197	.0064923	.0060535	.005754	.0055316	.0053715	.005242
40	.029167	.0113095	.0083333	.0071079	.0064394	.0060185	.0057292	.005518	.0053572	.0052305
50	.024167	.010833	.0081667	.0070238	.0063889	.0059848	.0057052	.0055	.0053432	.0052193
60	.020833	.010417	.0080129	.0069444	.0063406	.0059224	.0056818	.0054825	.0053295	.0052083
70	.018452	.01001467	.0078704	.0068694	.0062944	.0059211	.0056592	.0054654.	.0053161	.0051976
80	.016667	.009722	.0077381	.0067983	.00625	.0058908	.0056373	.0054488	.005303	.0051871
90	.0152778	.0094298	.007615	.0067308	.0062075	.0058616	.005616	.0054325	.0052903	.0051768

For any lesser inclination, divide 1 by the length of the plane to a height of unity, and add to the quotient .004167.

To use the table, look along the top line for the hundreds, and down the left hand column for the tens, of the rate of inclination, and at the point of intersection will be found a number which is to be multiplied by the total weight of the load in lbs. for the total resistance. Thus,—suppose a load weighing 8000 lbs. at an inclination of 1 in 560, .0059224 × 8000 = 47.3792 lbs.

ADHESION OF ENGINES.

The adhesion of engines may be taken as at least equal to $\frac{1}{10}$th part of the weight on the driving wheels. This will enable them to draw in the following proportions for each ton of the weight resting upon them, under the most unfavourable circumstances of weather, &c.

Inclination of the plane.	Load in tons for each ton adhesion.	Inclination of the plane.	Load in tons for each ton adhesion.	Inclination of the plane.	Load in tons for each ton adhesion.
1 in 4480	26.25	1 in 800	19.82	1 in 300	14.03
1 in 3360	24.21	1 in 700	19.14	1 in 250	12.83
1 in 2240	23.58	1 in 600	18.31	1 in 200	11.37
1 in 1680	22.40	1 in 500	17.25	1 in 150	9.56
1 in 1120	21.33	1 in 448	16.59	1 in 100	7.25
1 in 1000	20.86	1 in 400	15.88		
1 in 900	20.37	1 in 350	15.03		

The adhesion of the wheels is frequently least where the greatest is required; namely, at depots, stations, &c., the whole weight of the train having then to be overcome, and motion produced, for which reasons the regulator should never be suddenly opened in starting, as a rapid motion of the parts of the engine is only by such means obtained, and at a very great risk of derangement, with little effect upon the train. Strewing the rails with sharp sand, when they are dirty or greasy, is a means by which adhesion is considerably increased, consequently a greater force of steam can be effectively admitted, and a proper velocity of the train sooner obtained.

LOAD AN ENGINE IS QUALIFIED TO TAKE ON DIFFERENT INCLINATIONS.

The quantity of coke required to convert a cubic foot of water varies according to the quality, but, on an average, may be taken at 9 lbs. per cubic foot; hence the following table exhibits the load and velocity on different inclinations, when 60 cubic feet of water per hour can be converted into steam:

Inclination of the plane.	10 miles per hour	12½ miles per hour.	15 miles per hour.	17½ miles per hour.	20 miles per hour.	22½ miles per hour.	25 miles per hour.	27½ miles per hour.	30 miles per hour.
	Tons	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Level.	346	251	188	143	109	82	61	44	30
1 in 4480	326	236	176	134	102	77	57	41	27
1 in 2240	308	223	166	126	95	72	53	37	25
1 in 1120	276	200	148	112	84	63	46	32	20
1 in 1000	270	195	145	109	82	61	45	31	19½
1 in 900	265	191	142	107	80	60	43	30	19
1 in 800	256	184	137	102	77	57	41	28	18
1 in 700	246	177	131	98	74	55	39	27	16
1 in 600	235	169	125	93	70	51	37	25	15
1 in 500	220	158	116	87	65	47	34	22	13
1 in 400	201	144	106	78	58	42	29	19	10
1 in 300	175	125	91	67	49	35	24	15	7
1 in 200	138	98	70	51	36	25	16	8	2
1 in 100	84	55	38	25	16	9	3		

STATISTICAL DATA OF THE PRINCIPAL RAILWAYS IN GREAT BRITAIN.

STATIONS, TERMINI, &c.	Datum of Level.	Ft.	In.	Total Length. Mls.	Chs.	Lks.	Heaviest Gradient.	Rise in feet per mile.	Effect of gravity to 1 of horizontal traction.	Summit level above the sea.	Number of Shares.	Amount of Share.
Arbroath and Forfar,										Feet.		£
Commencing at Arbroath Harbour.....	Above high water mark at Arbroath.	1	8									
Terminus at Forfar........................	....	221	9	15	15	0	1 in 200	26.4	2.24	....	2800	25
Birmingham and Derby Junction,												
Commencing at its Junction with London and Birmingham Railway at Hampton..	Below the level of the rails at Junction.	21	9									
Junction with North Midland Railway, Derby..	....	153	3	38	68	0	1 in 351	15.04	1.71	....	6300	100
Birmingham and Gloucester,												
Commencing at Spa-road, Gloucester...	Above Trinity.	48	5									
Camp-hill, Birmingham Depot.............	....	410	10	51	30	30	1 in 37	142.7	7.72	529	9500	100
Birmingham, Bristol, and Thames Junction, commencing at Kensington Canal Basin, London	Below Trinity.	2	1									
Terminating in London & Birmingham Railway	Above Trinity.	102	6	2	71	43	1 in 30	176	9.29	....	7500	20
Bolton and Preston,												
Commencing at Bradford-sqr., Bolton,	Above low water mark at Liverpool.	311	4									
Junction with North Union Railway at Leyland	....	180	0	14	45	80	1 in 132	40	2.9	....	7000	50
Bristol and Exeter,												
Commencing at Temple-meads, Bristol	Above high water mark at Bristol.	23	8									
Wellan-moor, Exeter..............................	....	3	8	76	10	0	1 in 127	41.5	2.96	340	15000	100

CHESTER AND BIRKENHEAD, AND CHESTER AND CREWE, commencing at Woodside..................	Above low water mark at Liverpool.	42	4									
Brook-street, Chester	....	71	1	14	71	50	1 in 330	16	1.75	....	5000	50
And Joins Grand Junction at Crewe...	....	181	10	35	44	50	1 in 400	13.2	1.62	....	5000	50
CROYDEN, Commencing at Greenwich Railway, 1 mile 46 chains 50 links from London Bridge..................	Above Trinity.	17	0									
Terminus at Croyden..................	....	151	5	10	26	8	1 in 100	52.8	3.49	....	20000	25
EASTERN COUNTIES, Commencing at Shoreditch, London,	Above Trinity high water mark.	54	0									
Yarmouth		5	6	126	39	34	1 in 100	52.8	3.49	....	64000	25
EDINBURGH AND GLASGOW, Commencing at Haymarket, Edinburgh..................	Above high water mark in Clyde.	143	1½									
Terminus north end of Queen-street, Glasgow..................	....	26	0	46	0	0	1 in 42	12.5	6.9	226	18000	50
GLASGOW, PAISLEY, AND GREENOCK, Commencing at Boyle-st., Greenock,	Above high water mark at Greenock.	33	0									
Terminus at Glasgow..................	....	29	0	22	22	0	1 in 330	16	1.75	66	16000	25
GRAND JUNCTION, Commencing in Junction with Liverpool and Manchester Railway..........	Above low water mark at Liverpool.	125	4									
Depot Curzon-street, Birmingham.......	....	365	3	82	50	85	1 in 85	62.1	3.93	444	10400	100
GREAT NORTH OF ENGLAND, Commencing at the River Tyne, Newcastle..................	Above high water mark in the river Tyne.	20	11									
Termination at the York and North Midland Railway at York..................	....	46	10	74	19	70	1 in 330	16	1.75	324	10000	100

STATISTICAL DATA OF THE PRINCIPAL RAILWAYS IN GREAT BRITAIN.—*Continued.*

STATIONS, TERMINI, &c.	Datum of Level.	Ft.	In.	Total Length. Mls.	Chs.	Lks.	Heaviest Gradient.	Rise in feet per mile.	Effect of gravity to 1 of horizontal traction.	Summit level above the sea.	Number of Shares.	Amount of Share.
GREAT WESTERN,										Feet.		£
Commencing at Bristol Depot..........	Above Trinity.	17	0									
London Terminus, Paddington	....	44	0	117	32	34	1 in 100	52.8	3.49	226	25000	100
								New or half Shares			25000	50
HULL AND SELBY,	Above high water mark in Humber.											
Commencing at Station, Hull..........		5	0									
Junction with Leeds and Selby Railway	....	10	1	30	51	0	1 in 240	22	2.04	70	8000	50
LANCASTER AND PRESTON JUNCTION,	Above surface of Lancaster Canal.											
Commencing at Lancaster Station.....		120	10									
Junction with North Union Railway...,		87	1	20	18	0	1 in 500	10.5	1.5	....	5000	50
									New Shares		5000	37½
LIVERPOOL AND MANCHESTER,	Above low water mark at Liverpool.											
Commencing at Lime-street Station, Liverpool..................................		82	0									
Station, Manchester............................	....	116	6	30	53	0	1 in 88	60	3.83	215	7968¾	100
								Quarter Shares.....			546	25
								Half Shares.........			7968	50
LONDON AND BIRMINGHAM,	Above Trinity.											
Commencing at Station, Euston-square London..		58	5									
Birmingham Depot..................................	...............,	340	9	112	10	0	1 in 75	70.4	4.32	390	25000	100
								Quarter Shares.....			25000	25
								New Shares			31250	32

LEEDS AND SELBY, Commencing at Leeds Depot, Marsh-lane………………	Above high water mark river Humber.	110	1									
Terminus at Selby……………………	……………	10	1	20	0	0	1 in 137	38.5	2.82	242	2100	100
LEICESTER AND SWANNINGTON, Commencing at West Bridge, Leicester	Above low water mark at Liverpool.	190	0									
Ashby-de-la-Zouch……………………	……………	286	1	16	5	0	1 in 17	310.6	15.6	………	1500	50
									New Shares		800	50
LONDON AND BRIGHTON, Commencing at Croyden………………	Above Trinity.	151	5									
Terminus at Brighton……………………	……………	…………		41	13	92	… …………	………	………	………	36000	50
LONDON AND SOUTHAMPTON, Commencing at the Station, Nine-elms, London………………	Above Trinity.	2	0									
Terminus at Southampton……………………	……………	3	8	76	55	20	1 in 250	21.1	2	394	36000	$38\frac{8}{9}$
MANCHESTER AND BIRMINGHAM, Commencing at Store-street, Manchester……………………												
Terminus at Grand Junction Railway,	Above low water mark at Liverpool.	169	6									
Norton Bridge……………………	……………	298	0	45	52	50	1 in 378	13.9	1.66	………	30000	70
									Extension …		15000	70
MANCHESTER AND LEEDS, Commencing at Lees-street, Manchester……………………	Above low water mark at Liverpool.	210	7									
Junction with North Midland Railway, at Oakinshaw……… …………	……………	104	5	49	76	0	1 in 150	35.2	2.66	476	13000	100
									New Shares		13000	50

STATISTICAL DATA OF THE PRINCIPAL RAILWAYS IN GREAT BRITAIN.—*Continued.*

STATIONS, TERMINI, &c.	Datum of Level.	Ft.	In.	Total Length. Mls.	Chs.	Lks.	Heaviest Gradient.	Rise in feet per mile.	Effect of gravity to 1 of horizontal traction.	Summit level above the sea.	Number of Shares.	Amount of Share.
MANCHESTER, BOLTON, AND BURY, Commencing at New Bailey-street, Salford........	Above low water mark at Liverpool.	121	0							Feet.		£
Terminus at Bolton........	....	361	0	10	0	0	1 in 160	33	2.55	....	6200	100
MARYPORT AND CARLISLE, Commencing at South Quay, Maryport........	Above high water mark at Maryport Harbour.	13	0									
Junction with Newcastle and Carlisle Railway........	....	46	0	28	3	50	1 in 209	25.2	2.2	....	4000	50
MIDLAND COUNTIES, Commencing at Rugby Junction of London and Birmingham Railway....	Above low water mark river Humber.	322	0									
Station at Nottingham........	....	94	6	47	35	50	1 in 330	16	1.75	404	10000	100
NEWCASTLE AND CARLISLE, Commencing at Redheugh Quay, Newcastle........	Above high water mark river Tyne.	5	0									
Canal Basin, Carlisle........	....	57	3	61	70	0	1 in 106	49.8	3.35	446	3000	100
								Quarter Shares.....			3600	25
NEWCASTLE AND NORTH SHIELDS, Commencing at Pilgram-street, Newcastle........	Above high water mark river Tyne.	103	10									
Terminus North Shields........	....	86	3	6	79	20	1 in 180	29.3	2.38	....	2400	50

North Midland, Commencing at Castle Fields, Derby Depot, Hunslet-lane, Leeds..................	Above low water mark river Humber.	165 89	8 8	72	29	0	1 in 330	16	1.75	380	15000	100
									New Shares		15000	50
North Union, Commencing at Dock-street, Preston, Junction with Liverpool and Manchester Railway, at Parkside........................	Above low water mark at Liverpool.	87 111	0 0	22	1	0	1 in 100	52.8	3.49	285	6400	75
Northern and Eastern, Commencing in Junction with Eastern Counties Railway.......................... Terminus, Cambridge........................	Above Trinity.	14 27	0 0	53	11	0	1 in 330	16	1.75	....	12000	100
Sheffield and Manchester, Commencing at Stone-street, Manchester...................................... Terminus Effingham-street, Sheffield....	Above low water mark at Liverpool.	168 184	0 2	40	66	0	1 in 120	44	3.07	....	7000	100
Sheffield and Rotherham, Commencing at North Midland Railway.. Terminus, at Sheffield........................	Above low water mark at Liverpool.	116 154	4 3	4	65	50	1 in 377	14	1.66	....	4000	25
Stockton and Darlington, Commencing at Stockton Station Terminus Witton Park........................	Above low water mark river Tees.	21 485	0 2	25	30	32	1 in 33	160	8.54	583	2000	100
York and North Midland, Commencing at the Station, York... Junction with North Midland Railway,	Above summer level of river Ouse at York.	25 75	6 3	23	11	0	1 in 484	10.9	1.51	....	6700	50

LENGTH OF VARIOUS RAILWAYS IN JUNCTION WITH EACH OTHER.

London to Liverpool and Manchester.

	Miles.
London and Birmingham Railway	112¼
Grand Junction to junction with Liverpool and Manchester	82¾
From Junction to Liverpool	14¾
	209¾
Or Junction to Manchester 16, =	211

London to Leeds.

London and Birmingham Railway	112¼
Birmingham and Derby	38
North Midland to Leeds.....................	72¾
	223

Leeds to York.

North Midland to Methley Junction	7½
York and North Midland to York	23¼
	30¾

London to Brighton.

London and Greenwich Railway	1¾
Croyden line	8¾
Brighton Railway to Brighton	41¼
	51¾

Manchester to Leeds.

			Miles.
Manchester and Leeds Railway to Junction with North Midland			50
From Junction to Leeds			$10\frac{3}{4}$
			$60\frac{3}{4}$
From Junction to York	$27\frac{1}{4}$	=	$77\frac{1}{4}$
From Junction to Milford	$14\frac{1}{2}$		
Milford to Selby	$6\frac{1}{2}$		
Selby to Hull	$30\frac{3}{4}$	=	$101\frac{3}{4}$

NOTE.—It may be necessary, as the lengths in the preceding tables are given in miles, chains, and links, to observe, that the chain is composed of 100 links, each link being 7.92 inches in length, consequently the length of the chain equals 22 yards, or 66 feet, and 80 chains equal 1 mile.

Hence also, 5280 feet, or 1760 yards, equal 1 mile, and 1609.3059 French metres = 1 mile.

EFFECT OF INCREASING THE DIAMETER OF THE WHEELS OF A LOCOMOTIVE ENGINE.

It is essentially necessary for all who are actively engaged with locomotive engines to be well aware of the increased velocity and momentum of a train by an increased diameter of driving wheels on the engine, so that disappointments in stopping, &c., may be carefully avoided; as, for instance, an engine with 5 feet wheels will only go one-fourth of a mile by 84 revolutions of the wheels; an engine with 6 feet wheels will proceed onwards the same distance by 70 revolutions; and an engine with 7 feet wheels will make the same advance by the wheels only making 60 revolutions; consequently, to ascertain what will effect an equal velocity of the train,

Divide the velocity in feet per minute by the circumference of the driving wheels, also in feet, and the quotient will be the number of revolutions of the driving wheels to produce an equal velocity of the engine and train.

Thus, suppose an engine with 6 feet wheels, at a velocity of 30 miles per hour, or 140 revolutions per minute, required the number of revolutions of 7 feet wheels, so that the train shall retain an equal velocity.

$\frac{5280 \times 30}{60} = 2640$ feet per minute, and 7 feet diameter $= 22$ circumference nearly; hence, $\frac{2640}{22} = 120$ revolutions per minute, when the wheels are not slipping.

CIRCUMFERENCE OF WHEELS.

A wheel	3 feet diameter equals	9.42 feet circumference.	
	$3\frac{1}{2}$,,	10.99 say 11	,,
	4 ,,	12.56	,,
	$4\frac{1}{2}$,,	14.13	,,
	5 ,,	15.7	,,
	$5\frac{1}{2}$,,	17.27	,,
	6 ,,	18.85	,,
	$6\frac{1}{2}$,,	20.42	,,
	7 ,,	21.99 say 22	,,

REVOLUTIONS OF VARIOUS DIAMETERS OF WHEELS TO RETAIN EQUAL VELOCITIES.

5 ft.	wheels at	15	miles ℔ hour	= 84	revolutions ℔ min.
6	,,	15	,,	= 70	,,
7	,,	15	,,	= 60	,,
5 ft.	wheels at	20	miles ℔ hour	= 110	revolutions ℔ min.
6	,,	20	,,	= 93	,,
7	,,	20	,,	= 80	,,
5 ft.	wheels at	25	miles ℔ hour	= 140	revolutions ℔ min.
6	,,	25	,,	= 117	,,
7	,,	25	,,	= 100	,,
5 ft.	wheels at	30	miles ℔ hour	= 168	revolutions ℔ min.
6	,,	30	,,	= 140	,,
7	,,	30	,,	= 120	,,
5 ft.	wheels at	40	miles ℔ hour	= 224	revolutions ℔ min.
6	,,	40	,,	= 187	,,
7	,,	40	,,	= 160	,,

Those calculations only standing good when the wheels are not slipping upon the rails, which is seldom the case after an engine has once attained its proper velocity, that velocity being always acquired previously to stopping at any station; and, although the wheels are hid from the view of those standing upon the engine, the cross heads are easily observed, and sometimes the puffs of the blast pipe can be counted, by which, in either case, with a little practice and attention, the rate or velocity of a train can be ascertained.

RESISTING FORCE OF THE ATMOSPHERE.

The resistance of the atmosphere retards the velocity of an engine, and that resisting force increases nearly as the square of the engine's velocity, which has been proved by experiments for ascertaining the force of the wind, and from which the following approximate rule has been deduced:

Divide the square of the engine's velocity in miles per hour by 248, and the quotient is the resisting force of the air in lbs. avoirdupois per square foot of opposing surface. Thus,

Suppose the velocity of an engine 30 miles per hour,

$$\frac{30^2}{248} = 3.6 \text{ lbs. per square foot resistance.}$$

Or, $\frac{1}{248} = .00403$, consequently the square of the velocity multiplied by $.00403 =$ the resistance; thus,

$30^2 \times .004 = 3.6$ as before: hence the following table,—

Velocity in miles per hour.	Resistance in lbs. avoirdupois per square foot.	Velocity in miles per hour.	Resistance in lbs. avoirdupois per square foot.	Velocity in miles per hour.	Resistance in lbs. avoir dupois per square foot.
1	.00403	21	1.777	41	6.774
2	.016	22	1.950	42	7.109
3	.036	23	2.121	43	7.451
4	.064	24	2.321	44	7.802
5	.101	25	2.518	45	8.160
6	.145	26	2.724	46	8.527
7	.197	27	2.937	47	8.902
8	.258	28	3.159	48	9.285
9	.326	29	3.389	49	9.676
10	.403	30	3.627	50	10.075
11	.547	31	3.872	55	12.190
12	.580	32	4.126	60	14.508
13	.681	33	4.388	65	17.026
14	.789	34	4.658	70	19.747
15	.906	35	4.936	75	22.668
16	1.031	36	5.222	80	25.792
17	1.164	37	5.517	85	29.116
18	1.305	38	5.819	90	32.648
19	1.454	39	6.129	95	36.370
20	1.612	40	6.448	100	40.300

EFFECTS OF ATMOSPHERIC RESISTANCE ON INCLINED PLANES.

From recent experiments upon planes of different inclinations, and with loads of various magnitudes, it is found that the rate of acceleration gradually diminishes until the train becomes at a uniform velocity, that uniform velocity depending upon the weight, form, and magnitude of the train, also the inclination of the plane, and atmospheric resistance, the resistance being subject to considerable variation at different velocities. Hence, the results of those experiments tend to show that low gradients on railways are not altogether attended with the advantageous effects which have been hitherto ascribed to them; that, on the contrary, the resistance produced by steeper gradients can be compensated by slackening the speed, so that the power shall be relieved from as much atmospheric resistance, by the diminution of velocity, as is equal to the increased resistance produced by the gravity of the plane which is ascended. And, on the other hand, in descending the plane, the speed may be increased until the resistance produced by the atmosphere is increased to the same amount as that by which the train is relieved by the declivity down which it moves. Thus, on gradients, the inclination of which is confined within practical limits, the resistance to the moving power may be preserved uniform, or nearly so, by varying the velocity.

By some recent experiments on atmospheric resistance, it was ascertained that surfaces of the same shape, and proportionate to each other, as 9, 16, 36, 81, and moving with the same velocity, meet with resistance in the following proportions:—

$$9,\ 17\tfrac{1}{2},\ 42\tfrac{1}{4},\ \text{and}\ 104\tfrac{3}{4}.$$

A very considerable degree of attention requires to be paid to an engine on an inclined or undulating railway, to see that the boiler is properly filled upon the level or descending plane, as may occur, and also the fire well filled up and properly burnt through, especially if the engine is nearly loaded to the extent of its power, as the momentum of the train is soon destroyed upon the ascending plane, and, consequently, the effect of the blast pipe destroyed.

PRODUCTION OF STEAM.

Steam is water highly rarified by the action of heat; heat is produced by combustion; combustion is supported by oxygen; and oxygen is one of the elements of the atmosphere, of which it constitutes about one-fifth. Different species of fuel require different quantities of oxygen to support their combustion, but it is generally estimated that 1 lb. of either coal or coke requires about 2½ lbs., or 29 cubic feet of oxygen for their complete combustion, for which, 145 cubic feet of air must pass through the fire, and also it requires about 1800 cubic feet for each cubic foot of water converted into steam.

Temperature in this country is measured by degrees of Fahrenheit's scale, of which the freezing point is 32°, and boiling point 212°. In France it is measured by the Centigrade scale, the freezing point of which is 0°, and boiling point 100°.

Elastic force of steam is that degree of power by which it is enabled to counterpoise any opposing resistance above the pressure of the atmosphere, and generally estimated in inches of mercury or lbs. avoirdupois; the avoirdupois lb. = .4535 French kilogrammes. The elastic force of steam is also sometimes computed by atmospheres, the atmosphere being equal to 30 inches, or .762 metres of mercury; or, in other terms, 14.7 lbs. avoirdupois per square inch, or 11.55 lbs. per circular inch.

ELASTIC FORCE OF STEAM.

To find the elastic force of steam when in contact with the liquid from which it is formed, the temperature being given, RULE.—Add 51.3° to the temperature, and multiply the logarithm of the sum by 5.13; from the product deduct 10.94123, and find the natural number answering to the remainder as a logarithm, and this number increased by .1 will express the required pressure in inches of mercury.

Suppose the temperature to be 250° Faht., required the pressure.

Temperature	250		
Add	51.3		
	301.3	corresponding logarithm	2.47900
		multiply by	5.13
			12.7172700
		deduct	10.94123
Corresponding number	59.7 =		1.77604
To be increased by	.1		
Required force	59.8 inch. of mercury		

2.04 inches of mercury = a pressure of 1 lb. avoirdupois; consequently, 59.8 ÷ 2.04 = 29.31 lbs. per square inch.

SPACE WHICH STEAM OCCUPIES.

To find the volume or space the steam of a cubic foot of water occupies when the steam is of a given elastic force and temperature, and separated from the liquid from which it was generated,—

RULE.—To the temperature in degrees add 459, multiply the sum by 76.5, divide the product by the force of the steam in inches of mercury, and the result will express the space in cubic feet which a cubic foot of water will occupy.

Let the force be 4 atmospheres, or 120 inches of mercury, and the temperature 295° Faht., required the cubic space the steam will occupy.

$$\overline{295 + 459} \times 76.5 = 57681, \text{ and } 57681 \div 120 = 481 \text{ cubic feet.}$$

REDUCTION OF STEAM.

To find the quantity of water at a given temperature necessary to reduce steam at a given temperature to water of a given temperature.

Latent heat of steam = 1000° Faht.

Suppose it be required to reduce steam at 220° to water at 100° by water at 52°, required the quantity to any given quantity of steam.

$$\frac{\overline{1000 + 220} - 100}{100 - 52} = 23.3 \text{ times the quantity of water}$$

to that of which the steam was produced.

Again, suppose steam at 220° to be reduced to water at 180°, by water at 52°, or the ordinary temperature of the atmosphere, required the quantity.

$$\frac{\overline{1000 + 220} - 180}{180 - 52} = 8. \text{ times the quantity that pro-}$$

duced the steam.

A TABLE CONTAINING VARIOUS PROPERTIES OF STEAM.

Elastic force in lbs avoird. per square inch.	Elastic force in lbs. avoirdupois per square foot.	Elastic force in inches of mercury.	Temperature in degrees of Fahrenheit.	Volume of steam compared to the volume of water.
14.7	2116.8	30	212	1700
15	2160	30.60	212.8	1669
16	2304	32.64	216.3	1573
17	2488	34.68	219.6	1488
18	2592	36.72	222.7	1411
19	2736	38.76	225.6	1343
20	2880	40.80	228.5	1281
21	3024	42.84	231.2	1225
22	3168	44.88	233.8	1174
23	3312	46.92	236.3	1127
24	3456	48.96	238.7	1084
25	3600	51.00	241.0	1044
26	3744	53.04	243.3	1007
27	3888	55.08	245.5	973
28	4032	57.12	247.6	941
29	4176	59.16	249.6	911
30	4320	61.21	251.6	883
31	4464	63.24	253.6	857
32	4608	65.28	255.5	833
33	4752	67.32	257.3	810
34	4896	69.36	259.1	788
35	5040	71.40	260.9	767
36	5184	73.44	262.6	748
37	5328	75.48	264.3	729
38	5472	77.52	265.9	712
39	5616	79.56	267.5	695
40	5760	81.60	269.1	679
41	5904	83.64	270.6	664
42	6048	85.68	272.1	649
43	6192	87.72	273.6	635
44	6336	89.76	275.0	622
45	6480	91.80	276.4	610
46	6624	93.84	277.8	598
47	6768	95.88	279.2	586
48	6912	97.92	280.5	575
49	7056	99.96	281.9	564
50	7200	102.00	283.2	554

Elastic force in lbs avoird. per square inch.	Elastic force in lbs. avoirdupois per square foot.	Elastic force in inches of mercury.	Temperature in degrees of Fahrenheit.	Volume of steam compared to the volume of water.
51	7344	104.04	284.4	544
52	7488	106.08	285.7	534
53	7632	108.12	286.9	525
54	7776	110.16	288.1	516
55	7920	112.20	289.3	508
56	8064	114.24	290.5	500
57	8208	116.28	291.7	492
58	8352	118.32	292.9	484
59	8496	120.36	294.2	477
60	8640	122.40	295.6	470
61	8784	124.44	296.9	463
62	8928	126.48	298.1	456
63	9072	128.52	299.2	449
64	9216	130.56	300.3	443
65	9360	132.60	301.3	437
66	9504	134.64	302.4	431
67	9648	136.68	303.4	425
68	9792	138.72	304.4	419
69	9936	140.76	305.4	414
70	10080	142.80	306.4	408
71	10224	144.84	307.4	403
72	10368	146.88	308.4	398
73	10512	148.92	309.3	393
74	10656	150.96	310.3	388
75	10800	153.02	311.2	383
76	10944	155.06	312.2	379
77	11088	157.10	313.1	374
78	11232	159.14	314.0	370
79	11376	161.18	314.9	366
80	11520	163.22	315.8	362
81	11664	165.26	316.7	358
82	11808	167.30	317.6	354
83	11952	169.34	318.4	350
84	12096	171.38	319.3	346
85	12240	173.42	320.1	342
86	2384	175.46	321.0	339
87	12528	177.50	321.8	335
88	12672	179.54	322.6	332
89	12816	181.58	323.5	328
90	12960	183.62	324.3	325
91	13104	185.66	325.1	322

Elastic force in lbs avoird. per square inch.	Elastic force in lbs. avoirdupois per square foot.	Elastic force in inches of mercury.	Temperature in degrees of Fahrenheit.	Volume of steam compared to the volume of water.
92	13248	187.70	325.9	319
93	13392	189.74	326.7	316
94	13536	191.78	327.5	313
95	13680	193.82	328.2	310
96	13824	195.86	329.0	307
97	13968	197.90	329.8	304
98	14112	199.92	330.5	301
99	14256	201.96	331.3	298
100	14400	204.0	332.0	295
110	15840	224.4	339.2	271
120	17280	244.8	345.8	251
130	18720	265.2	352.1	233
140	20160	285.6	357.9	218
150	21600	306.0	363.4	205
160	23040	326.4	368.7	193
170	24480	346.8	373.6	183
180	25920	367.2	378.4	174
190	27360	387.6	382.9	166
200	28800	408.0	387.3	158

OF THE SAFETY VALVES.

Each locomotive engine is, or ought to be, furnished with two safety valves, the diameters of which may be determined by the following :—

To determine the dimensions of the safety valves for a locomotive engine :

RULE.—To the heating surface of the fire box, in square feet, add one-third the surface of the tubes, divide the sum by 13, and the square root of half the quotient equal each valve's diameter in inches at the narrowest part.

Suppose the heating surface in the fire box of a locomotive engine equals 50 square feet, and tube surface 360 or $\frac{1}{3}$rd = 120, the engine to have two valves, required the diameter of each.

$$\frac{50 + 120}{13} = 13.07 \div 2 = \sqrt{6.535} = 2.55 \text{ inches}$$

diameter each.

FUSIBLE ALLOYS FOR SAFETY PLUGS IN BOILERS.

An alloy of

				Faht.
Lead 1 part,	tin 3 parts,	bismuth 5 parts,	melts at	212°
Lead 1 ,,	tin 4 ,,	bismuth 5	,,	246
	tin 1 ,,	bismuth 1	,,	286
	tin 2 ,,	bismuth 1	,,	336
Lead 2 ,,	tin 3 ,,		,,	334
	tin 8 ,,	bismuth 1	,,	392

Fusible points of the metals of which the alloys are composed—

Lead ....612°
Bismuth 506
Tin 442

ON THE BURSTING OF BOILERS.

On the bursting of boilers, the generally-received opinion seems to be, that a sufficient quantity of gas to create injury cannot be formed, and that the chief cause is a sudden excess of steam, caused by some parts of the boiler becoming heated to a maximum degree of evaporization, while the engine is not at work, and the safety valve not being sufficiently large to allow an escape equal to the accumulation. On this account the steam acquires a greater degree of density, and the plates become heated, so that the instant the engine is started to work the boiler is relieved, and very probably the water rises or ferments upon the sides of the boiler, by which a greater surface is formed for accumulation. This may occur long before the plates of the boiler arrive at a degree of red heat, which would be more likely to lessen the tendency than assist it, which has been shown by experiments made for that purpose at the Franklin Institute of Pennsylvania; and, besides these, much older experiments testify that water will not evaporate so soon upon metal heated to a high degree, as it will by a degree of heat which is much sooner attained. Thus, a drop of water used to be the instrument by which the temperature of maximum evaporation was determined; and also by the American experiments it was shown that a drop of water upon polished copper took 210 seconds to be wholly converted into vapour, when the surface of the metal was at a temperature of 445°, whereas a like quantity was evaporated in 3 seconds at a temperature of 292°; and when the copper was in the worst state of oxidation, the maximum point of evaporation was only 348°, which is soon attained, and at that point in that state the same quantity of water was evaporated in one-fourth of a second.

In iron the temperature suffered but little variation, whatever was the condition of the metal, except it was very highly oxidated, and then its highest evaporating points were only about 35° above copper in the same condition. The time varied nearly in the ratio of the conducting power of the metals, being about $2\frac{1}{2}$ to 1, the copper requiring the least.

It was also shown by these experiments that either hot or cold water injected into an engine boiler in its average state of oxidation, and heated to bright redness, no hydrogen gas was produced ; but, that the resulting gas was nothing more than atmospherical air, deprived by the heated metal of more or less of its oxygen ; that is to say, nitrogen more or less pure, according to the quantity of oxygen which has been absorbed, atmospheric air being composed of $\frac{4}{5}$ths nitrogen and $\frac{1}{5}$th oxygen.

A recent occurrence at Newcastle seems fully to have established the fact of steam being highly charged with electricity, and which may ultimately be the means of increasing our knowledge on the subject of explosions; in the meantime, it is essentially necessary that constant precaution be maintained, by a careful examination of the safety valves, and more especially when the boilers are getting into a decayed state. In all cases of standing, when the steam is at its maximum height, one of the valves ought to be constantly eased, and the engine in no case suddenly started. Locomotive boilers, I consider, are not so liable to explode under such circumstances ; but it is well known that, if steam be confined, and evaporation still going on, it very soon acquires a high degree of density by small excesses of heat, as may be observed by the following table:—

Elastic force in lbs. ⅌ sq. inch above the atmosphere	Temperature in degrees of Fahrenheit.	Difference of or increase of temperature	Elastic force in lbs. ⅌ sq. inch above the atmosphere	Temperature in degrees of Fahrenheit.	Difference of or increase of temperature.
50	301.3	—	90	335.7	3.7° F.
55	306.4	5.1° F.	95	339.2	3.5
60	311.2	4.8	100	342.6	3.4
65	315.8	4.6	105	345.8	3.2
70	320.1	4.3	110	348.9	3.1
75	324.3	4.2	115	351.9	3.0
80	328.2	3.9	120	354.8	2.9
85	332.0	3.8			

QUALIFICATIONS AND DUTIES OF LOCOMOTIVE ENGINEERS, ENGINE DRIVERS, STOKERS, &c.

Locomotive engineer is a term applied to any person entrusted by the directors of a railway to superintend, and see kept in proper condition, the whole of the locomotive department, so that the company's benefit, and safety of the public, may be in some measure insured; consequently, any man filling this situation is highly responsible, and ought to be properly qualified.

1. He ought to be thoroughly acquainted with the nature of steam, its production, properties of expansion, calculation of effect, &c. so that he may be enabled in all cases to perform his duty with confidence, and, by a competent knowledge, be prepared to answer public or private demands when required.

2. He ought to be theoretically and practically ac-

quainted with locomotive engines, the nature of the parts as a mechanical arrangement, and the application of steam as a motive power, so that, by his mechanical acquirements, he may be properly qualified to set or arrange the parts whereby to produce the greatest mechanical effect; and also, by his practice, may have acquired a competent knowledge of those parts most liable to derangement, by which he may be enabled to apply to them some efficient means of protection, which, probably, might not be considered necessary by those not practically acquainted with the incidents that frequently occur in locomotive engines.

3. He ought also to be properly acquainted with the nature of the materials of which an engine is composed, the quality of such materials, the proportionate strength that one metal bears to another, the rubbing of metals, by which friction is produced, &c. so that unnecessary strength may not be applied where it might tend to pull another part to pieces, and oil economized where lubrication is required.

4. It is also essentially necessary that a locomotive engineer be possessed, to a certain degree, of mathematical acquirements, so as to enable him to determine the amount of load that may be attached to an engine with safety, that it may be enabled to keep clear of any following train. He should also set positive bounds to the engine drivers in nearing any station or stopping place, where the steam must be shut off.

5. His duties, of course, are an application of his qualifications, joined with strict attention and close

investigation, having a particular eye to cleanliness, and he should, if possible, never allow an engine to go out when uncertainty is exhibited in any of its parts.

6. Another important duty of a locomotive engineer is impartiality in selecting steady and efficient men for the various duties to which they are required, and to show to the directors that a trifle more paid for proper qualifications is soon returned by means of public estimation.

DUTIES, &c. OF ENGINE DRIVERS.

1. They ought to be active sober men, and not afflicted with any bodily ailment, as shortness of sight, deafness, fits, faintings, &c. whereby the lives of passengers are endangered beyond the reach of their control.

2. They ought to be perfectly familiar with all the various parts of a locomotive engine, so that, by watchful care, they may be the means of preventing, in many instances, any particular loss or material expense which might occur with a person unqualified, and not knowing the result of delay.

3. They ought to be men of strong nerve, and affable manners, so that, if any accident occur to an engine, causing a stoppage on some desolate part of the line, he may, in a great measure, prevent dissatisfaction amongst the passengers, by his active endeavours and intelligent conversation.

4. Their daily duties are, strict attention to their engines,—a careful look out upon the line,—and punc-

tual attention to the signals, whereby order is maintained, and safety secured.

DUTIES OF STOKERS.

The duties of stokers are very similar to those of engine drivers, and they ought to possess similar bodily qualifications; indeed, their duties are so much alike, that the term stoker might with propriety be changed to sub-engine driver. Their particular duties at each end of a journey are, to see the fire properly cleaned and filled up, the tubes swept, the engine cleaned, and properly lubricated, the tender supplied with the necessary quantity of coke and water, by which the return journey may be resumed with safety, during which time they must attend to the fire, keep a good look out, and attend to the break.

These constitute the chief outlines of the various duties and qualifications of locomotive engineers, engine drivers, and stokers; but there are other minutiæ to which they must attend, which can only be ascertained by practice from particular localities, and by the laws of the different railways and companies to which they belong.

SIGNALS.

Signals in general use upon railways, and which must be attended to:

A small red flag stuck in the ground upon the left side of the line the engine is upon signifies to go easy, that all is not right.

A red flag at a station by day, or a red light exhibited by a lantern at night, is to signify that passengers are waiting, and the train must be stopped.

A white flag at a station by day, or a white light exhibited by a lantern at night, signifies—no person waiting,—all right,—go on with safety.

A green flag exhibited by day, or a green light at night, signifies—to proceed cautiously—another train is immediately before.

TABLES OF PARTICULAR UTILITY IN MECHANICAL CALCULATIONS.

1.—PROPERTIES OF METALS.

Names of Metals.	Specific Gravity	Weight of a lineal foot 1 inch square in lbs. advoird.	Weight of a lineal foot 1 inch diam. in lbs. avoirdpois.	Melting point in degrees Fahrenheit.	Direct cohesion in tons of bars 1 inch sqr.	Proportionate resistance to torsion.
Iron, Cast......	7271	3.12	2.45	17977°	8.4	......
Iron, Wrought	7631	3.33	2.61	......	25.0	10.16
Steel............	7833	3.39	2.67	......	57.0	17.06
Copper..........	8915	3.84	3.02	4587	12.0	4.31
Zinc.............	7190	3.05	2.39	700	7.4	......
Lead............	11344	4.93	3.87	612	0.8	1.00
Tin.............	7292	3.16	2.48	442	2.3	1.44

Iron, Tin, and Zinc, each possess the property, at a red heat, of decomposing water: the other metals do not effect water at any temperature.

The friction of brass on wrought iron without unguents, equal about 1/7th of the whole weight or pressure upon the surface.—Cast iron on cast iron 1/6th.—Brass on brass 1/6th.—Cast iron on brass 1/8th, and brass on steel 1/8th.

Cubic inches of					
Cast Iron...	× .263	or cylindrical inches		× .2065	= lbs. avoird.
Wrgt. Iron	× .276	„	„	× .2168	„
Steel.........	× .283	„	„	× .2223	„
Copper......	× .3225	„	„	× .2533	„
Brass.........	× .3037	„	„	× .2385	„
Zinc	× .26	„	„	× .2042	„
Lead.........	× .4103	„	„	× .3223	„
Tin......	× .2636	„	„	× .207	„
Mercury....	× .4908	„	„	× .3854	„

PROPORTIONS OF WEIGHT WHICH VARIOUS METALS BEAR TO EACH OTHER.

Wrought iron being 1		
Cast iron	=	.96
Steel	=	1.03
Copper	=	1.17
Brass	=	1.1
Lead	=	1.48

426 cubic inches of cast iron = 1 cwt., and 8520 or nearly 5 cubic feet = 1 ton.

Avoirdupois lbs. multiplied by .009 = cwts., and avoirdupois lbs. multiplied by .00045 = tons.

2.—APPROXIMATE NUMBERS.

Yards multiplied by .000568 = miles.
Feet.....................00019 = ...

Square inches multiplied by	.007	= square feet
Cubic inches	.00058	= cubic feet.
Cubic feet.........................	.03704	= cubic yards.
Circular inches	.00546	= square feet.
Cylindrical inches..............	.0004546	= cubic feet.
Cylindrical feet..................	.02909	= cubic yards.
Square yards	.0002067	= acres.

183.346 circular inches = 1 square foot, and 2200 cylindrical inches = 1 cubic foot.

French metres multiplied by 3.281 = English feet.
.... litres .... .2202 = ——— imp. gallons.
.... grammes .... .002205 = avoirdupois lbs.
.... kilogrammes............2.205 = ...
Weight of a cubic foot of common water 62.5 lbs. avoidupois
..............cylindrical foot..................49.1.......................
....cubic inch ... . .03617..................
..............cylindrical inch.................. .02842... .. ..
..............lineal foot 1 inch square...... .434....................
..............lineal foot 1 inch diameter... .341....................
An imperial gallon of common water = 10.........................
11.2 imperial gallons ....= 1 cwt.
224..= 1 ton.
1.8 cubic feet........ ....= 1 cwt.
35.84 ....= 1 ton.
1 cubic foot = 6.25 imperial gallons.
1 cylindrical foot = 5. ....
Cubic feet multiplied by 6.232, or cubic inches multiplied by .003607 = imperial gallons.

WEIGHT OF A SUPERFICIAL FOOT OF WROUGHT IRON PLATES IN LBS. AVOIRDUPOIS, THE THICKNESS IN PARTS OF AN INCH.

$\frac{1}{16}$ = 2½l bs., $\frac{3}{16}$ = 7½ lbs., $\frac{5}{16}$ = 12½ lbs., $\frac{7}{16}$ = 17½ lbs.,
$\frac{1}{8}$ = 5 lbs., $\frac{1}{4}$ = 10 lbs., $\frac{3}{8}$ = 15 lbs., $\frac{1}{2}$ = 20 lbs.,
$\frac{5}{8}$ = 25 lbs., $\frac{3}{4}$ = 30 lbs.

WEIGHT OF A SUPERFICIAL FOOT OF BRASS AND COPPER PLATES, IN LBS. AVOIRDUPOIS, THE THICKNESS BY THE BIRMINGHAM WIRE GAUGE.

Brass.

No. 10 = 6.18 lbs.	No. 13 = 4.12 lbs.	No. 16 = 2.75 lbs.
No. 11 = 5.5 lbs.	No. 14 = 3.43 lbs.	No. 18 = 2.04 lbs.
No. 12 = 4.81 lbs.	No. 15 = 3.1 lbs.	

Copper.

No. 10 = 6.5 lbs.	No. 13 = 4.34 lbs.	No. 16 = 2.9 lbs.
No. 11 = 5.8 lbs.	No. 14 = 3.6 lbs.	No. 18 = 2.15 lbs.
No. 12 = 5.08 lbs.	No. 15 = 3.27 lbs.	

A TABLE CONTAINING THE SQUARE IN INCHES, SQUARE IN FEET, AREA IN INCHES, AND AREA IN FEET OF CYLINDERS FROM 12 TO 16 INCHES DIAMETER, AND ADVANCING BY AN EIGHTH.

Diameter.	Square in inches.	Square in feet.	Area in inches.	Area in feet.	Area in French square metres.
12 in.	144	1	113.0976	.7854	.07296
1/8	147.0156	1.0291	115.4660	.8082	.07508
1/4	150.0625	1.0504	117.8590	.8249	.07663
3/8	153.1406	1.0719	120.2766	.8418	.07820
1/2	156.25	1.0937	122.7187	.8589	.07979
5/8	159.3906	1.1157	125.1854	.8762	.08139
3/4	162.5625	1.1379	127.6765	.8937	.08302
7/8	165.7656	1.1603	130.1923	.9113	.08466
13 in.	169	1.1830	132.7326	.9217	.08562
1/8	172.2656	1.2058	135.2974	.9470	.08797
1/4	175.5625	1.2289	137.8867	.9651	.08965
3/8	178.8906	1.2522	140.5007	.9834	.09135
1/2	182.25	1.2757	143.1391	1.0019	.09307
5/8	185.6406	1.2994	145.8021	1.0205	.09480
3/4	189.0625	1.3234	148.4896	1.0394	.09656
7/8	192.5156	1.3476	151.2017	1.0584	.09832
14 in.	196	1.3720	153.9384	1.0690	.09931
1/8	199.5156	1.3966	156.6995	1.0968	.10189
1/4	203.0625	1.4214	159.4852	1.1163	.10370
3/8	206.6406	1.4464	162.2956	1.1360	.10553
1/2	210.25	1.4717	165.1303	1.1558	.10737
5/8	213.8906	1.4972	167.9896	1.1759	.10924
3/4	217.5625	1.5229	170.8735	1.1961	.11111
7/8	221.2656	1.5488	173.7820	1.2164	.11300
15 in.	225	1.5750	176.7150	1.2271	.11399
1/8	228.7656	1.6013	179.6725	1.2576	.11683
1/4	232.5625	1.6279	182.6545	1.2785	.11877
3/8	236.3906	1.6547	185.6612	1.2996	.12073
1/2	240.25	1.6817	188.6923	1.3208	.12270
5/8	244.1406	1.7089	191.7480	1.3421	.12468
3/4	248.0625	1.7364	194.8282	1.3637	.12668
7/8	252.0156	1.7641	197.9330	1.3855	.12871
16 in.	256	1.7920	201.0624	1.3962	.12970

REMARKS ON THE CONSTRUCTION OF RAILWAYS.

It is of the utmost practical utility in the construction of Railways, that they should be as straight and level as possible, decidedly giving way to a trifling augmentation in length, with gentle curves, rather than introduce heavy inclines, of any material length, the injurious effects of which have been fully demonstrated by the unprofitable working of the Leeds and Selby line.

From Selby, this line is nearly level for about 6½ miles, on which engines with 12 inch cylinders, 18 inch stroke, and 5 feet driving wheels, can easily transport 30 loaded waggons, each about 4½ tons in weight, or gross load of about 135 tons, not including engine and tender; but on arriving at the end of this 6½ miles, an incline commences, of about 7 miles in length, having a rise of 1 in 137, or nearly 39 feet per mile, and on which the same description of engine can take no more than 10 waggons at an equal volocity, with safety to keep clear of after trains.

In the first outset of this line it was contended in its favour, that the principal transport of heavy goods was down the incline, and empty waggons or lighter goods in return, but practice has declared this to be of little advantage, as the amount of wages for breaksmen, and the danger arising from accumulated momentum of the train, more than compensated for the extra expense of fuel upon a level line, which could have easily been obtained, and which has been ultimately and advantageously opened through, by the York and North Midland Company; its extra length, from Selby to Leeds, being only about 3 miles.

It is at present contended by some of our most celebrated engineers, that a series of severe gradients, varying from 30 to 40 feet per mile, is, and may be, advantageously introduced, for which the North Union Railway has been quoted in support of the assertion, 5 miles of which out of 22 being gradients of 1 in 100, and worked at less expense than the Grand Junction Railway. This, I have no doubt, is, and may be, the case, where short gradients can be obtained, the loads generally light, and where a velocity can be maintained of at least 30 miles per hour; but I have no hesitation in asserting it as my opinion, that on a level line of railway there is considerably less danger, and less expense for locomotive power, than on any other.

Another essential property a railway ought to possess is stability, for which reason the nature of the soil and the probable weight of the trains ought to be properly considered. Where the earth is firm and stone at hand, blocks of about 2 feet square and 1 foot in thickness may be laid three feet from centre to centre, on which to support rails of at least 60 lbs. per yard, with advantage; but where the ground is soft, the blocks sink by the vertical weight of the trains and deflection of the rails; they also become loosened by the lateral pressure, or oscillating motion of the engines: when such is the case, a considerable degree of expense is constantly incurred by having to remove the earth from around the stones.

Sleepers, or cross sectional pieces of timber, are also liable to give frequently very unequal support to the rails; but on account of not having the earth to remove, they are much easier to repair; and again, two chairs being placed on each piece of timber, or sleeper, the line is not so easily affected by lateral pressure; but I should say that continued bearings of timber possess a degree of firmness superior to either the one or the other of the preceding, first, because being one continued bearing, by which the rails are equally supported throughout, and also the timbers being bound together by cross sectional pieces, they are not so liable to sink, or become loosened by either vertical or lateral pressure; and secondly, the timbers being straightened upon the upper side to a broad flat surface, admits of rails which constitute both chairs and rails, consequently, they are considerably lowered in height, and the lateral pressure of the engines more firmly resisted.

As there is only one railway at present in this country of that description, namely, the Great Western, it may not be out of place to notice the mode of its construction, which is as follows:—

The width between each rail, or what is generally termed the gauge of the rails, is 7 feet, other lines being in general 4 feet 8½ inches.

At every 15 feet in length along this line of railway, beech piles are driven into the ground, at 15 feet apart transversely; in cuttings, they are driven into the ground from 8 to 10 feet, according to the nature of the soil; and in embankments, they are generally made of sufficient length to pass through the embankment, and 8 or 10 feet into the original ground on which it is raised.

To these piles double and single transverse ties, or sleepers of American pine, are attached in the following manner:—A square recess is cut 1½ inches into the pile on one side for single ties, and on the both sides for double ones. The single ties are 6 inches broad and 9 inches deep: the double ties are 6 inches broad and 7 inches deep, each being securely fixed to the piles by bolts. On these sleepers are laid longitudinal timbers of American pine, 15 inches broad and 7 inches thick, and bolted firmly to each other; and thus the line is of one continued frame from end to end. The line is then ballasted, and the longitudinal timbers packed, or rammed in the usual manner, with fine sand or gravel, until each 15 feet length is raised in the middle about half an inch; the timber is then planed to a uniform surface, after which planks of elm, oak, or ash $1\frac{1}{2}$ inches thick and 8 inches in breadth is fixed down by spikes; the upper surface of the planks are afterwards planed, so as to slope inward about $\frac{3}{8}$ths of an inch; and to these planks the rails are screwed, with a thickness of felt underneath, by which means the unpleasant rumbling noise so justly complained of on many railways, is on this almost completely avoided.

One decided advantage acquired in this form of construction consists in the piles being a constant retaining power, holding the road down against the packing, which has always a tendency to raise it up. It is asserted that the earth may be rammed under the timbers until the upward pressure, or resisting force, equal about one ton per square foot,—Hence the following advantage over stone blocks:—A stone of the usual description employed for that purpose contains about 4 cubic feet, and weighs only about a quarter of a ton, and suppose the impact with which the stone is forced into its seat be taken into account, which is a very uncertain quantity, but say half a ton, leaves a very decided claim in favour of longitudinal bearings.

The timber used in a mile of this railway is about 420 loads of pine, and 40 loads of hardwood. Of iron, 6 tons of bolts, and 30,000 wooden screws, 2 inches in length. The rails are about 44 lbs. per yard, but evidently too light, and would be much better from 50 to 55. In the present form, the cost per mile from London to Maidenhead, including laying, ballasting, sidings, draining, &c., is stated at £9,200 per mile, railways of other or more common descriptions having cost £10,000, and varying, with unfavourable circumstances, to £50,000 per mile, as exhibited in the following table.

NAMES.	Estimate.	Cost.	Royal Assent.	Capital I Cost.
	£	£		
Ballochney	18,431	38,431	May, 1826	2.09
Dundee and Newtyle	30,000	170,000	Do.	5.67
Edinburgh & Dalkeith	70,125	133,053	Do.	1.90
Glasgow & Garnkirk	28,479	148,195	Do.	5.12
Liverpool & Manchester	510,000	1,465,000	Do.	2.88
Clarence	100,000	500,000	May, 1828	3.00
Newcastle & Carlisle	300,000	750,000	May, 1829	2.50
Leeds and Selby	210,000	340,000	May, 1830	1.62
Leicester & Swannington	90,000	175,000	Do.	1.94
Manchester & Bolton	204,000	650,000	Aug. 1831	3.19
Belfast and Cavehill	7,500	38,700	April, 1832	5.15
London & Birmingham	2,500,000	5,500,000	May, 1833	2.20
London & Greenwich	400,000	733,333	Do.	1.83
Grand Junction	1,040,000	1,906,000	Do.	1.84
Whitby and Pickering	80,000	135,000	Do.	1.69
Durham Junction	80.000	130,000	June, 1834	1.63
South-western	1,000,000	1,860,000	July, —	1.86
Durham & Sunderland	102,000	256,000	Aug. —	2.51
London & Croydon	140,000	575,000	June, 1835	4.12
Brandling Junction	110,000	336,000	Do. 1836	3.05
		Mean		2.79

Part of the Hull and Selby line of railway is of a similar construction to the Great Western, but without the piles, and is said to give entire satisfaction, hence a comfortable road with a considerable degree of saving in the first cost.

The angle of repose upon railways, or that incline on which a carriage would rest in whatever situation it was placed, is said to be at 1 in 280, or nearly 19 feet per mile; at any greater rise than this, the force of gravity overcomes the horizontal traction, and carriages will not rest, or remain quiescent upon the line, but will of themselves run down the line with accelerated velocity. The angle of practical effect is variously stated, ranging from 1 in 75 to 1 in 330.

The width of land required for a railway must vary with the depth of the cuttings and length of embankments, together with the slopes necessary to be given to suit the various materials of which the cuttings are composed: thus, rock will generally stand when the sides are vertical; chalk varies from $\frac{1}{6}$ to 1, to 1 to 1; gravel $1\frac{1}{2}$ to 1; coal $1\frac{1}{2}$ to 1; clay 1 to 1, &c.; but where land can be obtained at a reasonable rate, it is always well to be on the safe side.

The following table is calculated for the purpose of ascertaining the extent of any cutting in cubic yards, for 1 chain, 22 yards, or 66 feet in length, the slopes or angles of the sides being those which are most in general practice, and formation level equal 30 feet.

SLOPES 1 TO 1.

Depth of cutting in feet.	Half width at top in feet.	Content in cubic yards per chain.	Content of 1 perpendicular foot in breadth.	Content of 3 perpendicular feet in breadth.	Content of 6 perpendicular feet in breadth.
1	16	75.78	2.44	7.33	14.67
2	17	156.42	4.89	14.67	29.33
3	18	242.00	7.33	22.00	44.00
4	19	332.44	9.78	29.33	58.67
5	20	427.78	12.22	36.67	73.33
6	21	528.00	14.67	44.00	88.00
7	22	633.11	17.11	51.33	102.67
8	23	743.11	19.56	58.67	117.33
9	24	858.00	22.00	66.00	132.00
10	25	977.78	24.44	73.33	146.67
11	26	1102.44	26.89	80.67	161.33
12	27	1232.00	29.33	88.00	176.00
13	28	1366.44	31.78	95.33	190.67
14	29	1505.78	34.22	102.67	205.33
15	30	1650.00	36.66	110.00	220.00
16	31	1799.11	39.11	117.33	234.67
17	32	1953.11	41.55	124.67	249.33
18	33	2112.00	43.99	132.00	264.00
19	34	2275.78	46.44	139.33	278.67
20	35	2444.44	48.89	146.67	293.33
21	36	2618.00	51.33	154.00	308.00
22	37	2796.44	53.77	161.33	322.67
23	38	2979.78	56.21	168.67	337.33
24	39	3168.00	58.66	176.00	352.00
25	40	3361.11	61.10	183.33	366.67
26	41	3599.11	63.55	190.67	381.33
27	42	3762.00	65.99	198.00	396.00
28	43	3969 78	68.43	205.33	410.67
29	44	4182.44	70.88	212.67	425.33
30	45	4400.00	73.32	220.00	440.00
31	46	4622.44	75.77	227.33	454.67
32	47	4849.78	78.22	234.67	469.33
33	48	5082.00	80.67	242.00	484.00
34	49	5319.11	83.11	249.33	498.67
35	50	5561.11	85.55	256.67	513.33
36	51	5808.00	88.00	264.00	528.00
37	52	6059.78	90.44	271.33	542.67
38	53	6316 44	92.39	278.67	557.33
39	54	6578.00	95.33	286.00	572.00
40	55	6844.44	97.77	293.33	586.67
41	56	7115.78	100.22	300.67	601.33
42	57	7392.00	102.66	308.00	616.00
43	58	7673.11	105.11	315.33	630.67
44	59	7959.11	107.55	322.67	645.33
45	60	8250.00	109.99	330.00	660.00
46	61	8545.78	112.44	337.33	674.67
47	62	8846.44	114.88	344.67	689.33
48	63	9152.00	117.33	352.00	704.00
49	64	9462.44	119.77	359.33	718.67

SLOPES $1\frac{1}{2}$ TO 1.

Depth of cutting in feet.	Half width at top in feet.	Content in cubic yards per chain.	Content of perpendicular foot in breadth.	Content of 3 perpendicular feet in breadth.	Content of 6 perpendicular feet in breadth.
1	16½	77.00	2.44	7.33	14.67
2	18	161.33	4.89	14.67	29.33
3	19½	253.00	7.33	22.00	44.00
4	21	352.00	9.78	29.33	58.67
5	22½	453.33	12.22	36.67	73.33
6	24	572.00	14.67	44.00	88.00
7	25½	693.00	17.11	51.33	102.67
8	27	821.33	19.56	58.67	117.33
9	28½	957.00	22.00	66.00	132.00
10	30	1100.00	24.44	73.33	146.67
11	31½	1250.33	26.89	80.67	161.33
12	33	1408.00	29.33	88.00	176.00
13	34½	1573.00	31.78	95.33	190.67
14	36	1745.33	34.22	102.67	205.33
15	37½	1925.00	36.66	110.00	220.00
16	39	2112.00	39.11	117.33	234.67
17	40½	2306.33	41.55	124.67	249.33
18	42	2508.00	43.99	132.00	264.00
19	43½	2717.00	46.44	139.33	278.67
20	45	2933.33	48.89	146.67	293.33
21	46½	3157.00	51.33	154.00	308.00
22	48	3388.00	53.77	161.33	322.67
23	49½	3626.33	56.21	168.67	337.33
24	51	3872.00	58.66	176.00	352.00
25	52½	4125.00	61.10	183.33	366.67
26	54	4385.33	63.55	190.67	381.33
27	55½	4653.00	65.99	198.00	396.00
28	57	4928.00	68.43	205.33	410.67
29	58½	5210.33	70.88	212.67	425.33
30	60	5500.00	73.32	220.00	440.00
31	61½	5797.00	75.77	227.33	454.67
32	63	6101.33	78.22	234.67	469.33
33	64½	6413.00	80.67	242.00	484.00
34	66	6732.00	83.11	249.33	498.67
35	67½	7058.33	85.55	256.67	513.33
36	69	7392.00	88.00	264.00	528.00
37	70½	7733.00	90.44	271.33	542.67
38	72	8081.33	92.39	278.67	557.33
39	73½	8437.00	95.33	286.00	572.00
40	75	8800.00	97.77	293.33	586.67
41	76½	9170.33	100.22	300.67	601.33
42	78	9548.00	102.66	308.00	616.00
43	79½	9933.00	105.11	315.33	630.67
44	81	10325.33	107.55	322.67	645.33
45	82½	10725.00	109.99	330.00	660.00
46	84	11132.00	112.44	337.33	674.67
47	85½	11546.33	114.88	344.67	689.33
48	87	11968.00	117.33	352.00	704.00
[illegible]	88½	12397.00	119.77	359.33	718.67

SLOPES 2 TO 1.

Depth of cutting in feet.	Half width at top in feet.	Content in cubic yards per chain.	Content of 1 perpendicular foot in breadth.	Content of 3 perpendicular feet in breadth.	Content of 6 perpendicular feet in breadth.
1	17	78.22	2.44	7.33	14.67
2	19	166.22	4.89	14.67	29.33
3	21	264.00	7.33	22.00	44.00
4	23	371.55	9.78	29.33	58.67
5	25	488.89	12.22	36.67	73.33
6	27	616.00	14.67	44.00	88.00
7	29	752.89	17.11	51.33	102.67
8	31	899.55	19.56	58.67	117.33
9	33	1056.00	22.00	66.00	132.00
10	35	1222.22	24.44	73.33	146.67
11	37	1398.22	26.89	80.67	161.33
12	39	1584.00	29.33	88.00	176.00
13	41	1779.55	31.78	95.33	190.67
14	43	1984.89	34.22	102.67	205.33
15	45	2200.00	36.66	110.00	220.00
16	47	2424.89	39.11	117.33	234.67
17	49	2659.55	41.55	124.67	249.33
18	51	2904.00	43.99	132.00	264.00
19	53	3158.22	46.44	139.33	278.67
20	55	3422.22	48.89	146.67	293.33
21	57	3696.00	51.33	154.00	308.00
22	59	3979.55	53.77	161.33	322.67
23	61	4272.89	56.21	168.67	337.33
24	63	4576.00	58.66	176.00	352.00
25	65	4888.89	61.10	183.33	366.67
26	67	5211.55	63.55	190.67	381.33
27	69	5544.00	65.99	198.00	396.00
28	71	5886.22	68.43	205.33	410.67
29	73	6238.22	70.88	212.67	425.33
30	75	6600.00	73.32	220.00	440.00
31	77	6971.55	75.77	227.33	454.67
32	79	7352.89	78.22	234.67	469.33
33	81	7744.00	80.67	242.00	484.00
34	83	8144.89	83.11	249.33	498.67
35	85	8555.55	85.55	256.67	513.33
36	87	8976.00	88.00	264.00	528.00
37	89	9406.22	90.44	271.33	542.67
38	91	9846.22	92.39	278.67	557.33
39	93	10296.00	95.33	286.00	572.00
40	95	10755.55	97.77	293.33	586.67
41	97	11224.89	100.22	300.67	601.33
42	99	11704.00	102.66	308.00	616.00
43	101	12192.89	105.11	315.33	630.67
44	103	12691.55	107.55	322.67	645.33
45	105	13200.00	109.99	330.00	660.00
46	107	13718.22	112.44	337.33	674.67
47	109	14246.22	114.88	344.67	689.33
48	111	14784.00	117.33	352.00	704.00

By the fourth, fifth, and sixth columns in each table, the number of cubic yards is easily ascertained at any other width of formation level above or below 30 feet, having the same slopes as per tables, thus :—

Suppose an excavation of 40 feet in depth, and 33 feet in width at formation level, whose slopes or sides are at an angle of 2 to 1, required the extent of excavation in cubic yards—

$$10755.55 + 293.33 = 11048.88 \text{ cubic yards.}$$

The number of cubic yards in any other excavation may be ascertained by the following simple rule :—

To the width at formation level in feet, add the horizontal length of the side of the triangle formed by the slope, multiply the sum by the depth of the cutting, or excavation, and by the length, also in feet; divide the product by 27, and the quotient is the content in cubic yards.

Ex.—Suppose a cutting of any length, and of which take 1 chain, its depth being $14\frac{1}{2}$ feet, width at the bottom 28 feet, and whose sides have a slope of $1\frac{1}{4}$ to 1, required the content in cubic yards,

$$14.5 \times 1.25 = \overline{18.125 + 28} \times 14 = 645.75 \times 66$$
$$= \frac{42619.5}{27} = 1578.5 \text{ cubic yards.}$$

Note.—English cubic yards multiplied by .7646 = French cubic metres, and French cubic metres multiplied by 1.308 = English cubic yards.

ON THE DIMINUTION OF FRICTION BY RAPID MOTION.

(From the Inventors' Advocate of Industry.)

Time is an essential element in the consideration of pressure as well as of motion; and the weight or bearing of any body is proportioned to the time which it remains on any given point, thus:—Suppose a ball of any weight or size to be rolled along a flat level surface, at a velocity of ten feet per second, it must press upon every part of the surface moved over with a force proportionate to its weight. Again, if it be rolled at double that velocity, its pressure will be distributed over twice the space in the same time; and, as the weight of the ball remains the same, the amount of force on any given point of its course must be diminished one-half. The total amount of pressure exerted in the second of time is the same; but, in the case of the double velocity, the space over which it is spread is doubled, and its intensity is therefore proportionally diminished; and the application of this principle shows clearly the mechanical advantages to be gained by rapid motion in the diminution of friction on railways: for the resistance to the motion of wheeled carriages, caused by friction, increases with the weight or pressure on the axles, and on the surface of the road; therefore, if we diminish the pressure by increasing the rapidity of the motion, we diminish the friction. The effect of increased velocity in diminishing resistance in traversing any given space on a railway is, however, different on the friction of the axles from the resistance of the surface of the road.

The pressure of the load on the axles of the carriages is constantly the same, because there is, in that case, no distribution of the weight over a larger surface; it has the same point of bearing whatever may be the velocity. The gain in this case depends entirely on the saving of time, for, as the weight, at a double velocity, rests on the points of bearing only half the time, the power required to overcome it is only half, or, what is the same thing, is only required for half the time. The advantage gained by diminution of resistance at the circumferences of the wheels, on the contrary, depends on the diminution of pressure. The weight at double the velocity is distributed over twice the surface, consequently its pressure on any given point is only half. The same weight is borne by twice the length of rails in one case that presses on half the length in the other; viewed in relation to time, it is the same in both.

These observations respecting the resistance of the surface only apply to a perfectly level and smooth railway, on which the hindrance to motion from the rails depends principally on adhesion, caused by weight. When the rails are uneven, or when the road inclines, the advantages of rapid motion, so far as the diminution of the surface resistance is concerned, is decreased. On an incline, the weight of the whole train has to be lifted as well as to be drawn, and the increased velocity gives no advantage in lifting a weight. It has, on the contrary, the effect of diminishing the mechanical advantages of the inclined plane. For instance, when the velocity is doubled on an incline, the weight is lifted twice the height in the same time, and twice the power will be required to do it. Viewed in relation to time, there is no loss of power, but the quantity of force required to overcome the obstacle must be increased. When higher velocities, therefore, are required, the importance of having the road level is the greater. A gradient of 1 in 200 is to a train travelling at the rate of twenty miles an hour equal to a gradient of 1 in 100 when the speed is doubled, for the weight will have to be raised twice the height in the same time.

The pressure on the axles remains constant, whether the motion be rapid or slow, up hill or down ; and it is in this friction that the great saving of resistance is made by increasing the velocity. The proportion which the resistance to motion from friction of the axles bears to the resistance presented by adhesion, inequalities, and inclines, on the peripheries of the wheels, may be stated at three to one. Putting out of consideration, therefore, the diminished resistance occasioned by diminished weight on the rails, we will take the surface resistance to be in arithmetical ratio to the velocity, and confine our view of the advantages of increasing the velocity to the diminution of axle-friction only. It is not that we think the diminution of the surface resistance unimportant that we leave it out of consideration, but because its amount must depend greatly on the state of the road. In axle-friction alone there would be a gain of power to the amount of nearly seventy per cent. by doubling the velocity, and of one hundred per cent. if it were trebled, whilst the loss arising from increased resistance by the air would be only in the proportion of 18 to 14.

For instance, if the force required to move a train at the rate of twenty miles an hour be 400 lbs., the obstruction of the road would absorb 100 lbs. of the power, and the friction of the axles 300 lbs. At double the speed, the power required would be 300 lbs. for axle-friction, and 200 lbs. for road-resistance, being together 500 lbs.; and at the speed of sixty miles an hour the power required would, in the same manner, be 600 lbs. In the same time, however, the train would be propelled in the latter case three times the distance by the 200 lbs. additional power, omitting from consideration the increased resistance of the air.

It may be objected to this calculation of the advantages to be gained by rapid motion, that experience on railways proves the reverse of gain to accompany increase of speed. This result, however, does not prove the unsoundness of the principle for which we are contending, but the defective construction of locomotive engines for rapid motion. If that objection be allowed against the theory of diminished resistance to motion at increased velocities on railways, it would be equally applicable to passage boats on canals, where the fact has been proved, and proved, too, in apparent opposition to the established law of the resistance of fluids. Though a speed of ten or twelve miles an hour on canals has been proved to occasion much less proportionate resistance than a speed of six or seven miles an hour, the slower speed is preferred, because the moving power is not adapted for greater velocities. It is the same with the present locomotive engines as with animal power. They are not adapted for very rapid motion, and when it is attempted, a great sacrifice of steam power is the consequence. Even at the velocities common to the slowest trains on railways, a great loss of power results, owing to the construction of the engines not being fitted for imparting rapid motion. An engine which would draw a train of sixty tons at the rate of twelve miles an hour, is not able to draw more than forty tons at fifteen miles an hour; and at a velocity of twenty miles an hour its power is reduced to drawing twenty tons only. Thus, an addition of eight miles an hour to the speed diminishes the power of the engine two-thirds. This effect is to be ascribed entirely to the imperfect construction of locomotive engines, and does not arise from the increased resistance of the air, or friction consequent on rapid motion. If an engine were constructed, able to exert its power advantageously at great velocities, we have no doubt that the advantages gained by increasing the velocity would fully equal our estimate. The power to be employed at higher rates of speed must necessarily be greater than at slower velocities, but the advantage gained by diminishing the time of its action would far exceed the increase of power required.

Table of Railways, with the Time of Opening, and the Gauge of Rails.

RAILWAYS.	*Date of opening.*	*Gauge.*
Arbroath and Forfar	Jan., 1839	5 ft. 6 in.
Birmingham and Derby Junction	Aug., 1839	4 ft. 8½ in.
Birmingham and Gloucester	Sept., 1840	4 ft. 8½ in.
Birmingham, Bristol, and Thames Junction, now West London	In progress	
Bolton and Preston	In progress	
Bristol and Exeter	In progress	7 feet.
Chester and Birkenhead	Sept., 1840	4 ft. 8½ in.
Eastern Counties	July, 1840	5 feet.
Edinburgh and Glasgow	In progress	4 ft. 8½ in.
Glasgow, Paisley, Kilmarnock, & Ayr	Aug., 1840	4 ft. 8½ in.
Grand Junction	July, 1837	4 ft. 8½ in.
Great North of England	In progress	4 ft. 8½ in.
Great Western	Aug., 1840	7 feet.
Hull and Selby	July, 1840	4 ft. 9 in
Lancaster and Preston Junction	June, 1840	4 ft. 8½ in.
Liverpool and Manchester	Sept., 1830	4 ft. 8½ in.
London and Birmingham	Sept., 1838	4 ft. 8½ n..
Leeds and Selby	Sept., 1834	4 ft. 8½ in.
Leicester and Swannington	July, 1832	4 ft. 8½ in.
London and Brighton	May, 1840	4 ft. 8½ in.
London and Southampton, now London and South-western Railway	May, 1840	4 ft. 8½ in.
Manchester and Birmingham	June, 1840	4 ft. 8½ in.
Manchester and Leeds	Oct., 1840	4 ft. 9 in.
Maryport and Carlisle	July, 1840	
Midland Counties	June, 1840	4 ft. 9 in.
Newcastle-upon-Tyne and Carlisle	1839	4 ft. 8½ in.
Newcastle-upon-Tyne and North Shields	June, 1839	
North Midland	July, 1840	4 ft. 9 in
Northern and Eastern	Sept., 1840	5 ft.
Preston and Wigan, now North Union	Oct., 1838	4 ft. 8½ in.
Sheffield and Rotherham	Oct., 1838	4 ft. 8½ in.
Stockton and Darlington	Sept., 1825	4 ft. 8½ in.
York and North Midland	June, 1840	4 ft. 9 in.

An Account of the Mileage and Composition for Duties on Railway Carriages for the Years 1836-7-8-9.

	1836.	1837.	1838.	1839.
Mileage	£9,097	£14,636	£36,251	£70,837
Composition	1,199	2,256	3,319	1,879

APPENDIX.

DIRCKS' PATENT METALLIC RAILWAY WHEEL WITH WOOD-FACED TYRE.

Among various other railway improvements, the wheel, of which the annexed engraving is an illustration, particularly offers itself to notice. A paper detailing its peculiar nature and advantages was read before the Mechanical Section of the British Association at Glasgow last year. It has been noticed in most of the scientific periodicals, and to an article on "Railway Improvements," which appeared in the POLYTECHNIC JOURNAL for December, 1840, we are indebted for the following abstract:—

"This improvement, which is due to the skill of Mr. Dircks, (of the firm of Messrs. Brocklehurst, Dircks, and Nelson, of Liverpool,) is thus described by that gentleman:—'The construction of the wheel may be understood by imagining a spoked wheel with a deep channelled tyre. The wheel may be made either of cast or wrought iron, it having been ascertained that tyre bars can be rolled to the required pattern. In this channelled tyre are inserted blocks of African oak, measuring about four inches by three-and-a-half inches, solidified by filling the pores with unctuous preparations, thereby counteracting the effects of wet by capillary attraction, to which, by this means, it becomes impervious, and at the same time is not liable to unequal contraction and expansion. The blocks of wood are cut to the requisite form to fit very exactly in the external circular channel of the wheel, with the grain placed vertically throughout, forming a complete facing of wood, as shown in the engraving. There are about from twenty-eight to thirty of these blocks round each wheel, where they are retained in their place by one or two bolts passing through each, the two sides of the channel having corresponding holes drilled through them for this purpose; the bolts are then well riveted. After being so fitted, the wheel is turned in the usual manner. The wheel when finished has all the appearance of a common railway wheel, but with a rather deeper rim, the tyre faced with wood, and the flange of iron. Woods of various qualities may be used, whether hard or soft, requiring different chemical preparations according to their porosity, and in some instances requiring to be compressed.'

A

B

DESCRIPTION—A represents the wheel half in section; B, complete; the view being a front elevation.

"There are many advantages to be looked for from the adoption of Mr. Dircks' wheel, in place of those ordinarily used. When wheels and rails become wet with rain, great difficulty is frequently experienced in starting and stopping a train, by reason of the extreme slipperiness induced by damp. This difficulty is met by the engines being provided with sand-boxes, from which the sand is spread upon the rail, and thus adhesion is obtained; if there is no sand there is no starting, or stopping within the ordinary bounds, if in motion. Much, therefore, during wet weather, depends upon the sand; so much, indeed, that we ourselves have seen driving-wheels running at full speed and serging or slipping for want of adhesion on the rail, until a man running before strewed sand upon it. These brief observations will serve to show that those who attend to the engines do not possess the control over them in wet weather which they do in dry; that is to say, they cannot stop them in the one case with the certainty that they can in the other. Now, the railway wheel invented and patented by Mr. Dircks gets rid of this difficulty. It will be seen by the description previously given, that the rim which travels over the rail is made of wood, and between wood and iron the adhesion is so considerable that no moisture overcomes it, and, consequently, sand or other extraneous assistance is not necessary to facilitate, control, or altogether arrest motion. In fact, the application of this wheel would enable an engine conductor to stop his train, under the most unfavourable circumstances, in less time and distance than he can do it at present under the most favourable circumstances.

"As an additional reason in favour of wheels on this construction, Mr. Dircks says,—'The action of an iron wheel upon an iron rail, though derived from a rolling motion, can only be compared to a series of blows, and the rebound occasioned by iron striking iron is well known to be considerably greater than is produced by wood striking on iron. To this simple fact we may trace the tremulous motion occasioned by iron wheels on an iron railroad; and when, by any trifling accident, as an inequality from the rising of one end of a rail, or sometimes even from small flinty pebbles getting on the rail, the rebound is not more fearful than dangerous. The tremulous motion of the rail just adverted to renders it necessary, in most cases, to lay the rails on wooden sleepers.'

"It would diminish much of the noise, which at present is a source of general complaint; the wood facing will wear a considerable time without requiring any repair; the wood can be refaced, by turning it up again in the lathe, as practised with worn iron tyres; the tyre can be refaced with wood at little expense, and at a far less loss of time than usual; and in the operations of refacing these wheels, or putting in new wood, the work can be performed without the labour and cost of removing the wheels from the axles, which, in the keying and unkeying, is known to be very troublesome; and, finally, the rails themselves will suffer less wear by using this kind of wheel, and the fastenings, sleepers, and blocks will receive considerably less injury, and thereby favour the laying of railroads on stone blocks, wherever they are considered to be most desirable."

E. SMITH AND CO., PRINTERS, LIVERPOOL.