ON THE RUNNING DOWN OF BATTERIES AS INFLUENCED BY THEIR PERFORMANCE OF MECHANICAL WORK.

By Dr. Oliver Lodge.

Although there is nothing but what is perfectly well known in the relation between the running down of a battery and the amount of external work it is doing, yet, inasmuch as batteries are not unlikely to be more and more generally used as sources of mechanical power, it may be worth while to answer the question of the Cromer "Student" in your issue of 22nd January somewhat fully.

The correspondent describes an interesting model of an electric hammer driven by a battery, which does about 150 foot-pounds of work per minute, or has about the two-hundredth of a horse-power; and he then proceeds to say that whereas the books tell him that his battery should run down faster when the hammer is stationary than when it is at work, he finds no such result; and he implies, or at least it is not unnatural for him to think, that he would have expected the battery to run down faster while doing mechanical work than while not.

Now the first thing to thoroughly grasp is that the consumption of material in a battery is simply proportional to the strength of current flowing through it; provided, of course, all local action is avoided; it depends on the quantity of electricity transmitted, and on nothing else. The amount of zinc dissolved in every cell of a series battery per ampère hour is accurately known, and is 1·21 grammes.

Hence any cause which increases the strength of current hastens the running down of the battery; and any cause which opposes the current retards the consumption of material. Now the performance of mechanical work of whatever sort, by a current, necessarily sets up an opposition E M F and weakens the current, as may be proved, and was proved by Helmholtz in 1847, as follows:—

Let E be the electro-motive force of a battery, supposed constant; and let C be the current flowing round a circuit of total resistance R, resistance also being supposed constant. Then, by definition of E M F, the "horse-power," or work done per minute by the current, is E C.

As the current flows round the circuit heat is generated, and this heat was found by Joule experimentally to equal $R\,C^2$ per unit of time.

Now if we first suppose that there is no working machine in the circuit—*i.e.*, no machine actually at work—stationary machines there may be as much as one pleases, and they may be holding up weights; but they must not be moving either in the way of raising or lowering them, neither must there be any chemical decomposition going on, or any form of activity other than that already considered in the battery; I say, given all these conditions, it follows, by the conservation of energy or the first law of thermo-dynamics, that

$$E\,C = R\,C^2 \quad . \; . \; . \; . \; . \; . \; . \quad (1)$$

an equation which asserts, when we compare it with the Ohm's law definition of R $\left(R = \frac{\text{E M F}}{\text{current}}\right)$, that throughout the circuit, under the supposed circumstances, there is no E M F, but E.

But now make another supposition: Suppose a working machine, or a decomposition cell, or some other form of activity, introduced into the circuit, whereby the current shall be made to do work—raising weights, for instance, or turning machinery—and let the horse-power of this machine be called P. Then no longer can we equate the power of the battery with the heat produced; we are compelled to take into account every form of energy which is being developed, mechanical or chemical as well as thermal, and so our equation becomes—

$$E\,C = R\,C^2 + P \quad . \; . \; . \; . \; . \quad (2)$$

And if again we compare *this* with the Ohm's law definition of R $\left(R = \frac{\text{E M F}}{C}\right)$ we find that E is no longer the sole or effective E M F in the circuit, but that the total E M F is $E - \frac{P}{C}$; that is, there is an opposition E M F, of strength $\frac{P}{C}$, and it is natural to consider this opposition E M F as set up in and by the moving machine; or in and by the decomposition cell, if such it be that has been included in the circuit, in which latter case the opposition E M F is known as polarisation. And be it noted that it matters not whether decomposition goes on in a special cell or in one of the battery cells—*wherever* it goes on it subtracts its full quota of E M F from the current, and is equally well called polarisation.

It is plain then that, since by an active machine the total E M F of the circuit is diminished while its resistance remains unaltered, it follows that the current must be weakened. And inasmuch as the wear of the battery depends simply on the current, the wear of the battery is likewise reduced by the activity of the machine.

It is easy enough to write down an expression for the strength of the current in terms of the power which the machine is exerting, *i.e.*, the work it is doing per second, by simply solving equation (2); and it is

$$C = \frac{E}{2R}\left\{1 + \sqrt{\left(1 - \frac{4RP}{E^2}\right)}\right\}$$

which shows that the greatest possible mechanical power obtainable by perfect appliances from the given circuit is $\frac{E^2}{4R}$; and that when this is obtained an equal amount is expended in generating waste heat. Moreover it shows that the consumption of material in the battery under these circumstances is exactly half what it is when the machine is held stationary and not allowed to work, and that no slower battery-wear than this half-rate is possible, so long as the machine is really worked by the battery and is not driven by some outside power; but that any faster wear is easy, up to the maximum, when the machine is stationary, of $\frac{E}{R}$.

The maximum rate of wear is $\frac{E}{R}$, corresponding to external power O and internal or waste power $\frac{E^2}{R}$;

The minimum rate of wear is $\frac{E}{2R}$, corresponding to external power $\frac{E^2}{4R}$ and internal or waste power $\frac{E^2}{4R}$.

But if the mechanical power obtained be small and insignificant compared with that put forth by the battery, as is always the case with small size models which can never be efficient and economical motors, then the rate of wear is so nearly equal to its maximum value $\frac{E}{R}$ as to be indistinguishable from it except by careful measurements.

Just one point before closing. No more work is called for from the battery whether a solenoid be sustaining a weight or keeping a piece of iron magnetised, or whether it is doing no such thing. Under all stationary circumstances the whole of the energy is frittered away as heat in the coil: the mere holding up of the weight or keeping a magnet excited involves no direct expenditure of energy. For a weight may be supported by a pillar, or a magnet may be struck into permanence by hardening it and fixing its molecules.

But a weight may also be supported by a man, or by a jet of water, and a magnet may be maintained by a constant current flowing round it: is there no expenditure of energy here? Do not the things get tired?

Yes, in truth they do, and there is expenditure of energy, *but not in holding the weight or maintaining the magnet;* it is all expended in bye-issues, it all reappears as heat. If we knew no simpler plan of keeping a weight supported than by putting a man to hold it up, like Atlas, we should have to pay him his day's wage and keep him working, wastefully generating heat; but we do know a simpler plan—we use a prop. Similarly, as we know no simpler means of maintaining a powerful magnet than by keeping a current constantly flowing round it we have to keep such a current flowing, although we feel that it is really all running to waste, and that a simple prop would be a far better plan. This, however, is the present state of our ignorance; we know no prop for magnetism of any real strength. Here is a field for discovery; the field-magnets of twentieth-century dynamos will probably be permanent ones, with the initial magnetic susceptibility of the softest iron, struck into the magnetic rigidity of the hardest steel.

Oliver Lodge.

University College, Liverpool, January 29th, 1886.

ROTARY ENGINES.

The construction of various types of rotary and so-called rotary engines has recently been described in our columns, but the subject will bear further consideration. The rotary engine has always been an attraction for inventors. They have pursued, it as the belated traveller follows an *ignis fatuus*, ever since the days of James Watt, and there is no reason to believe that they are nearer success now than they were half a century ago. We propose in the following article to explain the reason why, from our point of view, our acquaintance with rotary engines as they have existed in metal and on paper is extensive, and consequently what we have to say may be regarded as the outcome of practical knowledge of the subject.

It will be found that almost without exception inventors of rotary engines have attempted to run their engines at a very high velocity. One of the advantages which they always claim is that the rotary engine is not only smaller, but very much smaller than any other engine of the same power. This is the principal reason why rotary engines have not been successful. In a word, the principle on which they have been constructed has been wrong. A great point in the rotary engine is that the continuous motion of the piston permits it to be run at a very high velocity, but inasmuch as the diameter of the circle described has always been small, the high piston speed has been accomplished by a high velocity of rotation. This would be of no consequence were it not that, as "R." has very clearly explained, there must be a reciprocating member in every rotary engine; and to work a stop or abutment at 500 or 1000 strokes per minute is as bad, or worse, as to work a piston and crank shaft at the same rate. The proper way to construct a rotary engine is to make the piston move through a large circle at a moderate speed of rotation. This has never been tried in practice. Until it is, no really successful rotary engine will be constructed.

To illustrate our meaning we append a sketch. The centre or body consists of a disc A. To this is joined a piston B, shown in cross section in Fig. 2. An abutment is moved in and out by suitable mechanism. The piston revolves in a ring D. Inside this is a continuous slot in which A revolves, steam-tight, by means of two packing rings, as shown in Fig. 2. Of course, it will be understood that this is a purely ideal sketch. Let us assume now that the diameter of the ring is 20ft., its width 24in., and the depth of the piston, measured radially, 3in., the area of the piston will be 24 × 3 = 72 square inches. The circumference of the circle described by the piston will be, omitting fractions, 62ft. Let the revolutions be sixty per minute, then 60 × 62 = 3720ft. per minute. Let the average pressure be 50 lb. on the square inch, then $\frac{3720 \times 72 \times 50}{33{,}000} = 406$-horse power. The space occupied by such an engine would not greatly exceed that filled by the fly-wheel alone of an ordinary horizontal engine of like power. The design, too, is one of the most convenient that could be adopted, for the engine would stand against the wall. Smaller machines might, indeed, be bolted to a wall and have their axes coupled to a line of shafting by a universal or other flexible joint. The travel of the abutment would be very small—only 3in. It will be seen almost at a glance that this engine, as far as size and shape are concerned, has everything to recommend it. At sea, for instance, the saving of space and of weight secured by its adoption would be enormous.

FIG. 1

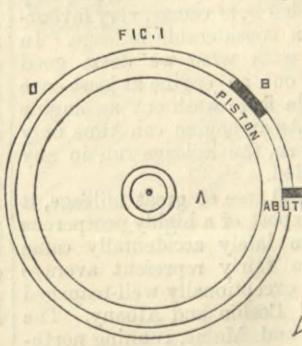


FIG. 2

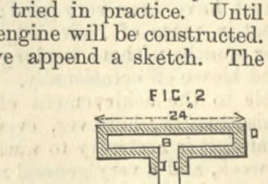


FIG. 3

Next let us consider what are the objections to be urged against it. In the first place, as it would be practically impossible to keep the centre of the main axis in the centre of the ring "cylinder," the piston must be secured by some flexible device to the disc. This may be done in various ways, as for example that shown in Fig. 3. Here the piston is dropped, so to speak, into a notch in the edge of the centre disc, the sides of which notch are shown by C C. There are, of course, obvious objections to such a plan, but it provides a remedy for the difficulty which we have raised, and equivalent, but really practical devices will readily suggest themselves.

A piston moving at 3700ft. per minute will, if it works with any friction, absorb a great deal of power; on the other hand, its leakage at such a velocity will be insignificant. It is for inventors to design a piston which while lightly packed will be steam tight. With first-class workmanship, and clean, dry steam, no packing rings would perhaps be required. The piston may be made of considerable length, circumferentially, and grooved. The loss by leakage will be very small. The disc will have to be made tight in the circumferential slot, and yet the friction must be very little. Here, again, invention and good workmanship are needed; we see no reason to think the difficulty insurmountable. The abutment can readily be made tight, save where it rests against the edge of the disc. As the disc would be very thin, say $\frac{1}{2}$in. thick steel plate, the area for leakage would be very small. It is almost impossible to see how it could be made tight by any packing.

If we compare this engine with any of the ordinary types of rotary engine, it will be seen that it has few or none of these disadvantages. Take, for example, an engine with pistons sliding in and out, as shown in Fig. 4. Here A shows one piston—this has to slide in and out of the central drum B a great many times in a minute while under the full pressure of the steam, and the wear and tear at D and C must be very great, with the result that in a very little time the pistons become so loose that they will rattle in the drums; lubrication cannot be maintained, centrifugal force driving away the oil. Again, if we take the type shown in Fig. 5 it will be seen that the abutment has a long stroke, and consequently cannot be quite closed until the piston has gone some distance, so that all the steam in the space A may be regarded as wasted. Furthermore, the end of the abutment can by no possible means be kept from hammering against the central drum. If it does not come in contact with it the leakage is enormous, because the joint is as long as the piston; if it does, then as the speed with which it moves inwards must be considerable, it must strike a severe blow, and accordingly all engines made on this system which we have seen are noisy to a degree. But besides all this, the wear and tear is much greater near the outer circumference than they are nearer the centre, and so leakage soon takes place next the piston end. "R." has so fully set forth the objections to "line" contacts that we need not dwell on them.

FIG. 4

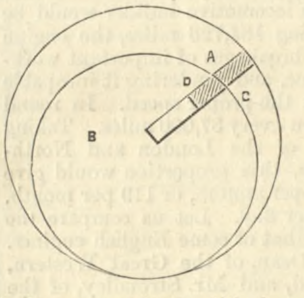
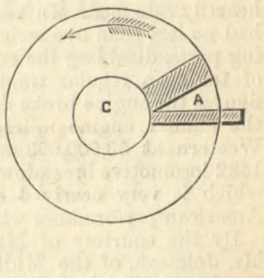


FIG. 5



That there are objections to this type of engine sketched in Fig. 1 is indisputable, but it must be remembered that no engineer has ever yet attempted to overcome the mechanical difficulties, the existence of which is sufficiently apparent. If such an engine can be made successfully, the reward of the maker will be very large. It is not too much to say, for example, that the modern marine engine would be supplanted in a very short time. A considerable expenditure of time and money and skill and patience will be needed, but no great success has ever been achieved in mechanics without the expenditure of both.

THE RELATIVE DURABILITY OF ENGLISH AND AMERICAN LOCOMOTIVES.

Some American writers have lately been striving, by help of arguments founded on very distorted statements of the facts, to prove that American locomotives are, after all, not the overworked, short-lived, and extravagant machines that everyone out of America believes them to be; and that American railroads have really the heaviest traffic, and are the most efficiently and economically administered lines in the world. We only wonder that these writers do not further show their ignorance of the subject by alleging that American trains are faster and safer than any others; and that American railroads have the soundest and most honest systems of finance.

For the present we shall content ourselves by examining a little more closely the facts on which a writer in the *National Car Builder* builds a theory that the

American locomotive is singularly durable. That paper quotes the following statement as to the performance of engine No. 137 of the Boston and Albany Railroad, but significantly enough omits to mention the numerous failures of the engine, and endeavours to give an impression that nothing of the kind occurred, by the following quotation, which we give *verbatim*:—"In doing this enormous amount of work, all the repairs effected on the engine, besides the minor running repairs, was turning the driving-wheel tires once and facing the valves once." This appears to be hardly correct in the face of the following statement of the performance of this engine which appears in another American paper, and which is said to be furnished by the locomotive superintendent of the Boston and Albany road.

"The following are the dimensions and record of passenger engine No. 137, built at the Boston and Albany shops:—

Weight	37 tons 10 cwt.
Cylinders	18in. by 22in.
Driving wheels, diameter	5ft. 8in.
Boiler, diameter	4ft. 4in.
Tubes, 2in. diameter, No.	221
Boiler pressure	160 lb.

"This engine came out of the shop April 23rd, 1883; and was taken in for general repairs October 30th, 1885; having run daily 30 months 7 days, or 921 days, making a total of 184,726 miles.

"During this time the engine lost 12 days for repairs, and deducting this from the total number of days run, the average mileage per day is 203 miles. No repairs were made until April 27th, 1884, when the engine had run 78,812 miles. During portions of the months of April and June, and the whole of the month of May, 1885, the engine ran 400 miles every day, making (with extra trips Sundays) 10,910 miles in May, and a total of 26,740 miles in the above-named months, or an average of 8913 miles per month.

"The twelve days lost and the causes were as follows:—

"April 1st, 1884: One day. Broken equalising beam.

"July, 1884: Four days. Tires turned, one broken driving box replaced, and regulator valve ground.

"July, 1884: Four days and a half. Broken piston-rod.

"May, 1885: Half a day. Broken piston-rod, front cylinder cover and casing.

"September, 1885: Two days. Broken driving box.

"The driving boxes were of cast iron, and in consequence of these failures have been replaced with steel. This record is furnished because it is an exceptional one."

It therefore appears that this much vaunted run of an American engine was accompanied by a series of breakdowns, of which any English locomotive builder would be heartily ashamed. In running 184,726 miles, the engine had no less than five serious breakages of important working parts, disabling the engine, and rendering it incapable of taking a regular train at the proper speed. In round figures the engine broke down every 37,000 miles. Taking the annual engine mileage of the London and North-Western at 53,000,000 miles, this proportion would give 1432 locomotive breakdowns per annum, or 119 per month, which is very nearly 4 every day. Let us compare the American performance with that of some English engines.

By the courtesy of Mr. Dean, of the Great Western, Mr. Johnson, of the Midland, and Mr. Stroudley, of the London and Brighton Railway, we are enabled to supply information of a kind which has never before been made public on this important question. We give the figures in the order of the dimensions of the lines concerned, beginning with the Great Western as the largest. It will be seen that the figures have been put into a somewhat different shape by each of the three gentlemen named. Mr. Dean has had the mileage between shop repairs for the year 1885 of the first twenty engines of five different classes taken out and put together for comparison in the following table:—

Average Mileage of Locomotive Engines between Shop Repairs, Great Western Railway.

Class.	Mileage.		
	Highest.	Lowest.	Average.
Passenger engines—			
7ft. express engines, single driving wheels	71,400	24,000	52,000
6½ft. coupled express engines.	79,600	21,000	54,200
5ft. coupled tank engines ...	94,000	26,000	48,000
Goods engines—			
Six wheels coupled tender engines, 5ft. wheels	68,300	17,300	42,200
Six wheels coupled heavy saddle tank engines, 4½ft. wheels...	55,700	17,000	33,500

It will be understood that these engines have been taken just as they happened to come on the books, and that some were in better condition at the beginning of 1885 than others, and that the repairs named do not refer to breakdowns alone, but to wear and tear as well. We have here a 5ft. coupled tank engine which made 94,000 miles between going into the shops—that is, 2·6-tenths times as many miles as the crack American engine. A 6½ft. coupled express engine beats the American record 2 to 1. Even the goods engines show an average record which compares most favourably with the American.

Mr. Johnson, of the Midland Railway, confines himself strictly to breakdowns. In 1885 there were sixty cases in which an engine was rendered idle for half a day or more. Among the causes was the breakage of crank and straight axles, slide valves, and valve spindles through wear and tear; also cases of hot guide bars, due to neglect on the part of the drivers; and cases where drivers had to give up their trains. Now, the gross engine mileage for 1885 was 43,657,427. The total number of engines 1803. The average mileage, supposing all the engines to have been worked, 24,200. There was one breakdown for every 727,623·7 miles. This includes engines of all kinds. Portions of the line are exceptionally heavy, and the trains run are the heaviest and fastest in the world. Such a record as this it will be found impossible to beat, or even come near, in the United States.

We come now to the London, Brighton, and South Coast, Mr. Stroudley has supplied us not only with general figures, but with minute particulars of the nature of the casualties which caused the engines concerned to be idle for half a day or more. The particulars apply to the six months, July-December, 1885, and there are over 400 engines on the line. Here are the particulars:—

July 25.—Engine 228 caused 43 min. delay through excentric straps getting hot—short of oil—breaking excentric-rod.

July 31.—Engine 202 caused 32 min. delay through left-hand crosshead breaking.

August. 1.—Engine 13 caused 24 min. delay through steam pipe flange breaking off.

September 14.—Engine 38 caused 11 min. delay through tube bursting.

September 16.—Engine 75 caused 10 min. delay through tube bursting.

September 28.—Engine 291 caused 8 min. delay through tube bursting.

September 28.—Engine 256 caused 50 min. delay through crank axle breaking.

October 9.—Engine 73 caused 28 min. delay through valve spindle cotter coming out.

October 31.—Engine 100 caused 1 hour 40 min. delay through tube bursting.

November 9.—Engine 425 caused 2 hours 57 min. delay through broken tube.

November 14.—Engine 419 caused 2 hours 13 min. delay through tube bursting.

November 19.—Engine 93 caused 1 hour delay through draw-bar of engine breaking, in consequence of two couplings being put on at once.

December 2.—Engine 336 caused 57 min. delay through quadrant link breaking. This link had flawed in case-hardening, which was not observed until it broke.

It will be seen that some of these failures are of the most trifling character, and that the majority involved no repairs more serious than plugging a tube. They are not to be spoken of in the same breath with the failures of the American engine. There is not one record of a broken spring as having interfered in any way with the traffic. The excentric straps, which were allowed to run hot from want of oil, broke the excentric-rod; but this can hardly be put down as a fair case against the engine, as it had been running perfectly for several years. The crosshead recorded as broken had evidently been strained in putting in the gudgeon, owing to the block going into the jaw for supporting it not having been a sufficiently perfect fit. This crosshead had been working for several years holding on by one side only, but this was not discovered until it broke. It did but trifling damage, but of, course, stopped the engine for the day. The crank axle which broke caused fifty minutes' delay, but did no other damage. The valve spindle cotter was allowed to work out from one of the small engines. This had evidently been taken out for some purpose, and had not been properly secured again. No. 336 engine broke the quadrant link, which, in turn, broke the excentric-rod. This quadrant link had, as before stated, flawed in case-hardening, but the flaw was not observed until it came asunder. It appears that on the Brighton line they almost never have any failure of the gear of the engine itself, the troubles being confined to broken crank axles and burst or broken tubes. The mileage is not easy to get at in a compact form, because there are seventy-four old engines and 338 of the new type, and it is not fair to include old locomotives, which are being replaced. The total engine mileage for the half-year was 4,986,893, and assuming that all the engines ran alike, which is not fair, however, to the standard engines, these made 4,087,000 during the half-year; or supposing all the engines to be in use, which is not the case, 15,110 miles per engine per half year, or 30,220 per annum—a high average. Supposing the number of breakdowns for the year to be twice that for the six months, or twenty-six, we have nearly 315,000 miles per breakdown. There were, it will be seen from the list, only three accidents, properly so called, namely, one crank axle broken, one link, and one crosshead. These may be compared with the broken piston-rod and broken axle-boxes of the American engine. Dividing the mileage by three, we have one serious breakdown to every 1,362,333 miles run. Can the United States show any truthful record to parallel this?

The Boston and Albany engine appears to have been run continuously on both week-days and Sundays, and therefore presumably without washing out. The water must have been very good; and, indeed, we understand that in parts of New England engines can be safely run for months without washing out, the boiler being filled up and blown off occasionally. This is, of course, very favourable to the achievement of a considerable mileage. In this country, however, even with what we deem good water, it is necessary to wash out an engine at least once a week, and a very general rule is to wash out an engine one day earlier every week. As an engine can thus only run five days out of the seven, the mileage run in any given time is effectually curtailed.

Passing from this exceptional case of great mileage, it is interesting to examine the report of a highly prosperous American railroad which we lately accidentally came across, and which may more fairly represent average American practice than such exceptionally well-managed roads as the Pennsylvania and Boston and Albany. The road we refer to is the Boston and Maine, running northward from Boston to Portland and New Brunswick. The length of the line is not stated in the report, but the annual receipts are at the rate of £25,000 per week, and rather more than half the gross receipts are derived from passenger traffic. As each passenger was carried an average distance of 13·1 miles, and no less than 15,587,000 passengers in all were carried, it is evident that, unlike most American roads, and like all English roads, the Boston and Maine has a considerable local passenger traffic; 2,132,000 tons of goods were conveyed an average distance of 53·7 miles. This is probably somewhat further than the average on English roads, but the average for both passengers and goods is near enough to make a fair comparison of the cost of locomotive power, &c., on the Boston and Maine and on English railways generally. In order to fairly compare English and American railways, an American line having, like our own, local traffic and short hauls, must be taken. This done, we find that the annual mileage per locomotive is very much the same in both countries, and that in speed, consumption of fuel, and mileage between repairs, the English engines have a considerable advantage.

The average annual mileage of each engine on the Boston and Maine is 23,787 miles, which is less than 2000 miles per month, presenting an instructive contrast to the exceptional results obtained on the Boston and Albany. On the London and Brighton Railway also, with local traffic and short hauls, it is, we have seen, 30,222 miles per annum.

This report is equally calculated to throw cold water on the figures given by the *National Car Builder* as to the marvellous mileage made by American engines between repairs. The Boston and Maine possesses 207 engines, and the report summarises the annual repairs effected as follows:—

Renewed entirely	19	engines.
Thoroughly rebuilt	6	„
General repairs	72	„
"More or less repairs"	111	„

Total number repaired 208 engines.

It will thus be seen that every single engine had been in the shop during the year for more or less serious repairs, and that no less than 12 per cent. of the engines had been renewed entirely or thoroughly rebuilt. It also appears that 97 out of 207 engines required either complete renewal, rebuilding, or general repairs during one year. The average mileage between very heavy repairs may, therefore, be taken at $\frac{207}{97} \times 23{,}787$ miles, or 50,762 miles, and the average mileage between more or less serious repairs may be taken at $\frac{207}{208} \times 23{,}787$ miles, or 23,675 miles.

If the terms "general repairs," and "more or less repairs" are used in the sense in which they are understood in this country, American engines certainly do not appear to be as durable as those built here, though the mileage run between repairs is not always a sure criterion. Many engines are sent into the shops here before it is absolutely necessary, on the principle that a stitch in time, &c. They would no doubt run a considerably longer mileage, but the boxes are beginning to knock, and the valves and pistons are blowing slightly, and the tubes leak occasionally, and some of the stay heads are getting burnt; the engine will, therefore, burn rather more fuel and stand a chance of breaking down on the road. In order to avoid any such risk it is just as well to take the engine in and put it in first-rate order. The mileage between repairs is thus curtailed.

It is hardly necessary, however, to analyse figures to ascertain whether American locomotives are as durable as those built in this country. When we find that the English engine has larger crank-pins, larger axle-box journals, larger crossheads, larger piston rods, larger motion pins, larger springs, and larger wheels, and is generally throughout built more substantially, and more carefully and accurately finished, it is evident that, leaving on one side the smaller number of revolutions made per mile, the larger bearings and more careful finish must make the English engine more durable under similar conditions. As regards the boiler work, the comparison is even more in favour of English practice. The plates are thicker, and therefore allow a greater margin against corrosion; the joints are stronger, and therefore not so liable to leak and furrow; the rivetting is hydraulic instead of hand or steam, and the boiler as a whole is better made, the workmen being more skilful, the tools better, and the standard of excellence higher. In what shop in Great Britain could sixteen men be counted caulking a locomotive boiler under test? Yet such a sight excites no surprise in the yard of one of the best American builders.

Many features in the design are, apart from any question of proportions and workmanship, favourable to the superior durability of the English engine. In American engines the axles are plain round bars with loose collars, and are shouldered down for the wheel seat. Such an axle, though cheaper to make, is not nearly so trustworthy as an axle forged to shape with solid collars, the middle of the axle being smaller than the journals, and the latter smaller than the wheel seat. Such an axle, with fillets of large radius, at every change of diameter has no point at which the strains are concentrated, and therefore is not liable to break at any one point. The sharp shoulder where an American axle enters the wheel is, on the contrary, a weak point, and must inevitably shorten the safe mileage of an iron axle, and render the use of steel highly dangerous. The part of the axle forced into a wheel with a pressure of 80 tons must necessarily be under a considerable compressive strain from which the rest of the axle is free. A little reflection will show that torsional and cross-breaking strains thrown upon an axle in service must also exist in the axle head. In English engines the additional compressive strain is provided for by the increased diameter in the wheel seat; but in the American axle, the part exposed to the greatest strain is the smallest in diameter, and is provided with a sharp shoulder as if to further invite a failure.

The great number of parts, and the insecure manner in which they are attached to one another, is another weak feature about an American engine. The coupling and connecting-rod ends are almost invariably fitted with straps, bolts, and keys, which are troublesome to fit up and repair, are very liable to fail suddenly, and weigh more than English solid rod ends with considerably larger bearing surfaces.

The link motion presents the same increased number of initial points of failure. The excentric sheaves are not keyed to the axle, but are merely secured by set pins, which are, of course, liable to slip. The excentric rods in like manner are only secured to the excentric straps by friction, the rod and strap being clamped together side by side by bolts working in slotted holes. This arrangement is rather more convenient for adjusting the length of the rods, but the rod may slip, though the bolts and nuts are intact. The usual manner in which this connection is made on English engines is more expensive to make, but is far more secure. The expansion link in American engines is generally made in two main parts—front and back—bolted together with distance pieces top and bottom. This construction has been long abandoned here, and a solid link is rightly regarded as less liable to failure though more expensive to make. The rocking shaft introduces yet another piece into the American link motion, and as it obliges the expansion link to be hung on one side, it entails a further disadvantage. The strain on the die block is also taken on one side. These additional parts and defective methods of meeting the working strains must, under equal conditions, increase the chances of failure. It may, however, be urged that the superior accessibility of the valve chest placed in American engines on top of the steam chest outweighs all the disadvantages enumerated. This argument might have had some weight before the advent of portable machines for facing valve seats. While the outside steam chest is more accessible for hammer, chisel, and file, it presents no advantages over the valve chests of even inside-cylinder engines where a machine is used. It has, moreover, several palpable disadvantages. The steam is more exposed to condensation, the steam and exhaust passages are longer, and the front end of the engine is somewhat heavier, as no part of the metal of the steam chest serves to brace the cylinders together, as in English engines.

American critics generally urge that English engines are too rigid for roughly laid tracks or sharp curves. It is perfectly true that the good permanent way of most of our great main lines renders the use of equalising levers and bogies unnecessary, but both these devices are very freely used wherever it is deemed they diminish the wear and add to the easy riding of the engine. On the North London, Metropolitan, Metropolitan District, London, Tilbury, and Southend, Highland, and Great North of Scotland lines, every engine has both equalising levers and bogie. With the exception of the London and Brighton, every important railway in the kingdom has a large proportion of engines fitted with some form of flexible wheel base. Moreover, most of these engines are fitted with Adams' bogie, which compares very favourably with the various American bogies and pony trucks tried here under similar conditions. As the springs used here are longer than those generally employed in America, they are probably more flexible, and it is safe to conclude that their greater weight makes them more durable. Judging from the numerous broken axle-boxes on the Boston and Albany engine, this mishap is not always caused by the tension of the spring, the only point that can be urged against the English practice.

American critics who have never seen an English locomotive invariably seem to imagine that the plate frame is more rigid laterally than the bar frame. The exact contrary is the case. It is obvious that a plate 20in. deep and 1in. thick is stiff vertically and very flexible laterally; while a rectangular iron bar 3½in. wide and 3in. deep will be very much more rigid laterally than the plate frame. As the vertical flexibility in all engines is supplied by the springs, the greater vertical flexibility of the bar frame confers no advantage, and renders it difficult to lift the engine without breaking the frame above the axle-box rubbing pieces. The lateral flexibility of the plate frame is, however, a very valuable feature, and in one case that came to our knowledge enabled six coupled rigid wheel base engines to work safely over sharp curves and badly-laid crossings, where American Moguls were frequently derailed. The idea that English engines are too rigid for rough roads is a mistake, and probably originated in the fact that the original English engines for the Grand Trunk of Canada were built by a firm who had little experience in building locomotives, and none whatever in making provision against the effects of a Canadian winter. It would be as unfair to judge English bridge builders of the present day by the Victoria Bridge at Montreal. Our knowledge of both bridges and locomotives has increased considerably in the thirty years that has elapsed since the Grand Trunk was built by Robert Stephenson and other pioneers of railways.

The use of inferior methods of construction, some of which have been explained above, reduces the cost of labour in building an American locomotive. The use of steel instead of copper for inside fire-boxes, cast iron instead of wrought iron for wheel centres, and iron instead of brass for tubes, enables American builders to effect a considerable economy in the price of the raw materials of a locomotive. Fire-boxes made of English Siemens-Martin steel are, however, in successful use in Canadian locomotives, and it is evident that where the absence of lime in the water renders the use of steel possible, fire-boxes of that material can be made more cheaply here than in America. Iron tubes are of course largely used by English railways for partly worn-out engines, and if the user of the engine desires the cheaper material, it can be used in the new engine. It will probably never be possible to make a satisfactory cast iron wheel in this country; but as far as we know there is no reason why locomotive builders should not generally imitate Mr. Webb's example, and use cast steel wheel centres. At least one firm in Sheffield makes an excellent steel wheel, tough, strong, homogeneous, and free, of course, from bad welds.

We therefore see no reason why English locomotive builders should not continue to be able to produce a more durable locomotive at a lower price than our American cousins, as the great cost of wages and materials must always counterbalance the saving effected by the use of inferior materials and methods of construction.

THE ELECTRIC LIGHTING ACT.—At a general meeting of the Electric Lighting Act Committee, recently held at the offices of the Anglo-American Brush Electric Light Corporation, Belvedere-road, Lord Thurlow in the chair, a resolution was adopted, on the motion of Viscount Anson, approving the action of the Executive, and expressing satisfaction at the announcement that Lord Rayleigh had, at the request of the Executive, agreed to introduce the Bill drafted by the committee into the House of Lords.

THE VYRNWY MASONRY DAM.

THE design and construction of masonry dams of large dimensions is perhaps not a matter of great professional importance to English engineers, as they are not often likely to be called upon to build them at home or abroad. The masonry dam is, however, a subject of much interest, and the graphic and analytical investigation of the conditions of its stability, as well as of the nature, intensity, and direction of the stresses in its materials due to insistent or impressed forces, have often provided attractive food for speculation and determination. The most complete investigations that have appeared in English upon the subject have been those which are published in THE ENGINEER, and of these we may instance the illustrated articles by Mallet based upon the previous investigations of MM. Sazilly, Graeff, Conte, Grandchamps, and Delocre,* and by whom many proposals were made and some difficult points solved by means of an ingenious assumption. Rankine also devoted attention to the subject in THE ENGINEER.†

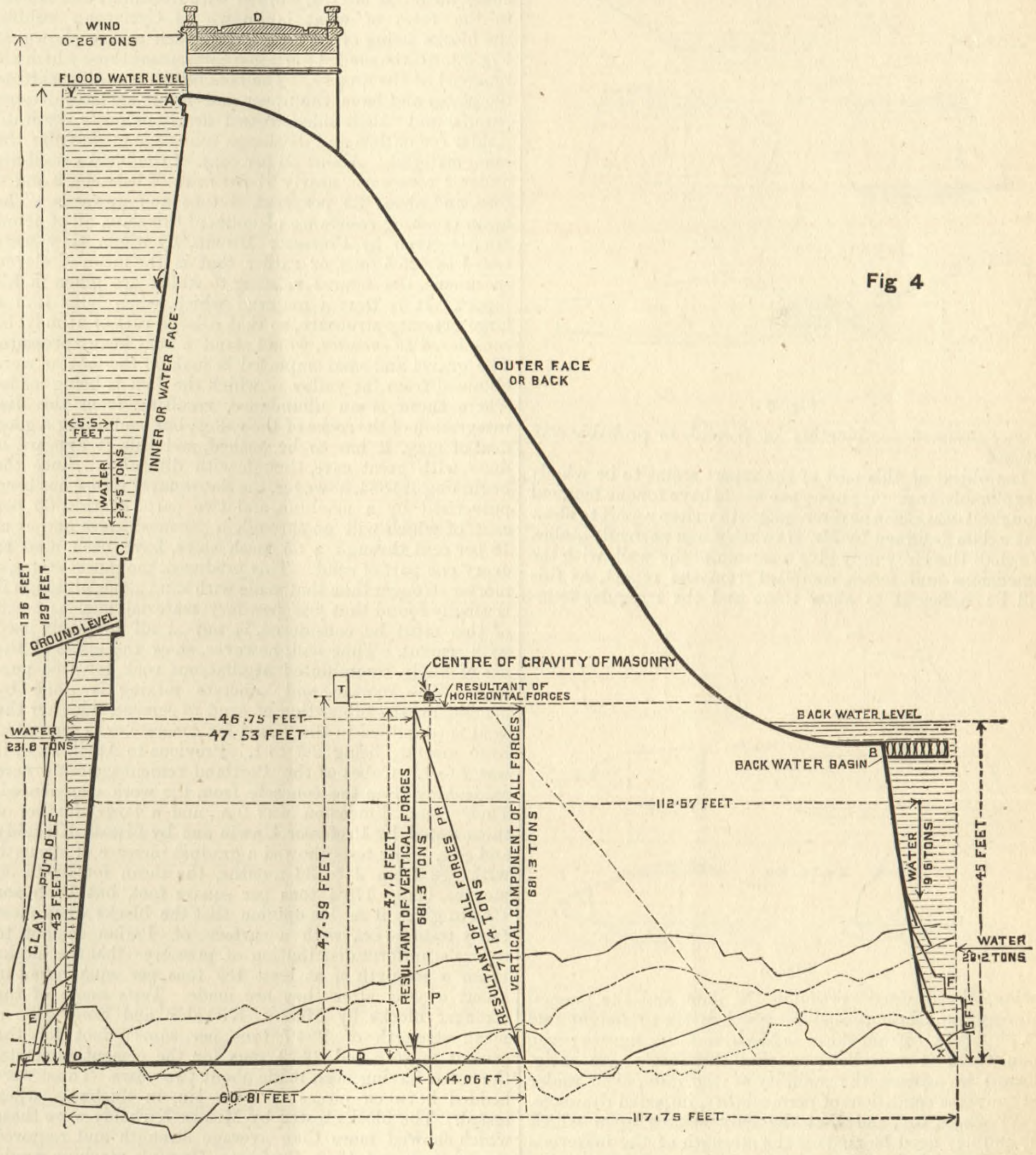


Fig 4

THE VYRNWY DAM.—SECTION SHOWING MAGNITUDE AND DIRECTION OF STRESSES AND CONTOUR OF FOUNDATION.

FIG 1

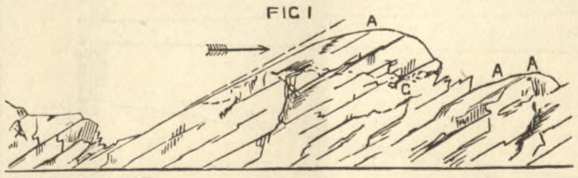


FIG.2

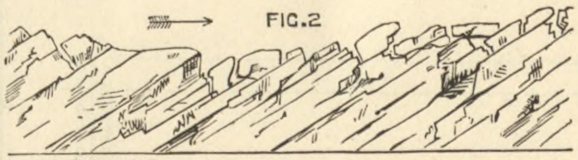
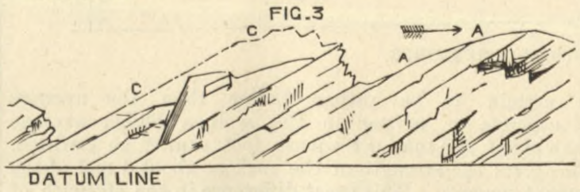


FIG.3



SECTIONS OF VALLEY IN LINE OF DAM.

An important paper, by Mr. Guilford Molesworth, entitled, "Notes on High Masonry Dams," with translations from the French of observations by M. Bouvier, was published in the Roorkee College professional papers on Indian engineering in 1883, contained a *résumé* of the researches of Delocre, Graeff and others, and showed that within certain limits the form of the section of a dam was a matter very much of taste. Calculations may be made on the assumption that a dam is of material flexible through a limited range; but such calculations are, except as ingenious checks, of little use, inasmuch as so great an excess of weight must be employed to prevent the initiation of any of the stresses which would occur on the assumption of even an almost unassignable amount of motion that the results of such calculations are wholly ignored in the final practical considerations.

French engineers have been called upon to design and construct some very large dams, including some of early date, which, to a great extent followed the earlier Spanish dams, which were large, successful, and enormously heavy. In later times came the Furens* and Settons† reservoir dams, the former closing a valley and forming the Rochetaillée reservoir upon the torrent of the Furens, which is an affluent of the upper Loire. This dam impounded water to a depth of nearly 165ft., but its length is only about 680ft. Dams of similar section were subsequently built; one upon the Ban, an affluent of the Gier, near St. Chamond, and another, the Ternay, near Annonay.

The Furens reservoir dam was one of the first built in accordance with the researches of M. Delocre, its section being original, and having hollow curved faces at both sides. It is built of rubble masonry laid in random courses, but every block set with and jointed with minute care. In design and construction it has an interesting bearing upon the Vyrnwy dam now being built for the water supply of Liverpool, and in the history of which a much to be regretted phase has occurred.

The Vyrnwy dam was designed by Mr. Thomas Hawksley, P.P.I.C.E., and the construction commenced under him, with Mr. G. F. Deacon, M.I.C.E., borough waterworks engineer, of Liverpool, as resident engineer. It seems, however, that some agreement was made between Mr. Deacon and some of the Council, which enabled him to disregard Mr. Hawksley's wishes as to the method of construction or the workmanship, and to act as though he were joint engineer. This at least seems to be the ground of Mr. Hawksley's complaints, and his refusal to be further connected with the work, inasmuch as, if Mr. Deacon's method of executing the work were not found permanently satisfactory, Mr. Hawksley would be held responsible. One result of Mr. Hawksley's retirement has been that Mr. Deacon has been called upon to make a report on the dam. This has been published, and while it deals with the stability of the section, and gives facts as to the nature of the materials employed, it does not seem to answer or refute Mr. Hawksley's allegations, but in some measure to support them. We have from time to time referred to this matter, and in our impression of the 15th January, to the most recent phase, and it is unnecessary to add anything further to the matter as a dispute, or to the accusations made on either side; but we propose to say

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* THE ENGINEER, vol. xxvi., 1868.

† THE ENGINEER, 6th January, 1872.

* THE ENGINEER, 11th October, 1867.

† THE ENGINEER, 13th August, 1875.

a little concerning the method of construction, the materials used, and the difference between these and those which Mr. Hawksley would, it is said, employ. Mr. Deacon's report we shall not reproduce, as, although an able report, the greater part of it is occupied in showing, by means familiar to everyone interested in hydraulic masonry, that the section designed by Mr. Hawksley is satisfactory in every respect, and has a very large factor of safety under any conditions, or any assumed combination of possible or probable conditions.

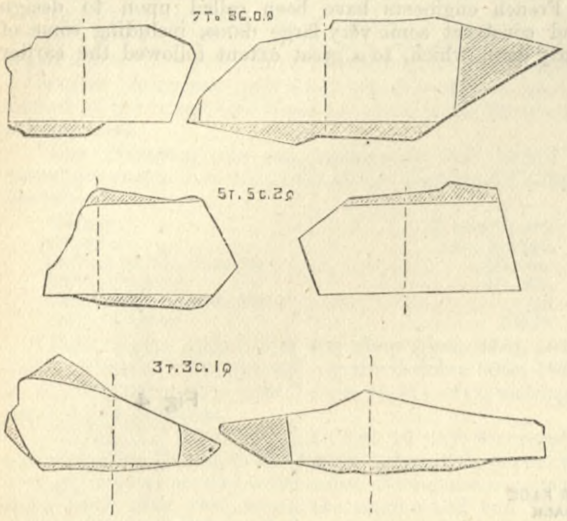


Fig. 6

The object of this part of the report seems to be wholly inexplicable, inasmuch as no one would have for one moment thought it other than supererogation to write a report to show that a dam designed by Mr. Hawksley was perfectly stable. We shall therefore only give a section of the wall, with the dimensions and forces, compiled from the report, as this will be sufficient to show these and the irregular foundation, the drained portion of the dam, and the general intercepting drain tunnel T, which is 4ft. in height and 2ft. 6in. wide. From these sections and the figures given upon them it will be seen that the forces are insignificant as against the stability of the dam, even under very adverse conditions of permeability, impeded drainage, heavy winds, &c., and that the only matter upon which any inquiry need be made is the strength of the materials used; their relative strength or resistances to compression or crushing; the method of building, including the forms of the blocks of rock used; and the relative quantities of the materials of different characteristics. Upon these we find a good deal of information in Mr. Deacon's report.

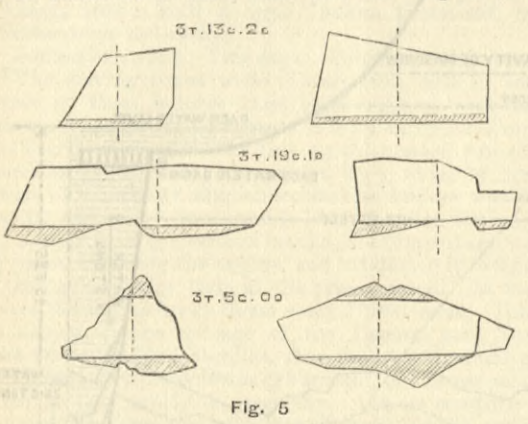


Fig. 5

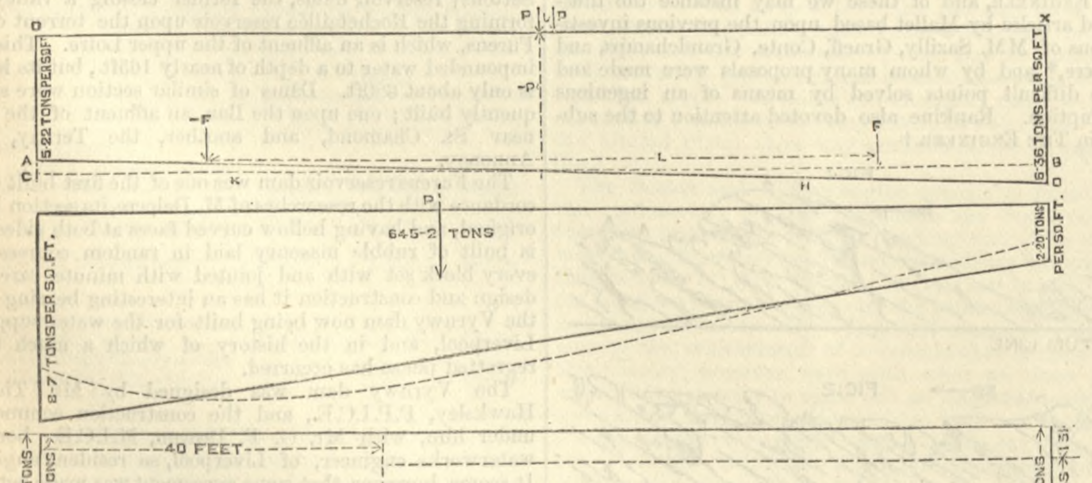


Fig. 7—DIAGRAMS OF VERTICAL PRESSURES.

The rock forming the valley and the foundation of the dam is clay slate of the Caradoc group of the lower Silurian system, to some extent traversed by beds of Bala volcanic ash. Figs. 1, 2, and 3 illustrate the dip of the strata, the direction of which is towards the future reservoir. The arrows indicate the direction of the striæ found upon the upper projecting outcrops A A, and either of glacial or drift origin. All dislocated blocks of the slate have been removed, and where the outcrop of one bed much exceeded in height that of the next it was cut, as shown in Figs. 1 and 3. Thus formed, the foundation varied in level across the 117·75ft. width of the dam foot to the extent shown in Fig. 4; and thus the bed may be said to be so joggled that no imaginable force would cause the dam to slide. The forces which will be visited upon it would not be anything like sufficient to move it even if it were on a floor comparatively smooth and not cemented, as will be gathered from Fig. 4, which shows the resultant of all the forces to have an unusually small angular departure from the vertical. The lines at the foot on either side E F, Fig. 5, show the form of the dam foot when the foundation is at the different levels shown.

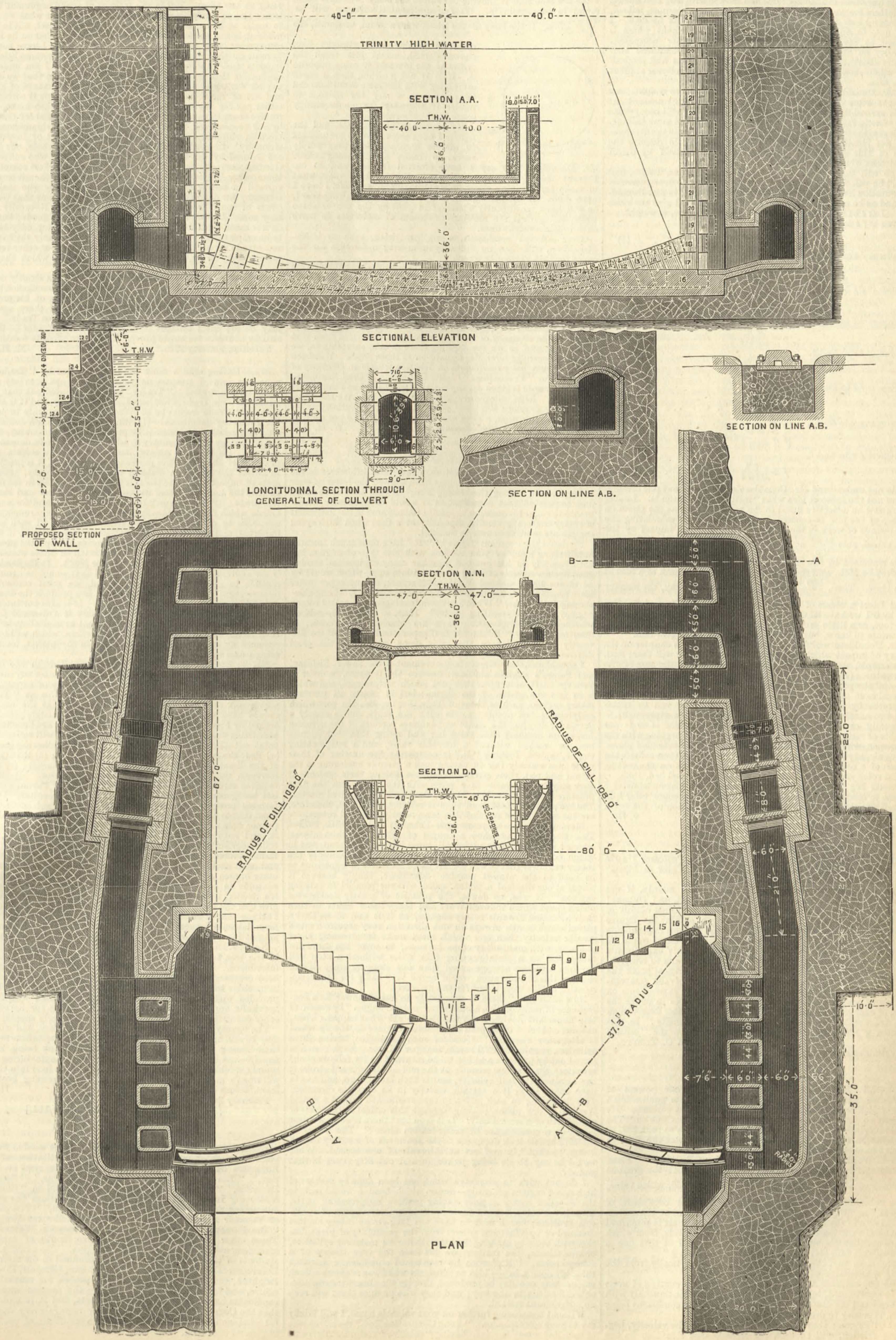
The slate of which the dam is being built is quarried about a mile from the dam and brought down by a railway with a gradient of 1 in 30 to the dam in blocks weighing from a few hundredweights to 7 and 8 tons. The specific gravity of the slate is 2·72, or about 2·06 tons per cubic yard. It is hard, worked with difficulty, and is used in the form of what is known as Cyclopean rubble, the blocks being of various forms, such as are shown at Fig. 5 and 6, the shaded portions representing those which are removed at the quarry. The face blocks are all worked to templates and have the upper and lower surfaces dressed parallel and "their sides dressed nearly or quite vertical." Ashlar for outlets and discharge tunnels is made from the same material. About 46 per cent. of the blocks used are under 2 tons each, nearly 21 per cent. of between 2 and 4 tons, and about 33 per cent. 4 tons and upwards. The mean crushing resistance of cubes of this slate, all of about 3in., is given by Professor Unwin, by whom they were tested as 823·5 tons, or rather that is the mean of eleven specimens, the figures relating to which are given in his report. It is thus a material which, when built into a large masonry structure, so that a large part of it may be considered as *encastre*, would stand a very heavy pressure. The gravel and sand employed in making the mortar were obtained from the valley in which the dam is being made, where there is an abundance, resulting from the disintegration of the rocks of the valley, but containing a good deal of clay, it has to be washed, and this, it appears, is done with great care, though with difficulty. Since the beginning of 1884, however, the slate quarry refuse has been pulverised by a machine, and two parts of this, 60 per cent. of which will go through a 20 mesh sieve and even 18 per cent through a 65 mesh sieve, have been used to every one part of sand. This produced, the report states, a mortar stronger than that made with sand alone, although it is usually found that fine powdery material, such as much of this must be considered, is not at all advisably used with cement. Time will, however, show the effect of the use of finely comminuted argillaceous rock for this purpose. The mortar and concrete mixing is done by machinery, the proportion of sand to cement, whether the sand is contained in the gravel for concrete or is separated from mortar, being 2·5 to 1. Previous to April, 1884, it was 2 to 1. Cubes of the Portland cement concrete were made daily from the concrete from the work commenced. Their mean dimension was 9in., and a large number of them tested by Professor Unwin and by Messrs Kirkaldy and Son. The tests showed a gradual increase of strength with age from 2 to 36 months, the mean for 32 to 36 months, being 170·4 tons per square foot, but Professor Unwin gives it as his opinion that the blocks when most fairly tested—*i.e.*, with a surface of Parian cement to secure a uniform distribution of pressure—that the blocks reach a strength of at least 187 tons per square foot in about a year after they are made. Tests made of the stronger blocks by Messrs. Kirkaldy and Sons gave a mean strength of 284·7 tons per square foot for the cement mortar and 224·9 tons for the cement concrete, the cubes having been made about two years. These were bedded between pieces of pine ½in. in thickness when tested. The blocks tested by Messrs. Kirkaldy were those which showed more than average strength and required greater pressure than Professor Unwin's machine would give, but although of abnormal strength, these blocks must be considered as fairly warranting an addition to Professor Unwin's average, but an examination of all the results, and bearing in mind that a test cube is certain to be rather better than the average of concrete or mortar in the wall, a higher average than about 200 tons per square foot cannot be credited. This gives the strength of the rock as about 4 to 1 of the cement concrete. This great difference in the strength of the rock and of the cementing materials need have no modifying effect on the strength of the masonry as a whole, unless the method of construction imports conditions under which the feebler strength of the concrete may initiate destructive strains in the large pieces of rock employed by giving it a support which is not uniform. Whether this is likely to be so may be gathered from Mr. Deacon's description of the way in which the work is done. Figs. 5 and 6 give a fair idea of the shapes of the blocks employed, and the figures already given show that a large proportion of the blocks are of a large and heavy size, while a considerable proportion of small blocks are also used. The method of building is thus described. "Assuming for the moment that there is a level bed, either of rock or of previously constructed masonry, a layer of cement mortar about 2in. thick, and rather larger in area than the base of the stone to be laid, is placed upon that bed. The mortar is then brushed to a proper figure, and beaten to get rid of air. The stone, with its flat but rough bed, is next lowered by a steam crane, and is beaten down by simultaneous blows from heavy hand malls. The mortar is of such consistency that during this process it fills every hollow; much of it being squeezed out around the stone and employed for another bed. Other stones are then similarly set with their nearest points close to but not touching the first. The spaces between the stones are next filled in with concrete thoroughly beaten down, and thrust with blunt-ended swords into the narrower spaces. Concerning this Mr. Deacon remarks in a footnote that too much importance cannot be attached to the proper performance of this portion of the work. It is well known that when the materials of concrete are mixed and tipped in large quantities the larger stones tend to leave the smaller, and the water tends to carry down the cement to lower parts. On this account the broken macadam-sized stones are not mixed in the concrete machines; but are brought upon the ground separately. A loose layer of concrete 2in. to 3in. thick is first thrown down; the broken stone is scattered over it, and the latter is thoroughly beaten into the former until the cement squeezes up to the surface. Another similar layer is then formed, and so on until the required height is reached. No laminated structure is thus produced, as would be the case if each layer were allowed to set before the next was formed. Under the beating, while all is soft, the stones of one layer interlock with those of another, and the result is much more perfect homogeneity than can readily be attained by any other treatment of concrete with the same proportion of stone. When the interstices are sufficiently large they are built up with smaller stones instead of with concrete only. An idea of the distribution of stone and concrete may be gathered from the fact that an endeavour to find a space between the stones containing a block of concrete 12in. cube has proved futile. There are, of course, both vertical and horizontal layers of concrete of much larger area than this; but their thickness is small. The joints having thus been filled to the level of the first stones laid upon the old work, the remaining inequalities are made up with beaten concrete, upon which other stones, bonding with those below, are set as before in cement mortar. The work within reach of each crane is thus carried on to a height of 6ft. or 8ft. before the crane gauntree is moved. The joints between the highest stones of each such course are not finished to the level of the stones for three reasons; one being that a more water-tight bond is thus obtained between the new and the old concrete when, some months later, the work is further raised, than when the old concrete is continuous over a large surface; another being that less damage is done to the surface when the men cannot conveniently walk on the concrete, and are almost obliged to step from stone to stone; and a third being that when lying below the level of the stones the concrete is less liable to damage from frost in winter, and is more likely to remain damp in summer. It occasionally happens that stones with small, or somewhat pointed areas, project above those immediately surrounding them. In such cases when, some months after the work has been left to set, the place is again reached, the concrete is not brought up to the higher level, but the projection is dressed down to the height of the surrounding work. The front and back faces of the wall differ from the hearting hitherto described in that the largest and squarest stones are selected for them. All such face stones are draughted to the exact batter required, and have their tops dressed as well as their bottom beds, and their sides squared as may be necessary, to make close vertical joints. In the inner face the ordinary concrete is not used, even where the joints widen out; mortar alone, with broken stone beaten into it, being employed for the first few feet. The object of this is to secure, not additional strength, but the highest attainable water-tightness of the inner face. When treating of the forces acting upon the dam it will be seen that if any part should be more water-tight than another it is the inner face. For this reason the portion of the inner face below ground is lined with puddled clay, while the joints of the upper part are made additionally water-tight."

Whether this mode of building is a satisfactory one remains to be seen, but it is obviously open to the objection that large masses of rock may be brought to bear upon a bed of very different bearing capacity, and that some of the stones are of such a form as to tend to initiate movements of the superincumbent and surrounding materials. Random rubble may, as in the case of the Furens reservoir dam, be perfectly successful when no pieces are large, interstices small, and settlement consequently uniform. But with Cyclopean random rubble the case may be very different. If a large or long block rest either at its centre or at one end upon the small area of the upper part of a stone of such a form as that shown at Fig. 5 and marked 3, tons 5, and depend for the rest of its support upon the concrete or mortar, which from the system of building may be in considerable masses, the result will possibly be fracture of the stone so supported; for although the pressure may be very small as compared with the crushing resistance of the concrete, the difference in the rigidity of the support of the materials may possibly be sufficient to cause unequal distribution of load. Unequal settlement may, it has been urged, also result from the system of building, and this may be supposed to be the more probable from the result of the use of stones which have their upper or side surfaces at angles considerably divergent from the horizontal or the vertical respectively. The tendency of the load upon the material resting upon surfaces such as these is to cause it to slide down them, and to produce cracks in it. This may be the more readily imagined by reference to the form of block shown at

SECTIONS OF LOCK, ROYAL ALBERT DOCK EXTENSIONS.

MR. ROBERT CARR, M.I.C.E., ENGINEER.

(*For description see page* 109.)



LETTERS TO THE EDITOR.

[*We do not hold ourselves responsible for the opinions of our Correspondents.*]

MOMENTUM AND INERTIA.

SIR,—I do not think that anything would be gained by continuing to discuss questions concerning force and motion with Mr. Donaldson. His letters are an inscrutable problem to me. I cannot, indeed, understand how a Cambridge Wrangler can write as he does. I have not, to my knowledge, made a single statement which is opposed to the teachings of Newton or any other competent authority on the subjects dealt with; but Mr. Donaldson continually attributes to me the origin of old statements and propositions which should be and are familiar to every second-year student of physics.

If Mr. Donaldson will procure from his kitchen two weights, one 1 lb., the other 2 lb., and will drop them at the same instant out of his second-floor window, he will find that they will occupy the same time in falling, and will strike the ground at the same instant. In this case the force has varied directly as the mass, and the accelerations are identical. I understand Mr. Donaldson to dispute the truth of this statement. He can settle for himself by direct experiment whether it is true or not.

If he will turn to pages 283-4 of Clark's "Rules, Tables, and Data," he will find eight rules which answer almost every conceivable question he can ask. As this is my final reply to Mr. Donaldson, and as he may not have the book in question, I give the rules here. Let t be time, v final velocity, s space, f force, w weight.

Given $w\,f\,t$ to find v,

$$v = \frac{32{\cdot}2\,f\,t}{w} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{1}$$

Given $w\,f\,t$ to find s,

$$s = \frac{16{\cdot}1\,f\,t^2}{w} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{2}$$

Given $w\,v\,f$ to find t,

$$t = \frac{w\,v}{32{\cdot}2\,f} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{3}$$

Given $w\,v\,f$ to find s,

$$s = \frac{w\,v^2}{64{\cdot}4\,f} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{4}$$

Given $w\,f\,s$ to find t,

$$t = \tfrac{1}{4}\,\frac{\sqrt{w\,s}}{f} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{5}$$

Given $w\,f\,s$ to find v,

$$v = 8\,\frac{\sqrt{f\,s}}{w} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{6}$$

Given $w\,s\,v$ to find f,

$$f = \frac{w\,v^2}{64{\cdot}4\,s} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{7}$$

Given $w\,t\,v$ to find f,

$$f = \frac{w\,v}{32{\cdot}2\,t} \quad . \; . \; . \; . \; . \; . \; . \; . \tag{8}$$

I do not understand Mr. Donaldson's question about pile driving. I have not the faintest idea what "initial" momentum is. I never before saw an adjective fitted to the word. So far as the stress on the top of the pile is concerned, that is found by calculating the foot-pounds of work in the monkey at the time of impact by the well-known rule $\frac{m\,v^2}{2\,g} = F$, and dividing the amount by the distance traversed by the pile. Thus let the monkey weigh 200 lb., the drop be 16ft., and the descent of the pile one-tenth of a foot at each blow. Then, $\frac{200 \times 1024}{64} = 3200$, that is to say, the monkey could exert a stress of 3200 lb. over a space of 1ft., and dividing this by 0·1 we have 32,000 lb. as the stress acting over one-tenth of a foot, or a little over 1in. I fear this is not what Mr. Donaldson wants to know, but it is the only answer I can give him.

Mr. Donaldson will find in Wiesbach, page 667, a chapter on the theory of impact which may serve his purpose. He will there find, for example, that at every instant of the impact, the sum of the momentums ($M_1\,v_1 + M_2\,v_2$) of the two bodies—that is to say, the ram and the pile—is the same as before the impact took place.

In almost any text-book he will find illustrations of little apparatus by which all the motion in one body can be transferred to another. It is a very simple lecture-room experiment.

I really cannot argue the point whether matter is or is not capable of resisting motion; I should not think of arguing with the gentlemen who maintain that the earth is a flat extended plane. I have already stated that the stress set up when a force solicits the motion of a body is a time factor. For my views on the matter I must refer your correspondent to my letter of April 3rd, 1885.

I must beg Mr. Donaldson not to hold me discourteous if I decline to continue this correspondence, and once more refer him to such a text-book as Dr. Lodge's for an exposition of the truth that is in me. Φ. Π.

London, February 1st.

THE FLOW OF WATER IN PIPES.

SIR,—I should like to put a few questions to Professor Unwin with reference to his article on "The Flow of Water in Pipes," which appeared in your issue of January 1st.

(1) Did not Hagen derive the formula quoted mainly, if not entirely, from the experiments of Bossut, Couplet, and Dubuat? If not, can Professor Unwin refer me to any published details of Hagen's experiments? (2) Did not Hagen obtain the figures representing the effect of temperature from his own experiments on very small pipes, and simply assume that the effect would be the same in all cases? (3) Do not Professor Reynolds' experiments on small lead pipes show the same marked change due to temperature at low velocities, and that above a certain critical point the discharge is "almost if not quite independent of the temperature?" (4) Can Professor Unwin refer me to any experiments on the flow of water, or any other fluid, through pipes in which the effect of change of temperature appears in any greater degree than that attributable to the necessary change of density? In this question I refer, of course, to the region above the "critical point." EDGAR C. THRUPP.

Westminster, January 21st.

REACTION WHEELS.

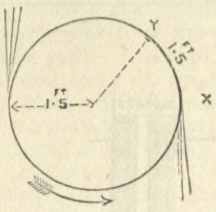
SIR,—Mr. Donaldson has greater faith in your powers of indulgence than I have, when he asks me to send for publication a copy of Rankine's investigations of the efficiency of turbines. He has only to go to his own library and take down Rankine on "The Steam Engine and other Prime Movers," and turn to page 189, to find what he wants. Fig. 70, on page 190, illustrates the drum to which I have referred.

As to Weisbach, I quote the following from Rankine:—"From experiments by Professor Weisbach it appears that the greatest efficiency of a good reaction wheel is $\frac{M_1\,a_1}{D\,Q\,h_1} = {\cdot}666$, which value, being substituted for Equation 3, gives for the coefficient of friction $f = {\cdot}136$, and for the ratio of the best speed of the orifices to that due to the available fall $z_1 = {\cdot}97$. This result is confirmed by general experience of the working of these wheels, from which it appears that the best speed is very nearly equal to that due to the available fall, and the greatest efficiency about $\frac{2}{3}$."

That is to say, the water should fall down vertically from the nozzle of discharge without any angular velocity.

I do not see that any general formula for the curving of arms can be constructed, because the curve must vary continuously with the head and the diameter of the wheel; but the conditions being given, it is easy to draw the curve.

Let us suppose that the head is 64ft. Then the velocity, neglecting friction, will be 64ft. per second. Let this also be the angular velocity of the orifices of discharge, and let the wheel be 10ft. in circumference. Then the orifices will pass over 6·4ft. in a second. The radius of the wheel will be 1·6ft., neglecting fractions. A molecule of water moving from the centre to the orifice will occupy $\frac{62}{1{\cdot}5} = {\cdot}4$ sec. going from the centre to the orifice. When the molecule started at the centre, the orifice was at some point x; while the molecule is moving outwards, the orifice will have come round to some point y. This circumferential distance will be $\frac{6{\cdot}2}{{\cdot}4} = 1{\cdot}5$ft. If the body of the wheel were a drum, as shown, the molecule moving in a straight line, shown dotted, would just reach the orifice at the moment it came opposite it. If it is not a drum, then a curve complying with the same conditions can be plotted in a way too obvious to render it necessary for me to occupy space by showing how.



My sketch is not to scale, and the figures I have given have no pretensions to minute accuracy, but they amply serve to make my meaning clear. Mr. Donaldson may say I have omitted friction, and so on. I grant this, but it is quite beside the mark; I only want to make my meaning clear to Mr. Donaldson, and this I hope I have done. If he will state any case and take a drawing-board, he will have no difficulty whatever in plotting the proper curve which will permit the molecule or stream of molecules to move outwards in straight lines.

Given all the conditions, a mathematician, such as is Mr. Donaldson, will have no difficulty in making a formula for the curve for that particular wheel.

Your correspondent, J. W. Norman, is wrong about the driving action of the stream on a curved arm; at least, the curve which will give a driving action is not that best suited for a reaction wheel.

Aberdare, January 25th. PYNX GRYPH.

SIR,—Rankine, on pages 197 and 199 of his "Steam Engine," examines the efficiency of reaction wheels as a deduction from that of turbines, and as we see nothing there to take exception to, we would respectfully refer Mr. Donaldson to those pages. Weisbach deduced from his experiments on reaction wheels an efficiency of ·66. In the "Proceedings" of the Institution of Civil Engineers, vol. lvii., a note is given on the reaction wheels at the Domnarfort Ironworks. Nine wheels are there employed to drive the mills. The largest develope 400-horse power each, and are entirely under water when at work. They are estimated to give 55 per cent. of the theoretical maximum efficiency. W. H. T.

Melksham, February 1st.

ROTARY ENGINES.

SIR,—It appears not a little strange that those interested in the manufacture of this class of engine have allowed the letter of your correspondent, "Long Connecting Rod," in your issue of the 15th inst. to pass without comment, as it would be extremely unfortunate to suffer his question to remain unanswered to the detriment of rotary engines generally, especially at a time when high speed engines are more than ever in demand.

No doubt the excellent papers of "R." have done much towards familiarising many of your readers with this type of engine, but unfortunately he has grouped together many engines and mechanical devices capable of being converted into such, which would by no means have satisfied Watt, or Murdock, or any other toiler after continuous rotary motion. Your correspondent, "Long Connecting Rod," asks, "What are the advantages of so-called rotary engines with reciprocating parts?" That, of course, depends on whether such reciprocating parts are absolute, or relative, as discriminated by "R." in his first paper; and it should be distinctly understood here that this alone constitutes the great difference between rotary and *so-called* rotary engines.

I should call the reciprocating movement of the Tower, Fielding, and Parson's engines absolute, because the pressure, in order to turn the shaft, acts upon that part which reciprocates, and which is in fact the piston of the engine; but in nearly all previous rotary engines, such as those of Yule, Napier, &c., the part which reciprocates has nothing to do with the shaft, and is simply a device for dividing the steam and exhaust portions of the cylinder just as an ordinary slide valve is; and seeing that such engines may be worked without a movable valve, and a reciprocating engine, cannot, I think "R." in comparing the number of their parts was scarcely fair in saying such a piece is analogous to the piston and rod, these particular engines having their pistons—if they may be so termed—in a piece with the shaft, and the fluid pressure acting upon them in the direction of the desired motion. The reciprocating part here then is relative, and these, therefore, are the only type of engines that can properly be called rotary.

More than a dozen years ago—February 2nd and 16th, 1872—THE ENGINEER published a couple of articles on this subject, which I would strongly advise all those interested to read, and in which occurs the following:—"The great point in favour of the rotary engine is that it will permit large measures of expansion to be used to the utmost possible advantage, simply because it places at our disposal a piston speed without parallel in existing engines." It was, no doubt, the promise of greatly accelerated piston speed which induced Watt and many lesser lights to turn their attention towards rotary engines, as it is easy to see that a piston which moves always in one direction may acquire a much greater velocity than one which must make innumerable short journeys, with momentary stops between, to cover the same distance, just as a train running fifty miles without a stop will develope a greater average speed than one stopping every mile or so; and this consideration would argue very badly for the reciprocating engine were it not for the fly-wheel.

Now although "there is practically no loss of power as a consequence of reciprocation alone in the normal engine" by reason of this important device, I am tempted to ask what happens when, as some makers of high-speed single-acting engines do, the fly-wheel is altogether discarded? Consider such an engine, having three cylinders, running at 1000 revolutions per minute. Each piston is forced out by pressure and has to be returned by its fellows about seventeen times in one second; at the end of its outward stroke it has attained its full velocity, and is then brought up, and has to have imparted to it a certain velocity in an opposite direction. This happening to each piston in the seventeenth part of a second is equal to one piston passing through this ordeal at intervals of one-fiftieth of a second only. Is it true that there is no power lost here "as a consequence of reciprocation alone?" The writer of the 1872 article took exception to the abutment of a rotary engine being "jerked" in and out at intervals of one second. What would he say to its being jerked in and out fifty times in that period?

I do not wish to disparage what has been done by makers of high-speed engines generally—under which head I would include the so-called rotary engines having positive reciprocating parts, these latter being, beyond doubt, very ingenious evasions of a difficult problem; but I wish to save the long-stroke rotary engines dreamed of by Watt and others from the possibility of identification with these by showing that the shorter we make our cylinders, or equivalents, the further we get from the true theory of a rotary engine. "R.," when he mentioned a pneumatic despatch tube, hit upon a happy idea to illustrate what was wanted. Such engines may one day be produced, despite the almost insurmountable difficulties in the way; and they who produce them will reap no insignificant reward.

Without trespassing further on your valuable space, I will briefly say to your correspondent, "Long Connecting Rod," the advantage of so-called rotary engines, having "relative" reciprocating parts only, is that the stroke may be miles or it may be inches, according to the length of the run. The advantages of such having "absolute" reciprocating parts, except as to space, are *nil*.

January 30th. LONG STROKE.

FREE TRADE AND NO TRADE.

SIR,—I do not wish, at least at this stage, to enter into controversy with "Trader," and I am not likely to have time for controversy at any stage. But in the interest of sound argument I wish to ask him to verify his statement that "we import what we ought to make at home, and we pay for what we import, not in goods made at home, but in money." A line or two further on he speaks of payment being made in "English gold." Now I have not time to hunt up the blue-books in which, as of other commodities, the imports and exports of gold are recorded, but I am under the impression that no fact is better established than that we do not pay for our imports in "English gold," the movements of gold in and out of the country being insignificant. If this is correct, we either pay for the German goods in goods of English make, or we receive them in payment for other services performed for Germany by our people, such as freight earned by English shipowners from German shippers, or as interest on money lent or invested in Germany. In neither case can I see that, as a whole, our people are injured by the German importation. Those who suffer from German competition in the home market should first complain of those other Englishmen, more enterprising than themselves, who succeed in selling goods in Germany. It is they who make the Germans our debtors, and it is to satisfy their claims that German goods of some sort have to be sent over here. Naturally when they come they fall foul of some English maker's goods; but they do not cause less labour to be employed here—they only cause it to be employed in a different manner, and presumably shift it from some trade which Englishmen, from geographical or other reasons, cannot carry on so well as Germans, to a trade which they can carry on better.

"Trader"—who has twice explained that he is strictly neutral—propounds an imposing syllogism, of which the conclusion is that "Protection is better than Free Trade." But one of his premises is the statement that "under a Protective tariff there are more men employed than would be employed under Free Trade." This may be so; but I thought it was just what "Trader"—though strictly neutral—set out to prove. So far the proof is wanting.

Surbiton, January 27th. M. H. R.

SIR,—Having read a most interesting letter by "Trader" in your last print, I trespass on your valuable space to say a few words on the subject. "Trader" has ably pointed out that indiscriminate Free Trade is not beneficial to a country, and it is evident that Fair Trade cannot be so either. I would venture to propose the following definitions:—(1) When a country has a demand for a certain article which cannot be produced in that country, it is to the advantage of that country to admit that article in demand free of duty. (2) When a country has a demand for a certain article in excess of the productive power of that country, it is inadvisable to admit the article in demand entirely free of duty, unless the costs of importation raise the sale price of the article in the market so that the home producer can sell in that market and realise a fair profit. (3) When a certain country has a demand for a certain article which it can produce in excess of its own requirements, it is advisable to protect this manufacture and tax all such articles imported, and to endeavour to establish an export trade, if such is not already established, by offering bounties on exported produce.

I will now endeavour to show the truth of these statements. We may take England as an example for No. 1. In England there is an enormous demand for sugar, and as it would be utterly impossible to grow sugar-cane in England, we must consequently import sugar from that country which can produce the best, and sell it in our markets at the lowest price. It is also our interest to import it free of duty. For where there is a demand for any special article, there will be an inducement to capitalists to invest their money in the production of that article, which will in itself promote amongst capitalists competition in the market, tending to bring prices to their lowest.

No. 2: England again serves our purpose. Though the quality of corn produced in this country is superior to almost any produced elsewhere, yet the country is utterly incapable of supplying its population with this prime support of life. Now as "Trader" points out that the Free-Trade axiom is "that the consumer should have what he consumes at the lowest possible price," it is argued by Free Traders that the working classes are benefitted by permitting bread to be imported free of duty. I will endeavour to point out that this is incorrect on the three following grounds: (*a*) That the capital of the country is diminished; (*b*) that it is one of the direct causes of the overstocked labour market; (*c*) that it increases the poverty among the labouring classes. (*a*) Farming requires capital, like every other manufacture. Farming capitalists are generally farmers who work their own capital. Destroy farming prospects, and the capitalist is either ruined or else he must devote his capital to some other manufacture. Generally the farmer does not know sufficient of any other branch to launch into it, and naturally has to emigrate to that country where he can follow agricultural pursuits, and with him goes his capital. (*b*) The farm labourer out of employment, and without capital, has to live, and must endeavour to obtain employment elsewhere, and in some other branch of manufacture. (*c*) Those farm labourers who still continue to obtain employment on farms cannot get high wages; his master, not being able to work his farm profitably, is forced to give him the lowest wages that he can induce him to work for, and I believe that in no other branch of manufacture are wages lower—farm labourers' wages in one agricultural district of England running at 12s. per week, out of which he has to pay 2s. house rent.

No. 3: Little need be said on this subject. Our prominent position in the iron trade could not be questioned before Free Trade was introduced. Since, however, America, Germany, and France have been creeping up, inch by inch, until we see America ahead of us in machine tools, Germany supplying us with cutlery, and France provided with shipbuilding yards fitted, it is true, with English hydraulic appliances, but able to produce ships for herself and other countries which England would have formerly supplied.

The bounty system has been adopted by Germany, and whatever may be said against it, it has certainly induced capitalists to invest their money from abroad—an enormous amount being English money—and has been the cause of that large manufacturing centre round Creféld and Eberfield, which certainly puts food into German workmen's mouths, to say nothing of the increasing beet-sugar manufacture in both France and Germany. HOPE.

February 2nd.

[*For continuation of Letters see page* 114.]

ENGINEERING STUDENTS.—During the current session five supplementary meetings of students of the Institution of Civil Engineers have taken place, when papers were read on "Friction," "The Foundations of the Forth Bridge," "Secondary Batteries," "The Flow of Water in Pipes," and on "Electrical-Measuring Instruments." For four other meetings the subjects announced are:—"Gold Mining in the Wynaad," "The Stability of Voussoir Arches," "Coining Gold at Melbourne Mint," and "The Hirnant Tunnel of the New Liverpool Waterworks." Three other meetings will be held in the month of April, the arrangements for which are still in progress. The activity of the students of the Civil Engineers is not confined to the metropolis. Local centres have been formed at Manchester, Glasgow, Liverpool, Brighton, and Hull for the reading of papers, for mutual intercourse, and for visits to works. During the present session 147 candidates have been admitted as students, and it is understood that the Council of the Institution now require every candidate for admission into that class to produce a certificate of proficiency in general education.

the vestry to revert to a scheme proposed twelve years ago by Mr. Abernethy, C.E., the total cost of which (including purchase of site) would be about £27,500, or (its supporters urge) "about half" the cost of Mr. Mellis' scheme. Although unsuccessful with the vestry, the dissatisfied members of that body will have another opportunity of urging their views at the Local Government Board inquiry, which will have to be held before the matter progresses any further.

LITERATURE.

A Catechism of the Steam Engine in its Various Applications in the Arts; to which is added a Chapter on Gas Engines and another of Useful Rules, Tables, and Memoranda. By JOHN BOURNE, C.E. New Edition. London: Longmans, Green, and Co. 1885. 610 pp.

MESSRS. LONGMANS, GREEN, AND Co. have done well to publish a new edition of this catechism, for it is a book which is very useful to a large number of readers and learners. The earlier edition had many friends; and seldom as the catechism form is met with in modern books, it is one which has the advantage of causing the author to place before himself a number of definite questions, and thereby to give the book greater clearness, order, and system in treatment of its subjects. It has also the advantage of rivetting the attention of the reader. We may assume that Mr. Bourne's catechism of the steam engine is sufficiently well known as a book useful to students to make it unnecessary for us to do more than record the appearance of this edition, which is in many respects a great improvement on that which preceded it. It is rather larger, has new engravings, bringing the book down to the recent times of Webb's compound locomotive, new compound pumping engines, and marine engines and boilers of the large and torpedo types. In style, the book, to some extent, remains a book of a bye-gone generation, but the author has done well what few writers like to do, namely, strike out a lot of their older writing for the insertion of the new. This, however, must be done in engineering works, or they became useless. We can recommend the book to-day, in its new form, as the old form recommended itself years ago, to another generation of readers and learners; but having said so much, we must remark upon a few points we have noted in perusing it. On page 16 is—"Q. Then if mechanical power cannot be lost, and is being daily called into existence, must not there be a daily increase in the power existing in the world? A. That appears probable unless it flows back in the shape of heat or electricity to the celestial spaces." This is very unsatisfactory, although supplemented by the explanation that the source of all mechanical power is the sun, and that the combustion of coal under a steam boiler merely liberates the power which the sun gave out thousands of years before. The ideas concerning force, motion, and power are not made to appear clear in the author's mind by the expressions used, though perhaps they may be; witness "A. No; force is eternal, if by force you mean power, or in other words, pressure acting through space." A curious expression occurs in an answer to a question concerning the greater velocity of a falling body during a succeeding than during the first second. "A. Because there is more of the force of gravity used up in a second when the falling body is moving fast than when it is moving slowly, seeing that the fast body will travel through a larger space in a given time." The matter is, however, made clear by figures afterwards. At page 56 we are informed that "combustion is nothing more than an energetic chemical combination, or in other words, it is the mutual neutralisation of opposing electricities." Concerning Regnault's experiments, showing, for instance, that the latent and sensible heat of steam are not the same at different pressures; it is remarked that these experiments were elaborate and more accurate than heretofore; but "nevertheless it is questionable how far it is advisable to disturb the rules of Watt and Southern, with which the practice of engineers is very much identified, for the sake of emendations which are not of such magnitude as to influence materially the practical result." Fortunately for the credit of the book, the following paragraph is devoted to showing that thirty-three units more are employed in generating steam at 90 lb. than at 15 lb. Anent a paragraph on page 71, it may be remarked that a slide valve is not a sluice valve, though a sluice valve may be a slide valve. The indicator is very insufficiently treated, and the only illustration is of an old form of Richard's indicator.

Chimneys are not properly dealt with. "Q. By what process do you ascertain the dimensions of the chimney of a land boiler? A. By reference to the volume of air it is necessary in a given time to supply to the burning fuel," &c. Reading this and the whole paragraph, we thought we were at last to have the dimensions put before a student in a proper manner, but the author drops this line, and fades away, repeating Boulton and Watt's practice. "A. A punched rivet-hole cannot be of less diameter than the thickness of the plate, else the punch will not pierce the iron, but will be crumpled up." For the information of Mr. Bourne, it may be remarked that this is a departure from the truth on the safe side. In speaking of pumping engines and how to start them, very old practice is dealt with. Locomotives are still open, we learn, to improvement. "Expansion should be carried to a greater extent, and in the case of engines with outside cylinders, and, indeed, in all locomotives, a little air should be forced into the boiler to mix with the steam." For all this, Mr. Bourne thinks "the benefits of the compound system, even in land and marine engines, have been greatly overrated, as the economy derivable from the use of high-pressure steam worked expansively has been erroneously imputed to some inscrutable virtue of the compound system, whereas there is no reason to doubt that the same steam used with the same measure of expansion in simple engines would have been equally economical and effective." What does Mr. Bourne think of the fact that shipowners have found it necessary to adopt the triple compound engines, or cease running some of their boats? Portable engines are illustrated by an engraving of one in which, with cranks and cylinders in the centre cylinders and brackets have to be too high, and the brackets having nevertheless small bases, they pull the boiler-plates about, and so the makers' used stay-rods between brackets and cylinders. The same firm of makers, Messrs. Ransome, Sims, and Jeffries, makes a very different engine now; and the portable engines made by Messrs. Clayton and Shuttleworth about twenty years ago, we may remind the author, were not precisely of the pattern made to-day. Steam ploughing is not satisfactorily illustrated by an engraving—Savory's system. Mr. Bourne is still fond of the gaseous jet or stream method of propulsion, and thinks it will come into use; and "although general incredulity will attend such a declaration, it is the incredulity of ignorance which has invariably attended all improvements not yet accomplished." The chapter on gas engines is new and useful. The author assumes the prophetic concerning steam engines, and their being superseded by simpler thermo-dynamic engines, but does not "discern in any of the projects which have been hitherto propounded the combination of the necessary qualities to effect this great amelioration." What the author specially means by a "thermo-dynamic engine," or by one which is more thermo-dynamic than present engines, he does not venture to say. It must not be a combined gas, air, and steam engine of the Siemens type, with hot cylinder and regenerator, "the line of advance must be in a different direction, and the innovation, when it comes, will astonish by its obviousness and simplicity." Oh, do tell us, Mr. Bourne; but if you will not, and if some fellow, after a time, comes along with it and startles the world, do not step forward and say, "I told you so."

BOOKS RECEIVED.

Guide pour L'Essai des Machines à Vapeur et de la Production Economique de la Vapeur. Par J. Buchetti. Paris: Chez L'Auteur, Rue Guy Patu, 11, and Bernard Tignol. 1885.

Vortraege ueber Brueckenbau gehalten an den Technischen Hochschulen in Prag, Wien, und Berlin. Von Dr. E. Winkler. Vienna: Carl Gerold's Sohn. 1886.

England's Supremacy: its Sources, Economies, and Dangers. By J. S. Jeans. London: Longmans, Green, and Co. 1885.

A Guide to Sanitary House Inspection. By W. P. Gerhard. New York: J. Wiley and Sons. London: Trübner and Co. 1885.

Theory of Stresses in Girders and Similar Structures, with Practical Observations on the Strength and other Properties of Materials. By Bindon B. Stoney, LL.D., F.R.S. New edition. Revised. London: Longmans, Green, and Co. 1886.

Almanack fuer die k.k. Kreigs Marine, 1886. Pola: Gerold and Co.

Rudimentary Treatise on Coal and Coal Mining. By Warrington W. Smyth, M.A., F.R.S. London: Crosby Lockwood and Co. 1886.

Select Methods in Chemical Analysis—chiefly Organic. By William Crookes, F.R.S., V.P.C.S. Second edition, re-written. London: Longmans, Green and Co. 1886.

The Electrician's Directory and Handbook for 1886. London: The *Electrician* office.

The Strength and Proportions of Rivetted Joints. By Bindon B. Stoney, LL.D., F.R.S. London: E. and F. N. Spon. 1885.

Lightning Conductors: their History, Nature, and Mode of Application. By Richard Anderson, F.C.S., F.G.S. Third edition. London: E. and F. N. Spon. 1885.

Differential and Integral Calculus, with Applications. By A. G. Greenhill, M.A. London: Macmillan and Co. 1885.

THE ROYAL ALBERT DOCKS EXTENSIONS.

THE engravings which will be found on pages 102 and 103 are the first of several which we shall publish illustrative of very important deep-water extensions now being carried out for London and St. Katherine's and Royal Albert Dock Company by their engineer, Mr. Robt. Carr. Descriptions of the works will appear with further engravings.

PRIVATE BILLS.

ALTHOUGH some slight interruption has been caused by the political complications that have arisen since last week, further progress of a kind has been made with the preliminary stages of Private Bills in Parliament. Several more of these measures have been passed as having complied with the Standing Orders, and a first selection has been made of Bills to originate in the two Houses. The Mersey Railway Bill, which seeks powers to make certain necessary extensions of the Tunnel Railway, the Ship Canal Bill, and one or two of the general railway Bills are among the number allotted to the House of Commons. One Bill is already dead, viz., that of the Blackpool Corporation. To the proposed railway from South Kensington, under Hyde Park to Oxford-street, there are now some signs of opposition, though it will probably not be as general or as vigorous as that offered to the original scheme, largely because the character of the project has been materially changed. On the previous occasion it will be remembered that the chief ground of objection to the subway was that the necessary ventilators would mar the picturesqueness of the park, while the steam and gases emitted would injure the plants and trees. It now appears that no openings of the kind are contemplated. In a report presented to the Kensington Vestry, who are, of course, deeply concerned in the matter, the surveyor states that "the proposed subway will be 10ft. wide by 12ft. high, internal dimensions, throughout the entire length of five furlongs, situate in Kensington, and the crown of the subway will average about 14ft. below the surface of the road. The carriage will be worked on the pneumatic principle—that is to say, by the creation of a partial vacuum—the cars will be blown, as it were, one way, and drawn back by suction the return journey. No openings for ventilation, &c., are proposed; in fact, any such opening would destroy the working principle of the subway; and by the enlarged drawing produced, the committee will perceive that it would be impossible to use the subway as an ordinary railway. In the construction of the subway two shafts would be required to be opened in Brompton-road, the whole of the work being done by tunnelling." The Bill contains clauses dealing with temporary openings, the underpinning of any buildings within 100ft. of the subway, notices of breaking up streets, to acquire vaults projecting under roads and footpaths without being compelled to acquire also the houses to which the vaults belong; compensation, and so on; the proposed capital is £320,000, in 32,000 £10 shares; and it is proposed to limit the toll between Exhibition-road and the Marble Arch to 3d. each person. Looking at the matter as a whole, the surveyor recommends the vestry to approve of the scheme, expressing the opinion that the growth of street traffic will make subways necessary as time goes on; but dissent has been displayed to many of the features of the work, and when the Bill comes before Parliament it will probably be strongly contested from some quarters. This Bill will originate in the House of Lords.

In connection with the Ship Canal and the payment of interest Bill now before Parliament, some interesting and important facts have been made public at the first ordinary meeting of the Canal Company, held a few days ago. From the statement of the chairman, it appears that so far only three-quarters of a million has as yet been subscribed; but this is not greatly to be wondered at when it is considered that, as the Act at present stands, the shareholders can expect no interest on their money until the canal is made—some years hence. Investors are naturally reluctant to sink their money for so long a period without any return, and the limited amount subscribed is likely to form a powerful argument in favour of the proposal to pay dividends out of capital during construction. If Parliament sanctions this course Messrs. Rothschild, the chairman explained, will be ready to provide the remainder of the capital straightaway, at 1 per cent. Lord Rothschild, when discussing the subject with the directors, is reported to have said: "Don't you believe that we are going to do anything but what is right and economical for you; we are satisfied that the negotiations of the finances of this great national enterprise will do our house great honour, and that we, with the strength of our name and associations, will be able to find all the money that you require." No stronger testimony to the soundness of the undertaking could perhaps, it is thought by some, be given, or surer proof that the necessary money can be obtained; but it is certain that if the present Bill be passed Messrs. Rothschild will not have to do all they are prepared for, for there are hundreds, and even thousands, of people who will be ready to invest larger or smaller sums in the canal if they can at once realise dividends. The Salford Corporation alone propose to subscribe a quarter of a million. And what the Bill proposes is the payment of interest at the rate of 4 per cent. per annum during construction, the total amount, however, not exceeding £750,000. The meeting was attended by considerably over 1000 shareholders, and the Bill was unanimously approved of, after these and other statements had been made.

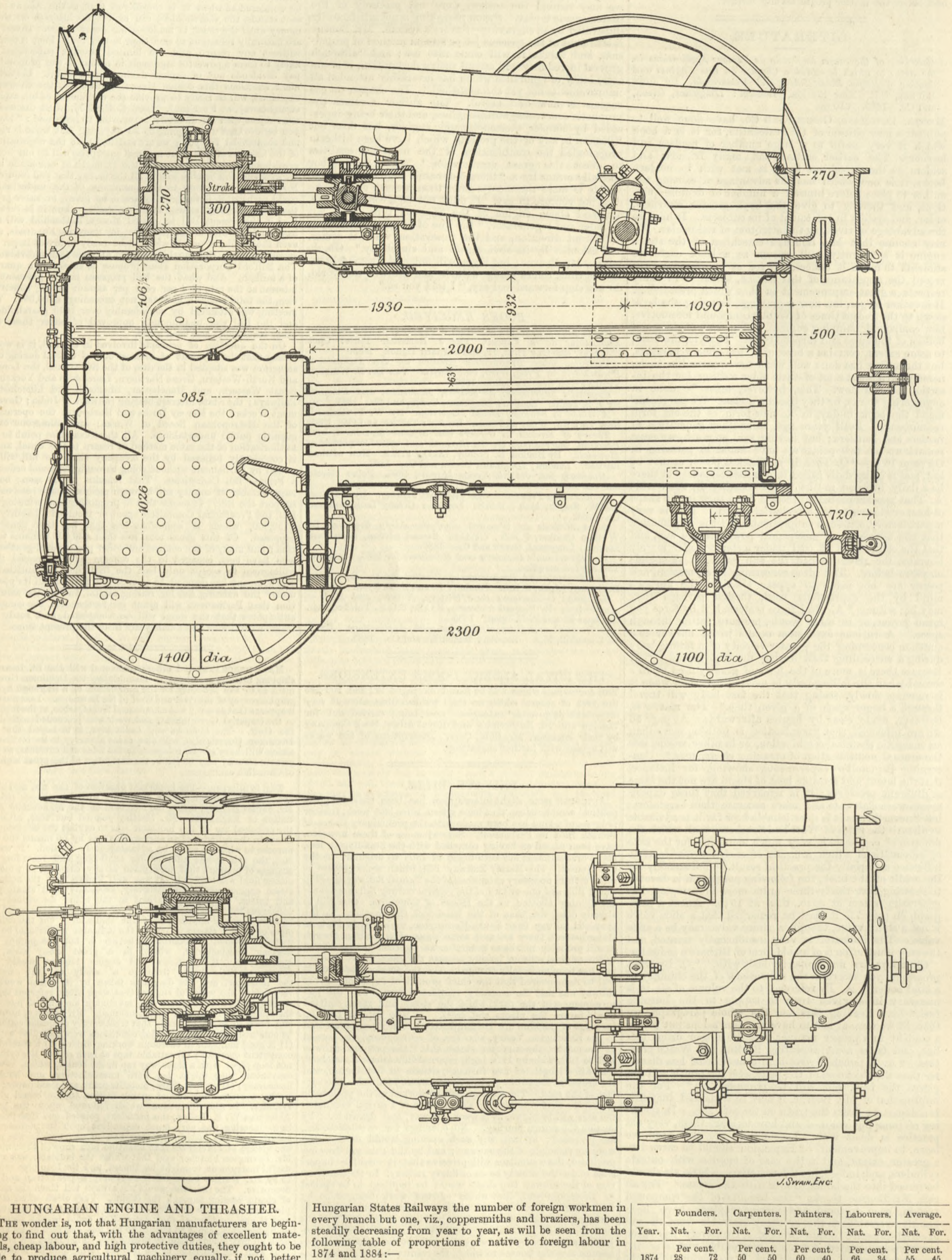
On the question of principle involved in the Bill, it is worth noting that the payment of interest out of capital during construction was adopted in the case of the Suez Canal, the London and North-Western, Great Northern, Lancashire and Yorkshire, Great Western, and Manchester, Sheffield, and Lincolnshire Railways; the State interest-bearing railways of India; Government Works; the Mersey Docks and Harbours; the operations of the Metropolitan Board of Works; and numerous other gigantic public undertakings. All these examples point to the authorisation of the same method in regard to the canal, and it is confidently believed by the company that the Bill will be passed by Parliament without going through the usual ordeal of a Private Bill Committee. That remains to be seen; but a large number of county and borough members have resolved to support the Bill. It seems that in promoting and winning the Bill, the Provisional Committee spent or incurred a liability for £150,000, which is somewhat less than has been generally supposed. Of this gross total less than £30,000 remains to be paid; and many of the counsel and other professional gentlemen who have been engaged in the scheme have expressed their willingness to accept only half the fees they are entitled to. The company has decided to at once put in force all its powers under the existing Act for raising capital, and on the assumption that Parliament will grant its further Bill, the company anticipates that the canal will be completed and ready for traffic within four and a-half years from the present time.

MANY MERCHANTS and others connected with the St. Lawrence shipping interest are about to memorialise the Dominion Government as to the necessity for the completion of a thorough hydrographic survey of the river and Gulf of St. Lawrence. Last autumn it appears that a survey was commenced from Quebec, at the instance of the Imperial Government, and work was proceeded with down the Gulf. The *Colonies and India* says, it is hoped that the Dominion Government will also cause a survey to be instituted, which will have special reference to the tides and currents, so that greater security may be felt in the navigation of this great highway of Canadian commerce.

THE INDICATOR.—The important question of the use and abuse of the steam engine indicator was dealt with in a paper read by Mr. James Hartley, before the members of the Manchester Association of Engineers. Mr. Hartley pointed out that, although the principal use of the indicator was to exhibit the behaviour of steam in the cylinder of an engine, this was by no means the only purpose to which it could be advantageously applied. It was, in fact, the sole means afforded for exhibiting and recording the changes of pressure that took place in any chamber in which an elastic fluid was confined. It was well known that the action of steam engines working expansively, especially with small pipes and valves, produced pulsations in the boiler sometimes of a dangerous character, and the extent of these pulsations could only be shown by the application of the indicator. On the delivery pipes of certain classes of pumps the indicator might also be very usefully applied to ascertain whether or not the pumps were working satisfactorily, which, in a great many cases, was questionable. If engineers and engine tenders would only devote a little more time to a study of the use of the indicator, and the diagrams taken by it, there would be very few of the wasteful engines that were often referred to, and we should be able to obtain the maximum amount of power for the minimum amount of fuel consumed. Mr. Hartley, however, laid down most emphatically that trustworthy diagrams could not be obtained unless the following conditions were complied with:—(1) A good indicator in thorough working order; (2) a careful and competent operator; (3) suitable taps at each end of the cylinder, not loop pipes with a three-way tap in the centre, which, however convenient they might be, were unsatisfactory, and liable to inaccuracy; (4) a good, sharp, metallic point, and good paper; and, lastly, a correct method of giving motion to the barrel of the cylinder. In the discussion which followed upon the paper, Alderman W. H. Bailey, the president, pointed out that progress in engineering was very much dependent upon the delicacy and accuracy of the instrument they had to use, and it was in the knowledge of differences that scientific men showed their ability. Mr. Lavington Fletcher said that whilst the indicator was a most useful instrument it might be abused, and the loop pipe referred to by Mr. Hartley he regarded as simply a great trap and very deceptive. The indicator would not always tell them the amount of steam passing through the engine. Very often when a complete test was made a discrepancy of 30 per cent. was discovered; and if any member of that Association could invent some kind of meter which could be applied to the hot overflow of an engine, such an instrument would be invaluable. They must not rest content with the indicator in its present form, and he hoped that someone would try the testing of the heat as it passed out of the engine. Mr. Lewis did not consider the indicator as by any means perfect, and no system of levers could be trustworthy. He thought some instrument might be devised for communicating the motion of the engine direct to the indicator. Mr. Taylor said that for very high-speed engines it was questionable whether any of the present forms of indicators were altogether trustworthy. The primary use of the indicator was that it should record the exact pressure of steam at any particular part of the cylinder.

10-HP. PORTABLE ENGINE AT THE BUDAPEST EXHIBITION.

CONSTRUCTED AT THE WORKS OF THE STATE RAILWAYS, BUDAPEST



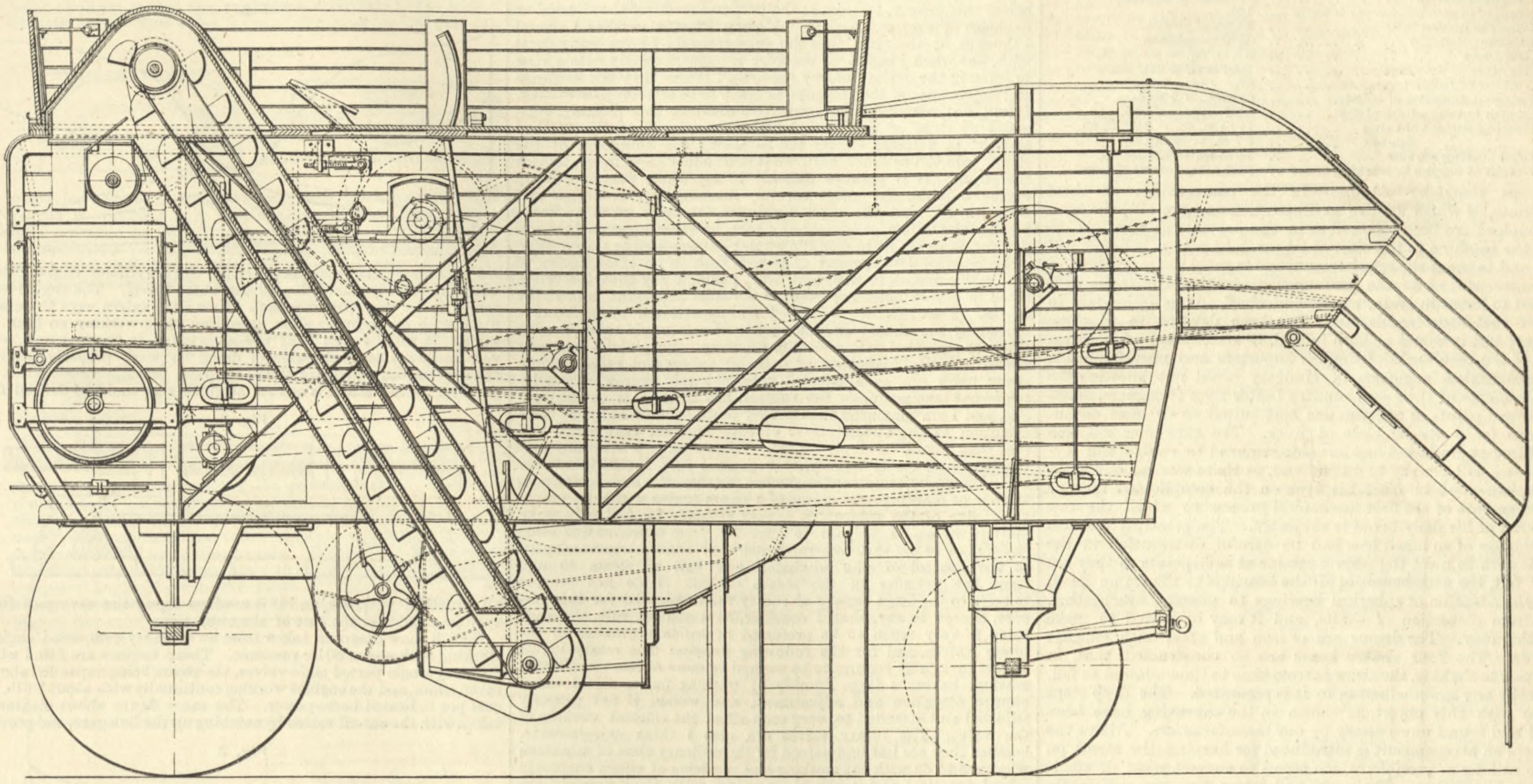
HUNGARIAN ENGINE AND THRASHER.

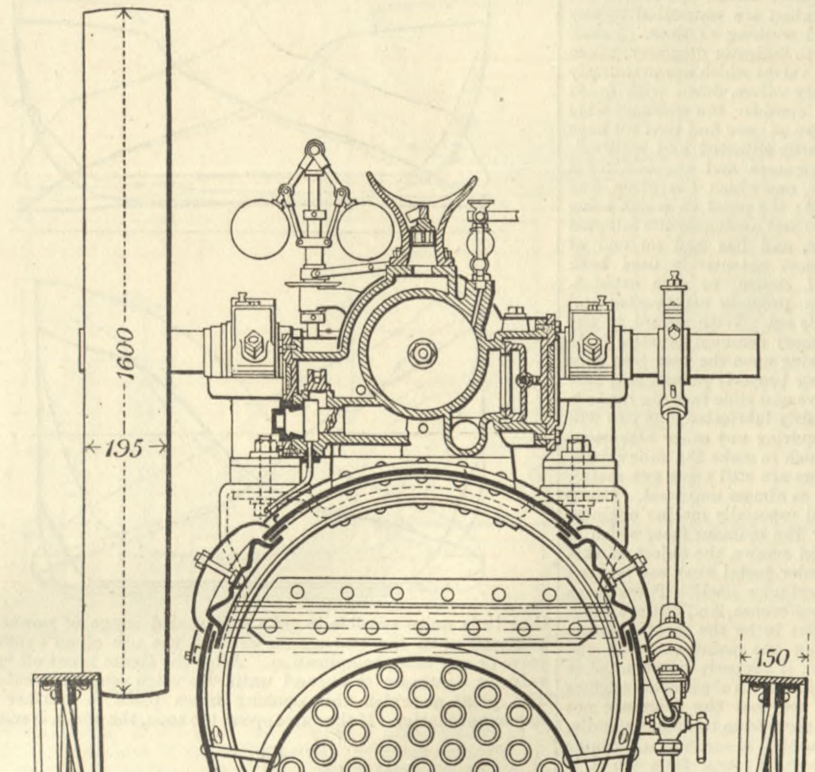
The wonder is, not that Hungarian manufacturers are beginning to find out that, with the advantages of excellent materials, cheap labour, and high protective duties, they ought to be able to produce agricultural machinery equally, if not better suited to the requirements of their country, than the more elaborately executed and finer finished importations which have so long been almost an English monopoly, but that they did not make the discovery and turn their attention to independent efforts in this direction years ago. It is a significant evidence of the prevailing tendency to free themselves from every semblance of foreign dependency, no less than of the advances achieved in the capabilities of native artisans, that in the workshops of the Hungarian States Railways the number of foreign workmen in every branch but one, viz., coppersmiths and braziers, has been steadily decreasing from year to year, as will be seen from the following table of proportions of native to foreign labour in 1874 and 1884:—

	Turners.		Planers.		Locksmiths.		Coppersmiths.		Smiths.		Boilersmiths.		Founders.		Carpenters.		Painters.		Labourers.		Average.	
Year.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.	Nat.	For.
	Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.		Per cent.	
1874	50	50	70	30	60	40	54	46	73	27	51	49	28	72	50	50	60	40	66	34	55	45
1884	60	40	77	23	89	11	24	76	80	20	75	25	40	60	70	30	80	20	72	28	70	30

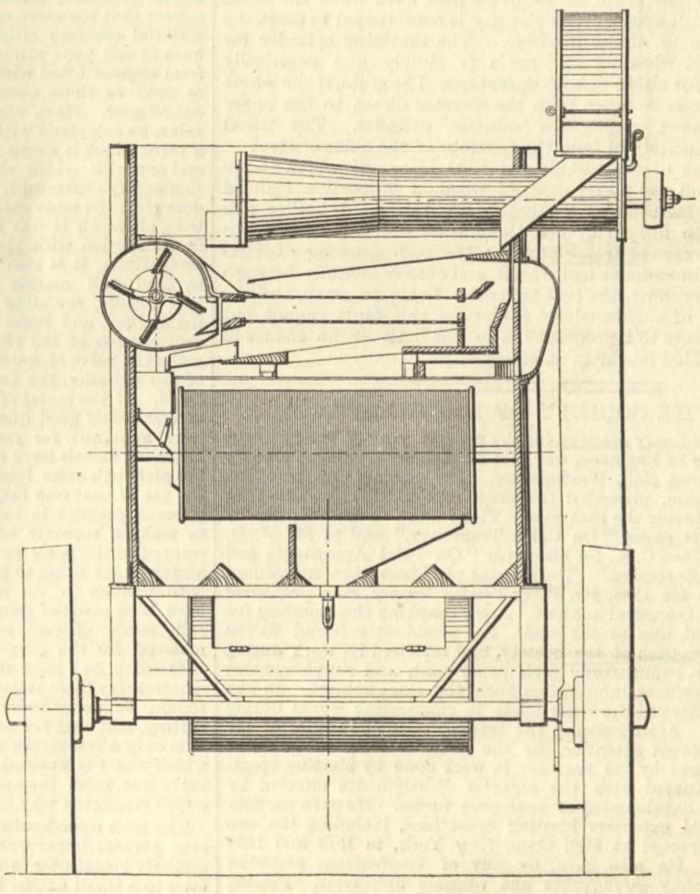
The specimens of portable engines and thrashing machines exhibited at Budapest last year are apt illustrations of the attention paid to the special requirements of Hungarian agriculture. Their general appearance although, owing to the sad and sombre colours of the paint, suggestive of consciousness of

THRASHING MACHINE AT THE BUDAPEST EXHIBITION.





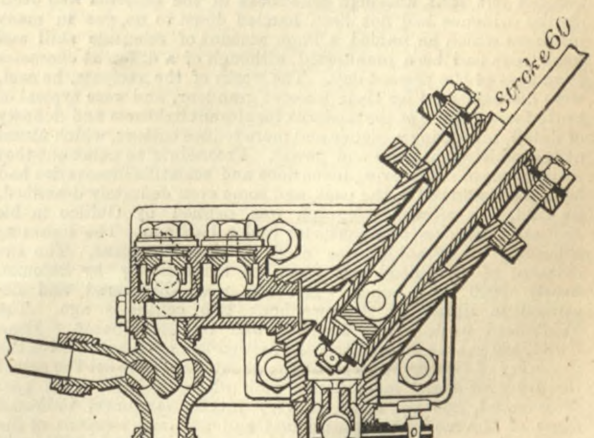
CROSS SECTION OF PORTABLE ENGINE.



SECTION OF THRASHING MACHINE.

the rougher usage to which they are destined, gives every promise of being able to endure it. Every part has been chosen with a view to avoiding the necessity of highly skilled labour in renewal and repairs, providing at the same time a superabundance of strength to compensate for the lack of this in the hands of those to whose supervision they will be entrusted.

As will be seen from the accompanying drawing of a 10-horse power—nominal—portable engine, the fire-box and grate area have considerably larger dimensions than engines of the same class and power in general, in order to suit inferior fuel, be it either coal, lignite, wood, or straw. The leading features in the construction are as follows:—The boiler and tubes are of "Fluss" iron, as well as the crown of the fire-box, which is corrugated, after Haswell's patent. Besides the simplicity of this form of construction, it is found to offer special advantages in preventing the formation of boiler stone, owing to the expansion and contraction of the corrugations under varying temperatures of steam. The sides of the fire-box are left plain, as being easier to clean or repair than corrugated plates. To protect the tube plate from the direct action of flame, and to effect a more thorough admixture of the combustible gases, a cast iron screen is attached to the base of it, springing from the front end of the fire-bars and curving upwards and backwards to about half the height and a quarter of the length of the fire-box. Instead of fastening the engine direct to the boiler, which method is always more of less accompanied by a chance of leakage at the bolt holes, to say nothing of the general pulling necessary for the renewal of any parts, the cylinder, crosshead guides, and main bearings are attached to saddles which have been previously rivetted to the shell. The boiler fittings are exceptionally massive; the crosshead guides are bored so as to facilitate accuracy in mounting, and the construction of the crosshead and piston-rod eliminates any difficulty in adjustment. The crank axle is of steel forged in one piece. An excentric on the main shaft, by which also the expansion may, within certain limits, be regulated, enables the engine to be reversed, should the necessity for doing so arise. The inlet valve is outside the boiler, attached to the cylinder, and worked by a lever. The manhole covers and stays, mud plug door, fire and smoke-box doors, are all pressed in light steel. The boiler is fed by a pump fitted with an arrangement for warming the feed-water with the waste steam. The chimney is provided with a spark catcher The under frames supporting the engine on two axles are entirely of



SECTION OF FEED PUMP.

iron. The leading dimensions of the engine are as follows, and show that it is large for its nominal power :—

Diameter of cylinder	270 mm. = 10·63in.
Length of stroke	300 mm. = 11·81in.
Number of revolutions per minute ..	140.
Effective horse-power	26-horse power.
Pressure of steam	4½ atmospheres.
Grate area	0·8 m. sq. = 8·6 sq. ft.
Diameter of fly-wheel	1600 mm. = 5ft. 3in.
Number of tubes	37.
External diameter of tubes..	63 mm. = 2·48in.
Length between tube plates..	2000 mm. = 6·56ft.
Heating surface of tubes	14·64 m. sq. = 157·5ft. sq.
,, ,, fire-box	3·7 m. = 39·8ft. sq.
Total heating surface	18·34 m. = 197·3ft. sq.
Weight of engine in working order ..	5600 kilog., about 5½ tons.

Steam thrashing machine.—In the construction of these machines, of which we give an illustration on page 111, the same principles have been followed as in the portable engines, viz., to suit the machine to the class of labour into whose hands it will fall, and to meet the requirements and to avoid the complaints of agriculturists as to the performance of other thrashers with regard to losses in grain, straw, and chaff. It is quite fair to admit that considerable study has been devoted to all these points; but it would be hard indeed, if after years of observation of the best works of English importers and manufacturers, the mechanical engineers of Hungary could not, knowing the requirements of their own country better than foreigners, adopt or discard points of construction best suited to or least advantageous for a special class of work. The thrashing machine exhibited at Budapest had one side removed to enable the layman—we will not say to understand, as there was no one there to explain—but to feast his eyes on the complicated interior arrangements of the first mechanical process to which the raw material of his daily bread is subjected. The principal features are the use of so much iron and its careful distribution in the framework to meet the several strains at such points as they are most felt, the attachment of all the bearings to the frame itself, and the adoption of spherical bearings to prevent overheating, &c., from distortion of shafts, and it may be added to make erection easy. The drums are of iron and steel with efficient guards. The four shaker boxes are so constructed that, in addition to shaking, the straw is from time to time allowed to fall, whereby any grain adhering to it is separated. The deep steps made with this object, as shown in the engraving, have been tried and found unnecessary by our manufacturers. Above the shakers an arrangement is introduced for keeping the straw on them as long as possible, which seems to suggest want of efficiency in the shaker. The upper and lower fans are sufficiently large to free the grain of all impurities, even when the drum is driven at full speed. The elevator is constructed to meet the highest capacity of the machine. The smutting cylinder for bearding and cleaning the grain is simply and practically constructed for either or both operations. The grain, if the wheat be blighted, can be taken from the elevator direct to the upper cleaner without passing the smutter cylinder. The wheel trucks are entirely of iron, the bearings of the axles of steel.

The weight of the machine is 4700 kilog., of which 75 per cent. is of iron and 25 per cent. of wood, a proportion claimed by the manufacturers as a valuable innovation. Whether this proportion be unique or not, there is no doubt that, with the intense difference of temperature in the corn growing districts of Hungary in summer and winter, and even sometimes between sunrise and evening, the best timber is liable to warp, and the introduction of a material not subject to this fault cannot but be of advantage to a proprietor who has little or no chance of obtaining skilled labour in an emergency.

THE SOCIETY OF ENGINEERS.

THE first ordinary meeting for the present year of the members of the Society of Engineers was held on Monday evening, February 1st, at the Town Hall, Westminster. The retiring president, Mr. Charles Gandon, presented the premiums of books awarded for papers read during the past year. These were to Mr. W. Newby Colam for his paper "On Cable Tramways," and to Mr. J. B. Redman, M. Inst. C.E., for his paper "On Tidal Approaches and Deep-Water Entrances." The retiring president then introduced the president for 1886, Mr. Perry Fairfax Nursey, who proceeded to deliver his inaugural address. After thanking the members for having elected him to the chair, the president referred to the satisfactory position of the Society, and reviewed its work during the past year, summarising each paper read, and supplementing some by subsequent information upon the same subject. In like manner he reviewed the visits made to engineering works during the vacation. After noticing the leading scientific events of the year, he directed attention to the comparatively insignificant effects produced by the engineer in work done by blasting operations as compared with the gigantic dislodgments effected by nature in the development of analogous forces. He gave particulars of several extensive blasting operations, including the two heaviest on record at Hell Gate, New York, in 1876 and 1885 respectively. He also gave, by way of comparison, statistics concerning many earthquakes and volcanic upheavals. Passing on to consider the present state of engineering science and practice, he observed that we were rather prone in the present day to exalt ourselves at the expense of the ancients, whom we were wont to consider as possessing no science whatever according to the modern acceptation of the term. But he pointed out that, although text-books of the ancients and other similar evidence had not been handed down to us, yet in many instances which he named a large amount of scientific skill and knowledge had been manifested, although of a different character from that of the present day. The works of the ancients, he said, were distinguished for their massive grandeur, and were typical of brute force; those of the moderns for elegant lightness and delicacy of detail, indicating a higher and more refined culture, which aimed at economising material and power. Proceeding to point out that many modern engineering inventions and scientific discoveries had been foreshadowed in the past, and some even definitely described, he said, the electric telegraph was defined by Galileo in his *Systema Cosmicum* two centuries and a half ago. The lightning conductor of Franklin was used by the Etruscans. The circulation of the blood was described symbolically by Solomon nearly 3000 years since. Bacteria were discovered and described in detail by Leeuwenhoek two centuries ago. The Whitehead torpedo was foreshadowed by Ben Jonson. Dean Swift, 160 years ago, credited the astronomers of Laputa with the discovery of two satellites revolving about Mars; whilst the actual discovery of Mars' moons only took place in 1877. The poet Drummond, 260 years ago, in very precise language, indicated some of the most important naval and military weapons of the present day, and for which he obtained letters patent in 1626; and finally, Shakespeare, in "Troilus and Cressida," had anticipated Sir Isaac Newton's great discovery of gravitation. The idealism of a bygone age had become transformed into a reality in the present one. The dreams of poets and sages of yore had become materialised, and produced the daily bread of the artisan.

It was announced that the Council had nominated Professor Francis Elgar, LL.D., F.R.S., of the Glasgow University, an honorary member of the Society, and had instituted a "President's Premium" of books, which would be awarded annually, in addition to the other premiums; and further, that, at Mr. Nursey's request, Sir Henry Bessemer—honorary member—had undertaken to present to the Society an annual premium of books, to be designated "The Bessemer Premium."

MODERN PRACTICE IN SLIDE VALVES.*

By Mr. TOM WESTGARTH, Middlesbrough.

WHEN the secretary asked me to prepare a paper to be read before this society, I accepted the proposal made by the Council as to choice of subject, namely, "Modern Practice in Slide Valves." I thought at the time that the subject would be one easily dealt with, but when I began to consider it more carefully with a view to framing the outline of my remarks, I found that the largeness and importance of the subject was likely to be almost embarrassing. It will not require any argument to convince this meeting, composed as it is of engineers, of the importance of the method adopted in a steam engine for governing the admission of the steam into the cylinder, and, what is of equal importance, its exit therefrom. It is perhaps difficult to say which part of a steam engine requires the most careful consideration in design and manufacture, and the most assiduous attention when at work, because the failure of almost any part, however apparently unimportant, is sufficient to stop the whole; but considering the question of economical development of power, both as to consumption of fuel and expenses in wear and tear, I should say that the valves fitted to the cylinder are perhaps the most important part of the engine. That this fact is grasped and appreciated by engineers is proved by the almost endless variety of valves and valve gearing which are adopted with a view to economy. But, whilst engineers are alive to the importance of cylinder valves and valve gearing, steam users are, as a general rule, not only almost necessarily somewhat ignorant upon the subject, but to a great extent careless, and I am convinced that if they could be induced to pay more attention to the steam valves of their engines, they would find that they would be amply repaid. Of course, it is necessary that the owners of steam engines, as a general rule, should be advised and directed by competent engineers, because, if a man commences to alter or rearrange the valves of a steam engine without a proper knowledge of the subject, it is very probable he will only make matters worse. I propose to offer for your consideration some remarks as to the various arrangements of slide-valves as adapted to the control of the admission and exit of steam to and from the cylinder of the steam engine. I do not propose to refer to the large variety of rotary valves adapted for this purpose, except to say, that I consider, as a general rule, the slide valve is very much to be preferred in ordinary practice to the rotary valves, and for the following reasons: The rotary valves almost invariably require to be worked by more or less complicated gearing, having a large number of working parts, all of which require attention and adjustment, and which, if not properly adjusted and attended to, very soon affect the efficient working of the valve. The rotary valves are also I think objectionable, because they are not understood by the ordinary class of workmen who have to do with the working and repairing of steam engines in actual practice; and again, these valves, with their gearing, are almost invariably more expensive than slide valves, and it does not appear that the extra cost and complication are warranted by any material economy either of fuel or in working expense. I shall have to call your attention presently to indicator diagrams, taken from engines fitted with ordinary slide valves which are practically as good as those obtained with rotary valves, fitted with quick cut-off gear. Now, when we come to consider the ordinary slide valve, as compared with other valves, we at once find that we have a valve which is cheap in first cost, easily adjusted and repaired, and one with which almost every engineman and engine-fitter is thoroughly conversant, and, moreover, one which has given, and does give, the most satisfactory results; the proof of which being that, although it was amongst the earliest arrangements adopted in connection with the steam engine, and has had no end of competitors, it is still by far the most extensively used both by land and marine engineers. Of course, to give satisfactory results, the slide valve must be properly constructed and maintained, and must also be properly set. With regard to the construction of the slide valve, the most common practice is to make the valve of hard cast iron, working upon the cast iron face of the cylinder, the two surfaces being properly planed and surfaced. If the metal of which the valve and slide face are made is of reasonably good quality and kept fairly lubricated, the two will work generally for years without requiring any other attention. Different metals have been tried of which to make the slide valves, but although some locomotive engineers are still using gun-metal, the use of cast iron may be considered as almost universal. It is a common practice in large engines, and especially marine engines, to make a separate or false face for the cylinder face, which is secured to the ports by recessed headed screws, the object of this arrangement being to get a face of harder metal than can be used with wisdom in the casting of the cylinder itself. These faces have been made of gun-metal, phosphor-bronze, &c., but are generally made of cast iron, which seems to be the most suitable material for the purpose. Concerning the maintenance of the slide valve, as I have already remarked, if properly constructed it requires very little attention; but the slide valves of all steam engines should be periodically examined to see that the faces are not cutting, and that the valve is properly secured to its rod or spindle. It is only a few weeks since I was requested to examine an engine which was not working satisfactorily, and I found that the slide valve was more than an inch loose upon the spindle, and yet the owner wondered why it would not work.

The next consideration, namely, the setting the slide valve, is of even greater importance. It appears to be very difficult to get an ordinary steam user to understand that his coal bill can be affected even to a small extent by the way in which steam is admitted into the cylinder of his engine and allowed to escape therefrom. Perhaps the best way we can consider this part of the subject will be to follow in fancy the operations of the slide valve of a steam engine during one revolution. The starting point is the lead, that is the amount which the valve opens before the piston reaches the end of its stroke. As a general rule it will be found advantageous to allow the valve to be opened from $\frac{1}{16}$in. to $\frac{1}{8}$in. at the end of the cylinder remote from the crank, and from $\frac{1}{4}$in. to $\frac{3}{8}$in. at the end nearest the crank when the piston is at the end of its stroke. The steam so admitted checks the momentum of the moving parts, and what is perhaps equally important, it is an advantage to have the valve open as wide as possible during the early part of the piston travel, so that there may be free admission of steam without wire-drawing and loss of pressure. Then comes the full opening of the valve, followed by the cut-off. If an economical result is to be obtained the point of cut-off must be early, and should be so arranged that, with a working pressure of 80 lb. to 90 lb., the steam is expanded into six or seven volumes; or with a working pressure of about 150 lb. the expansion should be about fourteen volumes. The consideration as to whether the steam should be expanded in one, two, three or more cylinders, is outside the scope of this paper. It is desirable that the valve should open as wide as possible for the admission of steam and that it should close quickly. These conditions make it necessary, when early cut-off is required, that the valve should have a long travel, otherwise it will open slowly and not very wide, the result being that the full boiler pressure will not be even approximately attained in the cylinder, and that the steam will be wire-drawn, that is, that the pressure will not be maintained even at the point reached at the early part of the stroke. I believe that the imperfect work of the slide valve at this part of its stroke is the cause of immense loss to steam users, which is more to be regretted as the fault could often be remedied, or, at any rate, much mitigated with very small trouble and expense. If, as in this case of a single cylinder engine, it is desired to obtain the full benefits of using high-pressure steam extensively, and the engine is large enough to do its work with an early cut-off—without which an economical result cannot be obtained—it is necessary to supplement the slide valve with an expansion valve, because if the ordinary slide valve were set off at, say, one-seventh of the stroke it would be found to be difficult to properly control the exhaust. If, however, the steam is to be expanded in more than one cylinder, as in the case of a compound engine, it will generally be found that a satisfactory result can be obtained without an expansion valve.

Fig. 1

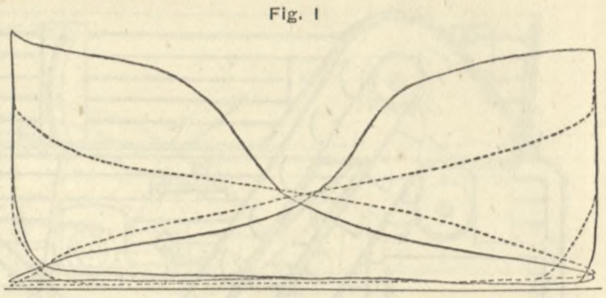
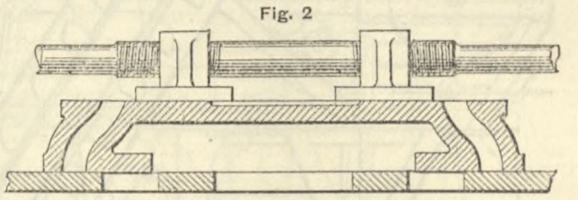


Fig. 1 shows diagrams taken from a single-cylinder engine fitted with an ordinary slide valve having short travel. The engine was found to be very uneconomical. New slide valves were therefore fitted with an ordinary slide expansion valve working on back of same. It will be seen that the slide valve, in the first case, was very badly set and incapable of doing its work properly. With the new valves, which are of the simplest possible construction—see Fig. 2—the steam is cut off as quickly as could be desired for all practical purposes, and it is needless to say the saving of fuel very soon paid for the cost of the alterations.

Fig. 2



Figs. 3 show diagrams taken from an ordinary compound engine working with steam 80 lb. pressure. These engines are fitted with ordinary single-ported slide valves, the steam being expanded about seven times, and the engines working continually with about 1·6 lb. of coal per indicated horse-power. The same figure shows diagrams taken with the cut-off varied by notching up the link gear, and proves that it is quite possible to get a very varied range of power well balanced upon the two cranks without the use of an expansion valve or any other complication. After the steam is cut off by the valve it continues to expand until the valve opens for exhaust. The point at which this opening takes place is another very important matter. If the valve opens too soon, the steam is released before it is fully expanded, or, in other words, before all the work is taken from it; if, however, the valve does not open for exhaust until the piston is nearly at the end of its stroke, the engine will not run smoothly. This is of particular importance in fast running engines. I have found in many cases where fast running engines have been unhandy, and could not be made to run with sufficient speed, that the difficulty is entirely got over by giving the valve negative lap on the exhaust side. It will sometimes be found that the power of the engine has been increased by the same means.

Fig. 3

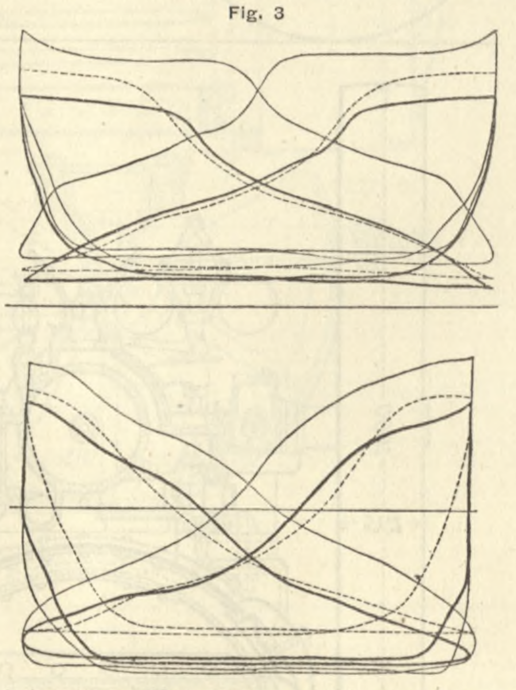
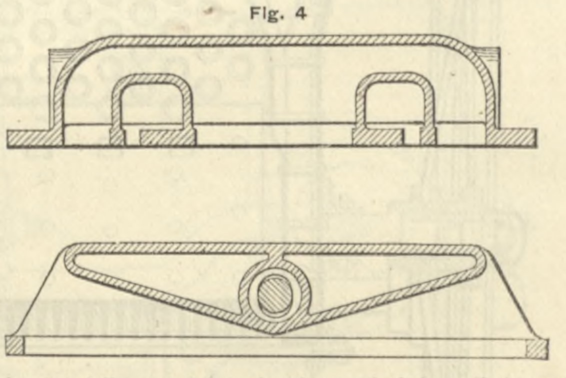


Fig. 4



The next point of consideration is the closing of the exhaust. This again requires careful attention. If it takes place too early, the engine is pulled up by excessive compression; if, on the other hand, you do not arrange to have a fair amount of compression, the admission of steam into the cylinder when the steam valve opens will cause sudden shocks and unsatisfactory working. The only way to ascertain satisfactorily whether the slide valve is properly set is by the use of the indicator; and I am convinced that it would be an immense advantage to steam users if they would have their engines properly indicated at regular and not too long intervals. We come now to the consideration of the various descriptions of slide valves, the first, of course, being the ordinary single-ported locomotive slide, which is so well known that I need not attempt to describe it in any way. Nearly all the other forms of slide valves are modifications of this valve, the most common being the ordinary double-ported slide as shown by Fig. 4. This valve gives a double opening for both steam and exhaust, and therefore gives the advantages of a large area of port opening and a quick cut-off without an abnormally long travel. The same arrangement is sometimes adopted for triple-ported valves. We then have the trick valve, sections of which are shown by Figs. 5 and 6. This

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* Cleveland Institution of Engineers.

Fig. 5

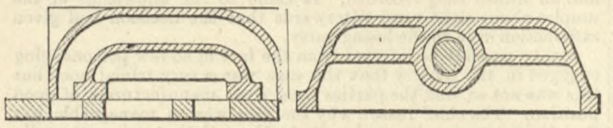


Fig. 6

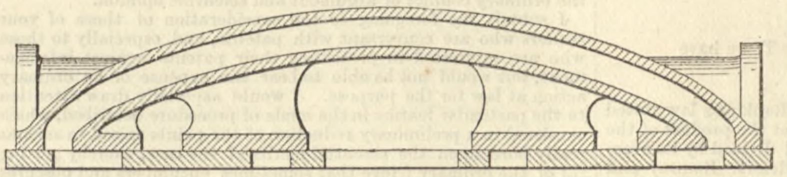


Fig. 7

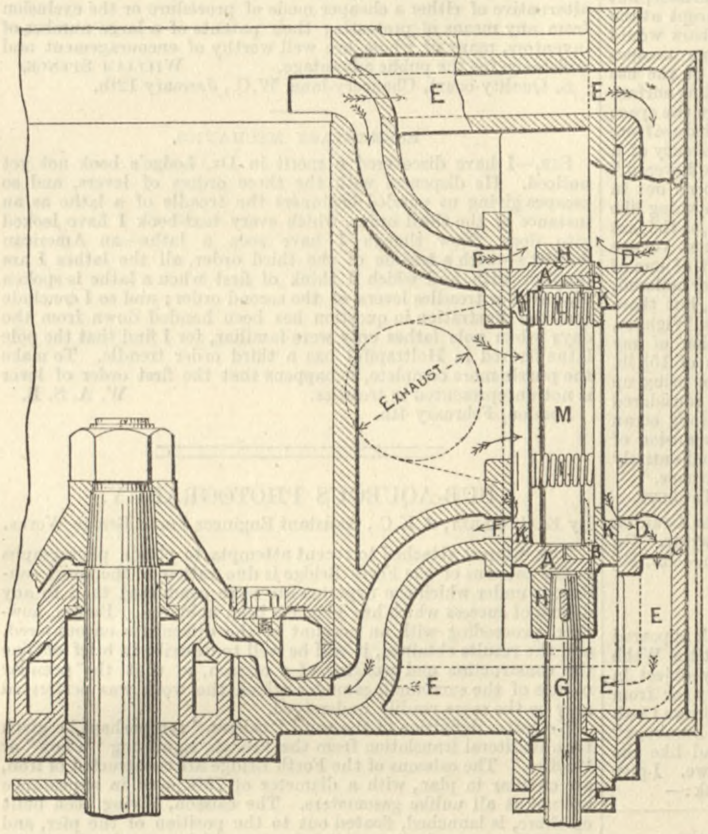


Fig. 8

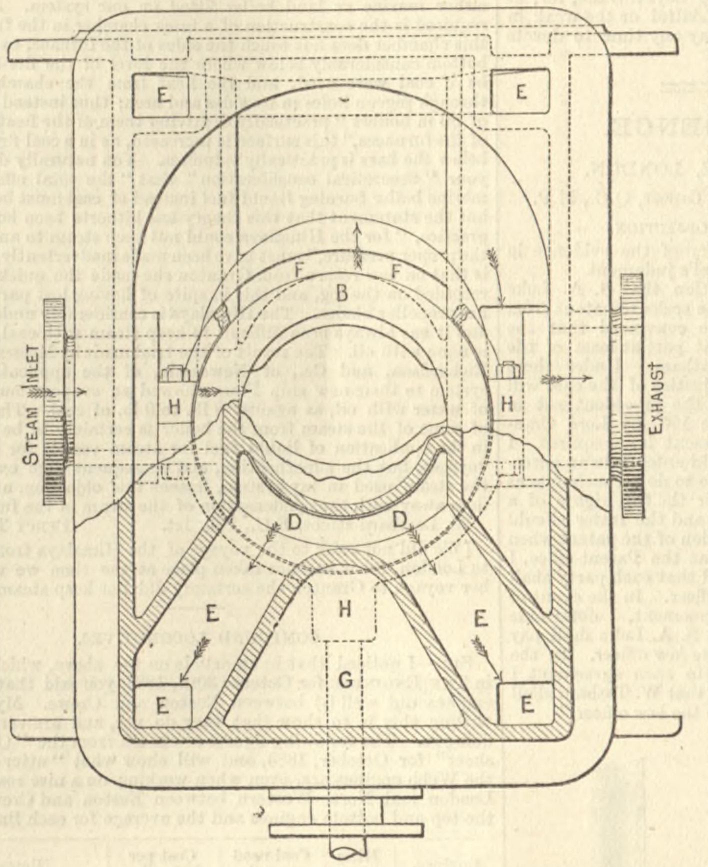
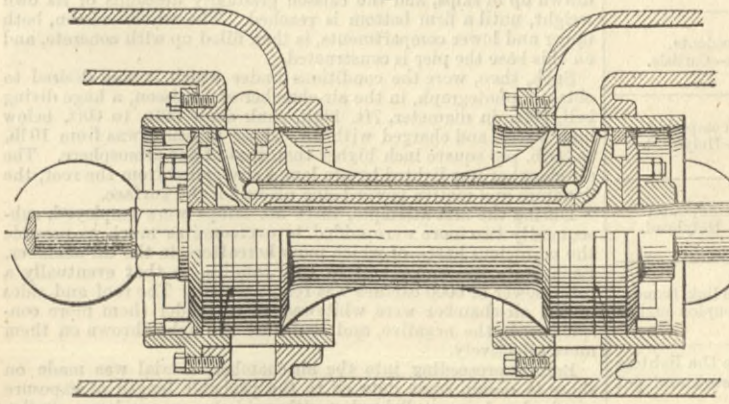


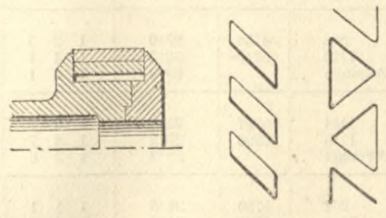
Fig. 9



consists of the ordinary locomotive slide, so far as the exhaust is concerned, but a double opening is given for steam, a port being cast *within the lap* of the steam side, carried round the back of the valve, and admitting steam from the opposite end, the valve face being arranged so that the port opens and closes at the same time at both ends. This valve is one of the most useful that can be fitted for engines of ordinary size, and gives very satisfactory results in practice. A modification of the trick valve has been patented by Mr. Thom, of Barrow-in-Furness. A section of the valve is shown by Fig. 6. The difference consists in a slight variation of the position of the port in the lap of the valve, which is so arranged that, in addition to passing steam into the opposite end of the cylinder from the steam chest, it also admits the exhaust steam from one side of the piston to the other just before the exhaust opens, so that the steam at its terminal pressure is admitted to the opposite side of the piston, and there compressed and so used again. It is claimed that this valve is particularly useful when fitted to the low-pressure cylinder of a compound engine, because the steam is there expanded down far below atmospheric pressure, and the compression ordinarily taking place is not sufficient to absorb the work stored in the momentum of the piston; it is also of use fitted to a high-pressure cylinder, as in both cases it saves the amount of steam required at each revolution to fill the ports and clearances, these being filled by the exhaust steam from opposite side of piston before the lead opened. The outer ports only are used for steam; they are therefore much larger; both ports are used for exhaust. This valve has been fitted to large steamships, it is said with very satisfactory results both as to economy of fuel and steadiness of engines when racing in a sea-way. The next valve to which I wish to call your attention is Messrs. Paton and Wilson's patent circular double-ported slide valve. The valve is shown by Figs. 7 and 8 and is circular in form, and is constructed of two rings A B, alike on their outer faces, but jointed together so as to act as one ring. The cover of the valve chest is provided with a port face, having ports D D, with passages E E leading to the ends of the cylinder, exactly similar to and opposite F F in the cylinder port face. The valve is driven by a valve rod G connected to a circular hoop H, within which the valve fits with sufficient freedom to allow of its turning within it, should it have any tendency to do so. As the valve moves it necessarily opens and closes two ports simultaneously at each reciprocation and acts as a double-ported valve. The steam is first admitted to the interior of the valve, from which it passes to the cylinder, and is then exhausted on the exterior of the valve into the valve chest, as indicated by the arrows, which acts as a receiver. As the width of the face of each part of the valve is only that of a port with the required lap added, it has no back upon which steam can press so as to keep it upon its seat when entirely covering a port, a flange K is therefore formed on the interior of each part of the valve for this purpose, and its area is determined by the width of the ports; with the exception of these flanges the valve has no surfaces subject to steam pressure; it is therefore balanced. The spiral springs L, shown in the drawings, are only used to keep the two parts of the valve expanded and in contact with their port faces when steam is turned off. The joint, where the two parts of the valve meet, is made steam-tight by means of a thin strip of brass M sprung over it inside the valve, and having the pressure of the steam on the back of it. The principal advantages claimed for this valve are its freedom to revolve upon the face and thus avoid cutting, the reduction of steam pressure upon the valve chest cover, and the greater freedom of exhaust due to the larger port opening on outer or exhaust edge of valve.

I have here a sample valve which was fitted to a cylinder 18in. diameter on board the s.s. Stormcock; it had been working nine months with a pressure of 75 lb. and was taken out for use as a sample. You will be able to observe the smoothness of the faces and the evidence of easy working. The increasing steam pressures which are gradually being used have caused a very general adoption, of late, of the piston valve. Where there is reason to believe that the friction of the slide valve upon the face, caused by the size of the valve or pressure acting upon it, is too great to be left unnoticed, I think it is much better to adopt the piston valve than to fit any of the ordinary forms of relief gear upon back of the slide valves. These relief gears are expensive and require a good deal of attention to keep them in working order, and, to make them sufficiently steam-tight to relieve the pressure on back of valve, they have to be set up so hard that I am inclined to think the loss in driving them is as great as the relief they give. The piston valve is in equilibrium, and if properly constructed there is no difficulty in making it steam-tight. Fig. 9 shows a piston valve of ordinary construction fitted with two steel spring rings. It is a common plan, however, to fit only one ring, and, in many cases, no springs behind it, simply a solid ring of cast iron. Fig. 9A shows the section of a valve fitted with a single cast iron ring, supported by a second ring also of cast iron in lieu of a spring. The outer ring is sometimes put in alone and not split, and if nicely fitted will run for a considerable time, after which it can be split, and a spring fitted. Various materials are used of which to make the rings, but I think cast iron is the best. Care must be taken that the ports in the cylinder are so arranged that the slot of the spring ring is at no time entirely uncovered; this is done by casting the ports at an angle as shown upon the drawing—Figs. 9B or 9C. Mr. Thom's patent can be applied to the piston valve, as shown by Fig. 9.

Figs. 9a 9b 9c



I have not been able to bring under your notice all, or indeed a majority of the slide valves which are doing good work, but have discussed only a few examples as illustrating the principal classes of valve in use. I had intended to refer to the use of separate slide valves for steam and exhaust, and also to discuss the various descriptions of expansion slide valves, but fear that I have already made my paper too long, and will therefore leave these matters to be dealt with by others.

PIECE-WORK IN THE RAILROAD PAINT SHOP.

THE following paper was read at the Toronto Convention of the Master Car-Painters' Association, by Mr. F. S. Ball, master painter of the Pennsylvania Railroad shops at Altoona. It possesses interest as showing an American view of the piece-work question:—

Has piece-work any advantage over day-work? We hold that it has. Day-work is a contract to pay a specified sum or compensation for a certain number of hours per day of labour, or a moiety thereof per hour. The amount of labour to be done does not usually enter into the contract, and is as variable as the will and ability of different workmen and the varied qualifications and executive abilities of the master painters can make it. Piece-work is a contract to do a stated amount of work, as per certain specifications, for a stipulated sum of money, and is invariable for all jobs of like character or class, which is not the case when labour is paid by the hour. Wherever it has been adopted, an increase of one-third more work and a reduction of cost in like ratio, without any increase of working force, together with an increase of earning power to the employé, has been the result. The following are some of the advantages to the employer, in addition to those referred to above:—Protection from loss by reason of damage caused by carelessness or want of skill on the part of the workman, the damage having to be made good at his own expense, all operations being inspected by the foreman in charge, when reported finished, and credit allowed only when satisfactorily performed, the foreman being the judge. It enables the foreman to determine the qualifications of each new employé more readily than under the day system, as under that system the slow and unskilful man is usually screened and assisted by those with whom he works, while under the piecework system each man in relation to the employer is an individual contractor and in limited partnership with relation to his fellow-workmen, and is not disposed to divide his earnings with any who are not as skilful and fully as able to earn their share of the proceeds of their joint labour. Hence he will object to the retention of any such as may be unwittingly employed, because, also, he becomes as a partner responsible for and must assist in repairing any damage occasioned by such unskilful or careless workman. It secures to the company the services of good workmen. Where shops are located at isolated points, at a distance from business centres, and employment at those shops the only means of support available to the men, except at the expense of moving away, much difficulty is usually experienced, at a time of a sudden influx of work, to obtain any increase of the working force, unless exceptionally high wages are offered, the reason being that men are not inclined to accept a job at such points on account of probable fluctuations in the work to be done, and the trouble and expense entailed, in case they should lose their job in a short time, in seeking work elsewhere. But piece-work, in allowing increased earning power to a definite number of hands for a length of time in each year, which can be averaged, say nine months, compensates for the enforced idleness of the other three, and much of this may be made up on odd jobs outside of the company's employ, besides insuring steady employment to that number, and obviating the necessity of any reduction of the working force, except at times of the most extraordinary business depression; and any increase of business or work can be met by an increase of the hours of labour, or overtime, without increasing the number of hands; hence the men, finding that their average wages the year round are as much as they can earn elsewhere, are not disposed to change for every trifling or temporary advantage offered them. It relieves the foreman of the immediate oversight of the men, and transfers it to the results of their labours alone, enabling him to devote more time to the perfecting of methods and details of shop management, and to the investigation of such questions relative to car and locomotive painting as are continually arising. It in a measure divides the responsibility, or, rather, furnishes him a means of self-protection against carelessness on the part of the workman, without resultant loss to the company, or the no less disagreeable alternative of disciplining by suspension or discharge. It is self-adjusting as to the relations of the employé with the company and one another, on a strictly business basis, because the skilful and industrious will naturally desire to work with those who are equally so; and where skill is not required, industry is the standard, and all who are unable or unwilling to meet the requirements must give place to those who can, for the reasons before stated. The advantages to the workmen are also important. The intelligent and skilled workman is enabled to reap the rewards of his superior acquirements, the industrious the reward of industry, each earning according to his ability and disposition; he is freed from servile dependence on the judgment and responsibility of his superiors, and is made to assume some of the responsibility himself, and has to depend upon his own judgment to a greater extent, which makes him self-reliant. His inventive faculties are called into exercise to devise new and easier, as well as quicker, means to attain desired ends, and he educates himself and fellows in business methods, and has every opportunity and encouragement to develope any latent faculties he may possess. He learns to set a value on every minute of his time, and is not disposed to waste it, because it is a part of his capital, and a very short experience in working by this system enables him to determine the exact money value of any job he may be given. Where it is desired to make trial of the system, the simplest method is for the master painter to base his prices for piece-work on the knowledge his experience has given him of the value of each operation under the old plan, represented by so many hours' labour, and deduct 30 per cent. from the cost; the remainder will be a fair price to pay for the operation under the piece-work system. He should first, however, make an alphabetical classification of all cars that come to his shop for repairs, to enable him to again classify the work to be done on them, all cars of one form of construction Class A, of another form Class B, &c., then the needed repairs to these as Class 1 repairs, Class 2 repairs, and Class 3 repairs, and more if desired, but the three classes will usually cover all ordinary requirements. This classification of work should be written or printed in form, and posted in the shop for the information of the workmen, and may be in form as follows:—

Class 1, *repairs—outside.*—Burn off old paint. (Here describe whatever method is pursued in re-painting, from priming to finishing.) Paint roof and block ironwork. Paint, stripe, and varnish trucks.

Class 1, *repairs—inside.*—Fill hard wood and varnish, or whatever other method is pursued, according to inside finish of car. Re-paint head line, or replace with a new one. Re-paint sash, varnish blinds and seats, stating number of coats, &c. Paint floor and platforms.

Class 2, *repairs—if hard wood finish.*—Prime new work and bare spots, and when dry putty up and face down with pumice stone or sandpaper, as may be the practice; then re-paint, stripe, and varnish on surface thus obtained; paint trucks, roofs, &c. Clean down and sandpaper, touch up and putty where needed, and give one coat of varnish; rub down and oil off. If inside is painted, give number of coats necessary to this class of repairs. Clean and touch up head linings, &c.

Class 3, *repairs—outside.*—Scrub down with—here describe what is used. Touch up—under this head a detailed statement may be made, and the amount of such touching up averaged—and varnish—say how many coats—one coat of paint on trucks, and re-stripe and varnish; paint roof and black irons.

Class 3, *repairs—inside.*—Scrub thoroughly—describe here whatever is the practice or method. Touch up scarred places, and tops of seat arms and window sills, and paint floor and platforms. Clean glass, &c. This classification may be varied according to the requirements of differently constructed cars and the prevailing practice of each shop. Then the working force may be divided into three gangs: No. 1, strippers and varnishers; No. 2, inside varnishers, or hard wood finishers; No. 3, brush hands—one in each gang being appointed gang leader or foreman, whose business it is to consult with the master painter in reference to all work, to distribute the work among the men to the best advantage, see that they are supplied with materials and tools as soon as wanted, keep the accounts for the gang, and doing his share of the work when not otherwise employed, the master painter assigning to the several gang foremen the cars as they are received into the shop, as their share of work. The account may be kept in the following manner: The master painter keeps a record of cars as they come into the shop, and to whom assigned, with the class of repairs needed or determined upon. The gang foreman also keeps a record of when car was assigned him, with class of repairs ordered; and from day to day, as an operation is completed on the car or cars, he enters the charge on his book, with date that the operation was completed, thus—

		Dols.
Sep. 1st.	To coat of priming, No. 123 Class A, pass. car ..	1·40
Sep. 3rd.	To second coat, No. 123, Class A, pass. car	1·40
Sep. 4th.	To puttying, No. 123, Class A, pass. car	4·00
Sep. 6th.	To third coat, No. 123, Class A, pass. car	1·20

and so on throughout until the car is completed. Each operation after being finished is reported as finished to the master painter, who inspects it at his convenience, and before the next operation is begun, when, if it is satisfactory, he accepts it, and gives credit in his account book for the amount due to that gang; if not, it must be made satisfactory before credit is allowed. On the day before the last day of the month the gang foreman closes the accounts of his gang, and hands his book in to the master painter, who compares it with the accounts kept by himself, and if found correct it is so marked and returned, and the master painter returns his to the office of shop clerk. In addition to keeping the accounts the gang foreman also keeps a time book, or record of the time made by each man, and at the end of each month the sum total of earnings is divided by the total number of hours' labour, which will give the amount per hour of earnings which each man is entitled to receive for the number of hours he has worked. That there are no objectionable features to the system is not to be expected, therefore we will close this paper with what appears to be the most serious, as we have experienced them. It fosters, if it does not create, intense selfishness and greed in the employé; the weak are crowded out, and the strong overwork and break themselves down in a short time, exemplifying in a manner the Darwinian theory of the survival of the fittest. It is a serious obstacle to apprenticeship, and a hindrance to teaching boys a trade, for, as we have shown, there is no place for the unskilful or the weak in piece-work, nor have men working in this way any time to devote to the instruction of learners.

LEGAL INTELLIGENCE.

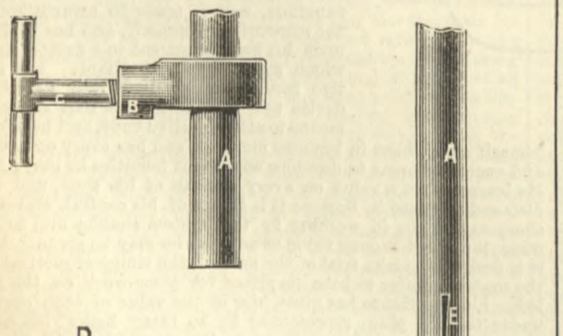
ROYAL COURTS OF JUSTICE, LONDON.

Before the Solicitor-General, Sir J. E. Gorst, Q.C., M.P.

LUKE'S APPLICATION—TATHAM'S OBJECTION.

In our last impression we gave a summary of the evidence in this case. We now give the Solicitor-General's judgment.

"It has not been proved to my satisfaction that S. A. Luke obtained the whole of the invention which he seeks to patent from W. Tatham; but I am at the same time convinced that the applicant is not the sole inventor, but that part at least of the merit of the invention is due to Wm. Tatham. Under these circumstances it appears to me that the justice of the case will best be met by following the principle of the precedent set in Russell's Pat. 12—*re* Gex and Jones, page 130—by Lord Cranworth, with such modifications as the present law requires. I think that S. A. Luke and W. Tatham should enter into an agreement by which the former should undertake to do all such acts as may be necessary for securing to the latter the full rights of a joint patentee in the invention in question and the latter should undertake to take no proceedings for revocation of the patent when granted. On the filing of such agreement at the Patent-office, I determine that the grant shall be made, and that each party shall pay his own costs of the appeal to the law officer. In the event of S. A. Luke refusing to enter into such agreement, I determine that the grant shall not be made, and that S. A. Luke shall pay the costs of both parties in the appeal to the law officer. In the event of W. Tatham refusing to enter into such agreement I determine that the grant shall be made, and that W. Tatham shall pay the costs of both parties in the appeal to the law officer."



LUKE'S PATENT COLLAR

The invention patented by Mr. Luke is illustrated by the accompanying engraving. In spinning machines the bobbins and flyers are carried on vertical studs A, called "collars." These are secured in the rail under ordinary circumstances by nuts and lock nuts underneath the projection on the rail; and each collar has to be specially fitted to its place that it may stand straight. The collars are tubular. Mr. Luke cuts a slot E with a circular saw in each, the collar is then compressed and turned until it will just fit the bored hole in the rail. To put it in place a screw key is put on which compresses the collar until small enough to drop in, the key is then taken off, and the expansion of the collar makes it a tight fit.

We give below an instructive story of the time absorbed and expense of carrying through a patent, the value of which makes opposition worth while:—Luke's application, 5156, April 25th, 1885. Tatham's opposition patent application, May 20th. Luke put in his complete specification May 28th. Opposition entered August 19th. Hearing before the Comptroller, November 20th; case not gone into by agreement between counsel, leaving open Tatham's right of appeal. Tatham's appeal hearing before the Solicitor-General, January 18th to 21st, held in the afternoons only; decision received February 1st. An order taken and supplied by Messrs. Dobson and Barlow, of Bolton, July, 1885, giving "complete satisfaction." Actual cost of opposition, £200 to £250 each side, and some months of delay.

LETTERS TO THE EDITOR.

(*Continued from page* 104.)

THE PHYSICAL SOCIETY.

Sir,—Your issue of January 29th contains a short *résumé* of "A Note on the Paper by Professor W. Ramsay and Dr. Young on 'Some Thermo-dynamical Relations,'" by Professors W. E. Ayrton and John Perry. These gentlemen think it is sufficient to examine one only of the laws propounded by Professor Ramsay and Dr. Young, viz., that the product $t\frac{dp}{dt}$ is constant, p being the pressure, and t the absolute temperature. Messrs. Ayrton and Perry state that the law is represented mathematically by the equation

$$t\frac{dp}{dt} = \phi(p);$$

but if $t\frac{dp}{dt}$ is constant, how can it be a function of the pressure? Clearly

$$t\frac{dp}{dt} = \text{a constant} = C\text{, say}$$

whence

$$p = C \log._e t + \text{constant.}$$

If P be pressure corresponding to temperature T, we have

$$p = P + C \log._e \frac{T}{t}.$$

This certainly does not agree either with Rankine's law stated in your paper, or with the law which states that the product of the volume of a gas multiplied by its pressure and divided by its absolute temperature is constant. Are both Messrs. Ramsay and Young and their critics, Messrs. Ayrton and Perry, wrong? I offer no opinion. William Donaldson.

2, Westminster-chambers, January 3rd.

LIQUID FUEL.

Sir,—The article in your issue of January 8th escaped my notice at the time, or I should have asked you earlier for space for a few remarks on it, and I hope you will grant it to me now, as the apparatus fitted on the Himalaya, to which you refer, was fitted by me. On board this ship no "modification of the structure of the boiler was made," nor is it necessary to do so with any class of either marine or land boiler fitted on our system. All that is required is the construction of a brick chamber in the furnace, but this chamber does not touch the sides of the furnace, except at the bottom considerably below where the level of the fire-bars would be if coal were used, and the heat from the chamber escapes through pigeon holes in its sides and arch; thus instead of the use of oil in boilers "practically depriving them of the heating surface of the furnaces," this surface is increased, as in a coal fire the space below the bars is practically valueless. You naturally deduce from your "theoretical consideration" that "the total efficiency of a marine boiler burning liquid fuel instead of coal must be lowered," but the statement that this theory has hitherto been borne out in practice, "for the Himalaya could not keep steam to anything like the proper pressure," must have been made inadvertently, as the fact is that on her return from Granton she made the quickest voyage recorded on the log, and this in spite of having lost part of one of her propeller blades. The Himalaya is considerably under boilered, and it has always been difficult to keep steam with coal, but there is none with oil. The result of the trial made by Messrs. Wigham, Richardson, and Co., of Newcastle, of the application of my system to their new ship Flora showed an evaporation of 15½ lb. of water with oil, as against 8 lb. to 9 lb. of coal. The using up of some of the steam from the boiler is certainly to be considered in the application of liquid fuel for steam vessels for long ocean voyages, but the superheating, and consequent high expansion of the steam used in my system, lessens this objection, and entirely does away with the condensation of the steam in the furnace.

75, Lombard-street, E.C., Feb. 1st. Percy Tarbutt.

[We did not refer to the voyage of the Himalaya from Granton to London, for it had not taken place at the time we wrote. On her voyage to Granton she certainly did not keep steam.—Ed. E.]

COMPOUND LOCOMOTIVES.

Sir,—I noticed that in an article on the above, which appeared in The Engineer for October 30th, 1885, you said that the Webb engines did well (?) between Euston and Crewe. My object in writing this is to show that they do not, and are very far from doing so. The following figures are taken from the "Crewe Coal-sheet" for October, 1885, and will show what "utter humbugs" the Webb engines are, even when working on a nice road like the London and North-Western between Euston and Crewe. I give the top and bottom engines and the average for each link:—

Engines.	Miles run.	Coal used per mile.	Cost per 100 miles.			Remarks.
			£	s.	d.	
113	2858	34·8	1	4	4	Big compound Euston—Crewe.
509	2394	38·1	1	6	0	
Average ..		35·1	1	5	1	
303	4947	30·2	1	3	1	Small compound Euston—Crewe.
306	2363	34·1	1	4	6	
Average ..		32·1	1	5	7	
789	5270	30·6	1	2	10	Precedents. Euston—Carlisle.
1187	7332	43·2	1	6	9	
Average ..		36·9	1	4	9	
333	4756	27·0	1	2	5	Small compound Crewe—Holyhead.
1116	5210	32·3	1	4	1	
Average ..		29·9	1	3	1	
1104	3997	28·2	1	2	7	Small compound Crewe—Holyhead.
1115	3396	33·2	1	4	7	
Average ..		30·8	1	3	6	
231	5750	24·8	1	1	1	Yorkshire link Ramsbottom 4-coupled engine.
1215	3285	35·6	1	4	0	
Average ..		31·6	1	3	4	

The compounds burn best Welsh coal, and they have the lightest and slowest trains. The Precedents do all the hard work and get inferior coal. Further comment is unnecessary.

January 26th. Anti-compound.

TRIAL OF PATENT CASES.

Sir,—The remarks in my former letter had reference to trials in the courts of law, but my main object is to offer a few suggestions as to a more economical mode of trying questions that are likely to arise under the new law in connection with patents owned by persons who are incapable of bearing the expenses of ordinary legal actions. In order to bring my remarks to a point, I will advert to a case that was tried above twenty-five years ago under a reference from the Court of Queen's Bench. Each party chose his own arbitrator, and these were required to choose an umpire within ten days, or one would be named by the law officers. The umpire, however, was chosen by the arbitrators within the specified time, and the three sat in a room at the Law Institution and took notes of the evidence as to matters of fact alone, it being supposed that the arbitrators and umpire acting together were competent to deal with matters of opinion on the mixed questions of law and fact—without the aid of special experts—as they were all well experienced in patent practice.

Two sittings of about five hours each sufficed, with the assistance of one counsel and solicitor on each side, for the work of getting the evidence on the notes of the investigators, after which they adjourned for a day to consider the evidence, and then met, when the arbitrators expressed their respective opinions. These being different, the umpire became sole referee, and after an interval of a few days delivered to the arbitrators a written judgment on the whole case. The decision was made a rule of court and an award duly recorded. It came to the knowledge of the umpire about eight years afterwards that the decision had given satisfaction even to the losing party.

It may possibly be inferred from the fact of so few persons being engaged in the inquiry that the case was a very trivial one; but this was not so, and the parties were rival manufacturers of good position. The chief reason why the case was so manageable was that the arbitrators began by eliminating all that was not really necessary to the merits of it, thereby greatly narrowing the issues to be tried, and avoiding much of the usual waste of effort on each side. And then another reason may have been that all the persons constituting what may be called the court of inquiry were antecedently qualified by practice to determine points of novelty and infringement, and that their minds were quite free to be exercised in a judicial manner on the points presented to them without the ordinary conflict of argument and scientific opinion.

I submit the foregoing to the consideration of those of your readers who are conversant with patents, and especially to those who are interested in protecting their patents against infringement, but would not be able to bear the expense of an ordinary action at law for the purpose. I would especially draw attention to the particular feature in the mode of procedure described, which consisted in a preliminary reduction of the points raised to such as really bore upon the essential merits of the case, thereby getting rid of the ordinary fringe that sometimes encumbers and obscures the only material issues that ought to be kept clearly before the mind of the Court. I think this a very material distinction from the ordinary course of procedure, and it involves a principle of adaptation to the varying character of patent cases that is not to be found in such procedure.

Solicitors and others find from experience that occasionally in the chapter of accidents a victory is obtained on a side issue, and this tempts them to raise all sorts of objections, in the shape especially of alleged anticipations of patented inventions, so that the practice is very much worse than one would be led to expect from what is said in the text-books.

I will only add that we have not to deal simply with a question of economy in trials, but with one involving no less than the alternative of either a cheaper mode of procedure or the exclusion from any means of protecting their patents of a large number of inventors, many of whom are well worthy of encouragement and assistance for the public advantage. William Spence.

8, Quality-court, Chancery-lane, W.C., January 12th.

ELEMENTARY MECHANICS.

Sir,—I have discovered a merit in Dr. Lodge's book not yet noticed. He dispenses with the three orders of levers, and so escapes giving us puzzled beginners the treadle of a lathe as an instance of the third order, which every text-book I have looked into does. Now though I have seen a lathe—an American dentist's—with a treadle of the third order, all the lathes I am familiar with, and which I think of first when a lathe is spoken of, have for treadles levers of the second order; and so I conclude that the illustration in question has been handed down from the days when pole lathes only were familiar, for I find that the pole lathe figured in Holtzapffel has a third order treadle. To make the puzzle more complete, it happens that the first order of lever is not unrepresented in treadles. W. A. S. B.

London, February 4th.

SUB-AQUEOUS PHOTOGRAPHY.

By E. G. Carey, A.K.C., Assistant Engineer Forth Bridge Works.

The interest attached to recent attempts to obtain photographs in the caissons of the Forth Bridge is due rather to the novel conditions under which the experiments were conducted than to any degree of success which has hitherto been achieved. Before, however, proceeding with an account of the difficulties encountered, and the results obtained, it will be well to describe in brief outline the construction and working of a caisson, so that the peculiar nature of the surroundings under which the work was performed may be the more readily understood.

No better definition of the word "caisson" can perhaps be given than its literal translation from the French, signifying "a box" or "coffer." The caissons of the Forth Bridge are constructed of iron, are circular in plan, with a diameter of 70ft., and in appearance are not at all unlike gasometers. The caisson, having been built on shore, is launched, floated out to the position of the pier, and sunk, the upper edge being slightly above high water level. Seven feet above its lower edge is placed an iron floor, which divides the caisson into an upper and a lower compartment. The lower compartment is charged with compressed air, forced in through piping by machinery on the surface, and forms, in fact, a huge diving bell. The compressed air excludes the superincumbent water, and enables workmen to descend into the lower compartment, or air-chamber, through airlocks, similar in principle to the locks on a canal, and excavate the bottom on which the caisson rests. The "spoil" is drawn up in skips, and the caisson gradually descends of its own weight, until a firm bottom is reached. The whole caisson, both upper and lower compartments, is then filled up with concrete, and on this base the pier is constructed.

Such, then, were the conditions under which it was desired to obtain a photograph, in the air-chamber of a caisson, a huge diving bell, 70ft. in diameter, 7ft. high, sunk some 50ft. to 60ft. below high water, and charged with air, whose pressure was from 10 lb. to 30 lb. per square inch higher than that of the atmosphere. The air-chamber was lighted by arc lamps suspended from the roof, the dynamos and motive power being placed on the surface.

During the first attempts, three arc lamps were employed, subsequently two more were added to overcome as much as possible the pernicious haze—of which more hereafter—in the air-chamber. Each lamp was equivalent to 1200 candles, so that eventually a total power of 6000 candles was requisitioned. The roof and sides of the air-chamber were whitewashed to render them more conspicuous in the negative, and to diffuse the light thrown on them more effectively.

Before proceeding into the air-chamber, a trial was made on shore to obtain some data as to the probable length of exposure required. A group, lighted on either side by an arc lamp, similar to those employed in the caisson, was taken on an instantaneous plate of the same rapidity as those subsequently exposed in the air-chamber; the lamps being carefully shaded by screens. An exposure of ten seconds with the largest stop gave fair results, and this period was assumed as the basis of operations in the caisson.

The first difficulty that presented itself inside the air-chamber was the formation of moisture on the lenses. After a few minutes, however, the glasses became warmed, and being carefully wiped, no futher trouble was experienced on this score. The author had provided himself with glycerine, intending to rub a film over the lens to check the formation of moisture on the glass;* but this was not required.

The first exposures were 12, 20, 25, and 30 seconds respectively, with the largest stop; instantaneous plates of average rapidity being used. Three arc lamps lighted the caisson, but one only shone directly on the objects focussed. The whole of the plates

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* A method due to W. D. Valentine, of Dundee, and employed by him when engaged on submarine photographic experiments in connection with the ruins of the Old Tay Bridge.

were found, on development, to be considerably under-exposed. It was decided to considerably increase the length of exposure, and ten days later a second attempt was made under similar conditions of lighting and plates. Exposures of 5, 10, and 15 minutes were given; but the results were very poor, indistinct, and blurred, and particularly disappointing. Increased lighting power was obviously required; and for the next attempt five arc lamps were fitted in the air-chamber, being suspended from the ceiling.

Augmentation in lighting power was followed by an immediate improvement in the negatives obtained; and two groups, exposure seven and eight minutes, instantaneous plates, and largest stop, gave results of a more encouraging nature than any yet obtained. A lamp was placed on either side of the group, another immediately behind it, whilst the two remaining lamps illuminated the rest of the caisson.

In the final experiments made, it was decided to try the effect of plates of exceptional rapidity, and in this last attempt xxxxx plates, similar to those in use for the most rapid yacht work, were employed. A further improvement resulted: a considerable gain in definition and sharpness was secured, due, no doubt, in part to the shortened exposure (one and a-half to two minutes being found sufficient), a great desideratum when figures are embodied in the subject. In this instance, the whole of the arc lights were arranged in rows parallel to a straight line drawn from the camera to the centre of group in front, and sufficiently far away from that line to avoid shining directly into the lens, whilst throwing as much light as possible on the objects.

There can be, in conclusion, but little doubt that the haze in the air-chamber must always render the highest results unattainable. All that can be done is to seize the most favourable moment, when the haze is at its minimum, for the range of clearness of the atmosphere inside the air-chamber is very considerable. The air-compressing machinery should run slowly and steadily during the experiments, for any sudden inflow of fresh air will at once tend to raise the haze. Similarly, any sudden expansion of the air, such as that due to its escape, when the excavated material is drawn up through the lock provided for that purpose, at once produces a marked accession of fogginess.

If figures are introduced into the photograph, they should wear as light-coloured clothing as possible, for an inspection of the results obtained indicate at once with what greatly increased clearness all white objects stand out; whilst it will be noticed with interest that the human eye, presumably from its glistening properties, has caught the light, and gleams out of the picture with an unnatural glare, hardly calculated to reassure the timorous visitor, scanning the records of what he will encounter below, whilst endeavouring to brace his mind for a descent.

Owing to the hazy atmosphere it will be found advantageous to keep the camera as close as convenient to the subject, thereby reducing the length of supervening fog as much as possible. So far as could be ascertained, no injury resulted to the plates, either from the moisture below, or from the heavy atmospheric pressure to which they were subjected.

The lens used in the above experiments was by Dallmeyer, 2½in. aperture and 18in. focal length, the plates being 12in. by 15in.

Another caisson remains to be founded, when it is hoped further efforts may be made in this direction to secure photographs under conditions as novel as difficult, and with more success than has hitherto attended the attempts here briefly sketched.

The best thanks of the author are due to W. D. Valentine, of Dundee, who accompanied him on two occasions into the air-chamber, for much valuable advice and assistance, kindly afforded to him in this matter.—*Photographic News.*

AMERICAN NOTES.

(*From our own Correspondent.*)

NEW YORK, January 23rd.

The events of the past few days in trade circles are indicative of a further improvement in demand for foreign material, iron and steel wire rods, tin-plates, &c. The streng upward tendency of the past two months has led a great many large consumers to defer buying in order to weaken the market if possible. Prices have not declined and the urgent demand felt by consumers is compelling them to place requirements for raw materials, including crude and finished iron, construction iron and steel, and lumber. In trade parlance, the market from Boston to St. Louis is termed quiet. Prices, however, are fully maintained at every point. No weakness is observable and it is not believed by the best commercial authorities that there is any probability of weakness between this and April 1st. For this reason railroad agents are placing orders for cars, lumber, stone and hardware, and builders are placing orders for material to be used during the summer. Steel rails are selling at 35 dols. per ton; bar iron, 1·50 dols. to 2 dols.; nails, 2·25 dols. to 2·50 dols. Old rails are extremely scarce and are held at 23 dols. to 24 dols. for American and 22 dols. for English. A further advance seems probable. Old steel rails have advanced to 20 dols. from 15 dols. four months ago. Bessemer pig is quoted at 20 dols; spiegeleisen, 29 dols.; plate iron, 2 dols.; beams and channels, 3 dols. There is less movement in lead, copper, zinc and antimony, and the preparations are being made in the copper field for an increased production, provided prices and demand warrant.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

THE reports which ironmasters attending 'Change in this town to-day—Thursday—and yesterday in Wolverhampton, gave of the state of business were not of a more favourable character. Specifications still come to hand with unaccountable sluggishness, and new orders are for small lines in other than exceptional cases.

Prices keep unsatisfactory. Nearly every fresh order is a matter of negotiation, and a disposition has to be shown to meet consumers' views in every reasonable way. The competition in the common bar trade is such that while Staffordshire bars cannot be delivered in the Thames at any profit at under £6 per ton, Belgian bars are being freely delivered into the Thames at £5. This circumstance is quoted by ironmasters this week as one potent argument in favour of a larger reduction in wages than the 5 per cent. which Alderman Avery recently awarded.

£7 10s. as the recognised quotation for marked bars is still upheld, while medium bars are £6 10s., and common £5 to £5 10s. The makers of sheets appear in some cases to be moderately well employed in the execution of contracts, common sheets—singles—being offered at £6 2s. 6d. and upwards. Doubles are £6 7s. 6d. upwards, and lattens 20s. additional. Rivet-making iron has been latterly asked for in fairly large quantities, and a somewhat better demand for nail, rod, and hoop iron has likewise been noticeable.

Hoops are abundant at £5 5s. to £5 15s., and gas tube strip up to 6¾in. is £5. The full extras of 5s. per ton for 8½in., and of a further 15s. per ton for 10½in. and 12½in. have in times of trade like the present had to be very largely abandoned, and makers have now to be content with a fraction of such extras. There is perhaps more doing in strips than in any description of iron other than sheets. Working-up and stamping-sheet firms are more regularly employed than most of the other ironmasters, and quotations stand at £10 to £11 for the former, and £11 to £12 for the latter. Tank plates are quiet at £7; merchant plates, £7 10s.; and boiler sorts, £8 to £9.

Boiler and other plates are quoted by the New British Iron Company as—£8 for best Corngreaves, £9 for Lion, £10 for best Lion, £11 for double best scrap Lion, £12 for treble best Lion, and £13 for extra treble best. Sheets of 20 gauge are quoted £8, £9, £10 10s., and £11 10s., according to quality; and best charcoal sheets £13. Ship and fender plates are £7 10s. to £8 10s. Slit rods the New British Company quotes:—£6 5s. for Corngreaves, £7 C.G.C. brand, £7 10s. Lion, £9 best Lion, and £11 10s. best charcoal. Steel rods are £8, and iron horseshoe rods £6 10s., £7 10s., and £9, according to quality. Hoops the company quote —£7, £8, and £9 10s. Steel hoops are £8 10s. and best charcoal £12.

The current list of Messrs. Wm. Millington and Co., Summerhill Ironworks, Tipton, is as here:—Bars, £7 10s.; small rounds and squares, £8; $\frac{5}{16}$in. bars, £8 10s.; ¼in., £9; No. 5, £9 10s.; $\frac{3}{16}$in., £10; No. 7, £11; No. 8, £12; and No. 9, £13 10s. Best bars they quote £8 10s.; double best, £9 10s.; and treble best, £11 10s. Plating bars and cable iron, £8; and best ditto, £9; with double best £10. Rivet iron, £8 10s.; best, £8 15s.; and double best, £10 5s. Angles, £8 10s. to £9, and on to £10, according to quality. Boiler plates and sheets, £9; best, £9 10s.; double best, £10 10s.; and treble best boiler plates, £12 10s.

The proposition for restricting the make in the galvanised sheet iron trade continues to be discussed; but it is scarcely thought likely that the carrying out of any definite scheme will be found possible, the more so as production in this district is on the increase. Some satisfactory orders are coming to hand for South America, India, Canada, and elsewhere, while the Australian markets continue to receive large consignments. Galvanised sheets of 24 w.g. are abundant, £10 12s. 6d. upwards, f.o.b. Mersey.

The strike or lock-out of ironworkers at the Bilston Ironworks of Messrs. Sparrow and Co., against a reduction of 7½ per cent. continues, and so likewise does the strike at the Albion Ironworks, West Bromwich, of Messrs. Lees, against a 10 per cent. reduction. At the latter place, however, no interruption to business is caused.

The pig trade is mostly slow, though some better parcels of common native sorts are credited as having lately changed hands. Best sorts are also selling with a little more freedom for foundry purposes, and for the manufacture of shot and shell. All-mines are 55s. to 60s. for hot blast sorts, and cold blast 20s. per ton additional. Part-mines are still 40s. to 42s., and cinder 32s. to 35s. Northampton pigs are 37s. 6d. delivered, and Derbyshires 38s. 6d. to 40s. North Staffordshire are quoted 39s., but without securing sales.

The advanced prices of purple ore are maintained. The price delivered in this district from Runcorn is about 14s. per ton, which is a rise of 2s. during, say, the last three months. The advance results from the heavy purchases on U.S. account.

The Arbitrators to the South Staffordshire Mines Drainage Commissioners presented a report to the Commissioners on Wednesday, in which they recommended the construction of additional surface works, comprising connecting conduits between the Moat and the Bradley pumping engines, situate in the Tipton district, and the old watercourses for carrying off the water from the various engines. The Commissioners resolved to carry out the recommendations.

The South Staffordshire and East Worcestershire Association of Millmen held its second annual meeting at Bilston on Saturday. The report set forth that the enthusiasm formerly manifested in the Association had largely collapsed. Yet the meeting pledged itself to resist any alteration of the wages system in a sectional form.

At the sheet iron rolling mills and roofing works of Messrs. Morewood and Co., at Soho, near Birmingham, the electric light upon a combination of the arc and incandescent system has for some time past been answering admirably. The arc system is used for all the large spaces, and the incandescent system for smiths' shops, warehouses, and offices. The installation comprises ten 1500 candle power arc lights, and thirty 20-candle power incandescent lamps, fed by three Gulcher dynamos, and worked by two vertical engines, one of which drives a roll-turn and lathe during daytime.

Railway engineers have received with much satisfaction the announcement from Melbourne that 250 miles of railway are to be commenced in "a few months' time," and that works of irrigation estimated to cost £300,000 will also "be shortly undertaken." Such works will almost certainly mean increased trade to this district. Railway wheels and axles are being turned out in large numbers on export account. The Patent Shaft and Axletree Company, Wednesbury, which is the largest concern of the kind, is engaged upon 70,000 pairs of axles, the bulk of which are for shipment.

Some constructive engineers hereabouts have submitted tenders to the Director-General of Stores for India for girders of 150ft. span which are just now required for the State Railways, and an attempt will also be made to secure some of the steel and ironwork for the bridges. The stores supplies just now needed by certain of the Indian railway companies should work to the advantage of local manufacturers.

It does not appear that any definite steps are yet being taken by engineering shops in the Birmingham and South Staffordshire district in connection with the movement in the Lancashire centre for a reduction of wages. It is doubtful what course will by-and-bye be pursued, but certainly nothing will be done until after some arrangement has been come to by the Lancashire masters.

In memory of the late Mr. P. D. Bennett, managing director of the Horseley Engineering Works, Tipton, the inhabitants of Horseley Heath and neighbourhood have suggested to the Local Board of Health that a Free Library should be established.

The competition of the Germans in the brass cabinet branch of the lock trade is becoming increasingly severe in the London market. The German goods are produced by machinery, and have a style and finish unpossessed by our similar manufactures. This circumstance is doing much to enable them to more than hold their own in the London market, notwithstanding that some Wolverhampton and Willenhall makers are now producing from German patterns and offering the goods at the German prices. English wages have been reduced 15 or 20 per cent. in the past two or three years.

A report has gained currency this week that the monopoly possessed by Messrs. Nettlefolds in the screw trade is threatened. The statement is that a new method of screw manufacture has been invented by which screws can be produced at 20 per cent. under Nettlefolds' prices. It is further reported that Nettlefolds have offered a heavy sum for the patent rights, but that the offer has been declined, and that the inventor intends forming a company in London for working the patent. It is not at present ascertained whether the report is wholly correct. For some time past Messrs. Nettlefolds have professed to deny the accuracy of a report which was started last October that they had resolved to remove their Shropshire iron and steel and wire works to Newport, Mon., to avoid the heavy railway freights to the ports. Now, however, they have officially confirmed the report.

The position of the wrought iron tube-makers at Netherton is inducing the tube-makers of other districts to form themselves into an association. A meeting of delegates, representing, it was said, about 4000 men employed in the trade, was held at Wolverhampton on Monday, when resolutions were passed in support of the men on strike at Messrs. Lee's Albion Works, West Bromwich.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—A feeling of general depression still pervades the iron trade of this district; there is a continued absence of any movement whatever towards improvement, and that there is a despondent outlook with regard to the future is beginning to show itself in a disposition to sell for long forward delivery at the present extremely low prices, and in some instances even at a little under makers' present rates. Low prices, however, bring forward no weight of buying, and business in all departments continues excessively dull.

The Manchester iron market on Tuesday brought together about an average attendance, but there was again very little business doing. For pig iron a general absence of inquiry was reported, and quoted prices were scarcely more than nominal. Here and there small sales are made, upon which makers get something like their list rates, but there is no business of sufficient weight offering to really test what they would be prepared to accept for anything like good orders. For hematite pig iron, 39s. to 39s. 6d., less 2½, remain nominally the quoted list rates for delivery into the Manchester district, but 38s. to 38s. 6d., less 2½, represent more nearly the figures which local makers would accept to secure orders. In district brands there are makers who are still quoting 39s. to 39s. 6d., less 2½, for delivery here, but it is only in very exceptional cases where more than 37s. 6d. to 38s. 6d., less 2½, is being actually got. Outside brands are offered at very low figures, and there is no difficulty in getting good foundry brands of Middlesbrough at about 40s. per ton net cash delivered equal to Manchester.

Hematites still meet with only a slow demand, and during the past week have shown a tendency towards weakness, 53s., less 2½, being a figure which sellers would now readily accept for good foundry qualities delivered into this district.

The manufactured iron trade shows very little alteration since quarter-day. One or two of the leading firms are still working pretty near full time, and for the season of the year are fairly busy; most of the smaller makers are, however, badly off for orders, and many of the forges are not kept running more than three to four days a week. For all descriptions of finished iron there is but a very dull demand, with prices cut excessively low. For good ordinary qualities of Lancashire and North Staffordshire bars, delivered into the Manchester district, the average price remains at about £5 2s. 6d. to £5 5s. per ton; but there are common bars offering in some instances at as low as £5 per ton. Wages are being reduced 5 per cent., not, however, without opposition from the men in some cases, but the assistance accruing to makers in this direction is very trifling. It is only under exceptional cases that present selling prices more than cover the cost of production, and in most departments makers are manufacturing at a considerable loss.

The condition of the engineering trades remains without material change. An absence of new work coming forward in any bulk is still reported generally, and in most cases works in this district are but very indifferently employed. With regard to the wages question, it seems to be generally anticipated that an amicable arrangement will be come to between the employers and the men. Mr. Burnet, the general secretary of the Amalgamated Society of Engineers, has been over in conference with the Employers' Association, and the notices for the reduction, which expired last week, have been suspended until the 11th inst., and next week a second conference between the Employers' Association and the representatives of the men will be held, when some agreement will no doubt be come to, by which a settlement of the wages question will be arrived at without entering into any struggle between the employers and employed. In fact, a settlement of the question is already being here and there arrived at without waiting for the conference next week, and at some of the boiler works the men have agreed to a reduction of 2s. per week in a fortnight, and a further reduction of 2s. in three months. In the Liverpool district efforts are also being made to effect an amicable arrangement between the masters and the men, but nothing will be definitely decided until early next week.

At the monthly meeting of the Manchester Geological Society, held on Tuesday, an interesting discussion took place on mining questions which had been dealt with in papers previously read before the members. With regard to sudden outbursts of gas, Mr. Clifford Smith said he was of opinion that when these took place the gas had accumulated between strata that had parted, and did not come direct from the coal. Mr. Garforth quite coincided with this view, and remarked that the quantity of gas which was frequently contained in cavities in the strata was quite sufficient to overwhelm the best ventilated colliery. On the question of safety lamps considerable discussion took place, and it was generally urged that these ought to be provided by the mineowners, and also kept in proper working order by them. As to the recent introduction of glass lamps in the place of ordinary gauze lamps, Mr. Hall, inspector of mines, said he had found the percentage of breakages with the glass lamps very largely in excess of the breakages with the gauze lamps. This being so, we were still a long way off a safe lamp, and it was questionable whether we were not advancing in the wrong direction. It was pointed out by other members that the breakage of the glass lamps arose chiefly from expansion under heat, and that the introduction of asbestos rings to the glasses almost entirely removed the liability to breakage from this cause. Mr. Martin, inspector of mines, pointed out that with the present shields much greater care would be requisite in cleaning the lamps, and that with more pieces in the lamps the necessity for careful supervision was increasing. Another important question raised was with reference to workmen's inspections of the mine, the importance of which had been strongly urged by Mr. Burrows in a paper he had read. Mr. Hall, inspector of mines, was of opinion that the proper persons to inspect a mine were those who had the power to enforce what they required to be done, and that if they had workmen to inspect a mine they only substituted unskilled for skilled inspection. Mr. Joseph Dickenson, her Majesty's chief inspector of mines, entertained, however, a very different opinion. When workmen's inspection was first introduced into the Mines Act, he looked upon it as a most important concession to the miners, and an experience now of thirteen years of this regulation made him prize it more and more, the only drawback being that the men so seldom exercised this privilege.

In the coal trade a fairly steady tone is being maintained, owing to the tolerably good demand which has recently been coming forward for house fire consumption, and which has kept the pits going on pretty near full time. Apart, however, from this, trade is only very dull; common round coals meet with but a slow sale for ironmaking and steam purposes, and engine classes of fuel are in but very moderate demand, the threatened renewal of the wages dispute in the cotton trade tending somewhat to unsettle the market. Quoted prices are unchanged from last month, but the tone, if anything, is weak. At the pit mouth best coal can be got from 8s. 6d. to 9s.; seconds, 7s. to 7s. 6d.; common round coals, 5s. 3d. to 5s. 9d.; burgy, 4s. to 4s. 6d.; and slack, from 2s. 6d. to 3s. 6d. per ton, according to quality.

For shipment there is a moderate demand, with good ordinary qualities of steam coal averaging about 7s. 3d. per ton, delivered at the high level, Liverpool, or the Garston Docks.

The trustees of the North-East Lancashire District Mining Fund have issued their first annual report, in which they state that they had at disposal on the 1st January, 1885, the sum of £2788 6s. 11d., of which they invested £2000 in Bolton Corporation bonds, but owing to the lamentable accident at the Clifton Hall Colliery they were compelled to withdraw £500. During the year the trustees had paid to the representatives of 224 persons who died from the effect of accidents in the district the sum of £1082 10s., viz., to 209 cases of sixteen years of age and upwards at the rate of £5 each, and to fifteen cases under sixteen years of age at the rate of £2 10s. The interest received from the Bolton Corporation and the bankers amounted to £66 17s. 5d., and the cost of working expenses to £15 12s. 3d., leaving a balance in the hands of the trustees on the 31st December last of £1757 2s. 1d.

Last week I gave an abstract of the annual report and balance-sheet of the Manchester Coal Exchange; the annual meeting of the members was held on Tuesday, and Mr. John Rawcliffe, the president for the ensuing year, congratulated the members on the success which had attended the working of the exchange since its establishment. During the past year they had again made a very substantial profit; the number of members had also increased, and their membership, which was now 434, was larger than it had ever been before.

Barrow.—The strong tone which last week characterised the iron market of this district remains undisturbed, but there are indications which lead to the belief that we shall have much more active times during the spring and summer season than those which at present are experienced. The inquiry, however, is more particularly confined to Bessemer descriptions of metal, inasmuch as they are in demand, principally for steel-making purposes. The general consumption of forge and foundry iron is very much restricted, as the purposes for which this class of metal are required are in every instance for the moment in a very dull and a very quiet state. The output of pig iron has been increased during the past few days by the relighting of a few furnaces which have been standing idle for some time, and if the indications which are at present showing themselves are maintained, other furnaces will soon be put in blast. Stocks are not so large as they have been, and some heavy deliveries have been made lately, while others are arranged for. Steel makers are much better off for orders than they have been for some considerable period past, but the activity is chiefly observable in the rail department. Orders for other descriptions of steel are very few in number, but it is believed that the improved business in the heavier trades will soon show itself in the lighter goods. Some progress will soon be made here in the rolling of steel plates. Prices of steel are firmer and quotably higher than they have been. Shipbuilders do not report the acceptance of any new orders. Indeed, exceptionally few are on offer. The difference with the men as to the proposed reduction of wages has not yet been settled. It is not improbable that a strike will ensue. Iron ore finds a rather better market at fuller prices. Coal and coke exceptionally quiet. Shipping is indifferently employed, although freights remain very low. Engineers, ironfounders, and boiler-makers are doing a very slow trade, and the minor industries of the district generally are still feeling the full force of a long depression.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

Some coalowners tell me that it is extremely difficult to get rid of "hard" coal, *i.e.*, fuel suitable for manufacturing purposes, and prices are slightly lower than at the corresponding period of last year. Household sorts have not risen with the severe weather, as has usually been the case in former years. The explanation is not hard to find—more is being raised, and there is no extra demand. Gas coal is in brisk request, as is the rule at this season of the year. Prices, of course, are not affected by any pressure at this time, as the gas coal contracts are all made in June for the twelve months. The colliers in this district are now working, taking all classes together, about four days a week. It is satisfactory to know that the efforts which have latterly been made to bring about a sliding scale for the regulation of wages in the coal industry are not going to prove so abortive as previous attempts. An arrangement has been come to between the Executive of the Yorkshire Coalowners' and the Council of the Miners' Association, and the consent of the general body of the coal proprietors is all that is needed to have the new and more sensible method of adjusting colliers' remuneration fairly put to the test of trial. The details of the scheme are not yet disclosed; but it is expected on both sides that the practical result will be to put an end to strikes and lock-outs, and admit of wages rising and falling with the fluctuating values of coal.

The American demand for English hematites is still important, but it has decreased since the beginning of the year. In common iron there has been no advance whatever, the iron markets being very flat, in sympathy with the languid state of the Cleveland industry.

In steel rails there is still less doing, no work of any consequence having been given out since the last American contract, 10,000 tons of which came to England.

No successor has yet been appointed to the late Mr. George Wilson, of the Cyclops Works, in the presidency of the Steel Rail Manufacturers' Association—commonly known as the "Steel Rail Ring," and it is freely stated that the Association may probably not be so long-lived as its friends desired. Its operations have certainly had the effect of staying the downward tendency of prices. Rails are now at £4 15s. per ton. Suppose they were to fall to £3 15s.—which would not be at all improbable if the "Ring" ceased its work—it would be impossible to manufacture at a profit, certainly by no firms whose works were not close to the coast and raw material.

The Staveley Coal and Iron Company, with Messrs. Macfarlane, Strang, and Co., have taken together an important contract for cast iron pipes for the Thirlmere waterworks of the Manchester Corporation. The total weight of cast iron pipes needed will be 51,000 tons, the distance being forty-five miles. The value of the united contracts of the two firms named is £233,193. The Staveley Company has just declared an interim dividend of £1 per share on the A and C shares (£60 paid up), and 3s. 4d. per share on the B and D shares (£10 paid), being at the same rate as at the corresponding period of last year.

German competition is being more severely felt than ever. The largest house in the edge tool trade recently told his men that as his customers on the Continent had ceased to store his goods, he could no longer produce tools to lie on his shelves unless at a reduction of 15 per cent. in wages. This the men declined to grant. The employer then intimated that he was compelled to confine his work to such orders as might come in. The result, of course, has been that the men have been out of work, with the exception of the actual orders which have been received. In this way, as has been pointed out, the English and German workmen are now brought face to face. It is for the former to say whether they are prepared to contest the matter with the German workmen, or be beaten out of the field. There will be a diminution of work for the English artisan until the manufacturer is able to meet the low wages and hostile tariffs he has to fight against on the Continent.

The Australian sheep shear season is about to open. Two circumstances are expected to militate against its prosperity. The market is already overstocked, and the results of the disastrous drought are still severely felt. In New South Wales alone, owing to the ewes dying through lack of water, it is estimated that there are 14,000,000 fewer sheep than would have been in these parts if the season had been favourable. Of course, if there are few sheep to shear, fewer shears and all kinds of cutlery requisites needed by the wool-growers are required. The South American markets, which do not open until April, are expected to be fairly brisk.

The dispute at Messrs. Hornsby and Sons, Spittlegate Ironworks, Grantham, to which I have already referred, has terminated in the acceptance of the employers' terms, which involved a reduction of wages.

Mr. J. Willis Dixon, who represents one of our oldest firms and families—being head of the great silver and plating establishment of Messrs. James Dixon and Sons, Cornish-place—has again been unanimously elected president of the Sheffield Chamber of Commerce. Mr. C. E. Howard Vincent, M.P. for the Central Division, was present, and gave an admirable address, which made a favourable impression on the Chamber.

The Sheffield Technical School, which has been established at a cost of £11,500, was formally opened last Monday by Sir Frederick Bramwell, F.R.S., President of the Institute of Civil Engineers, and chairman of the Executive Committee of the City and Guilds of London Institute. The latter body gave £300 a year for five years; the Duke of Norfolk, £3000; Mr. F. T. Mappin, M.P., £2000; Town Trustees, £3000; Mr. T. Jessop, £500; Duke of Devonshire, £500; several local iron and steel companies, £100 each. At the evening meeting a letter was received from Mr. Howard Vincent, M.P., offering a prize to the most successful pupil in the coming year in the course of study most closely connected with the cutlery trade, of a tourist ticket to the schools of thought and work in Brussels, Berlin, Dresden, Vienna, Munich, and Paris. The offer was received with much applause.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

The tone of the Cleveland iron trade continues exceedingly flat and gloomy. At the market held at Middlesbrough on Tuesday last but little business was done, and prices were somewhat easier than they were the week before. Makers are indisposed to entertain present prices at all; what little business is transacted is, therefore, done by merchants. For prompt delivery small lots of No. 3 g.m.b. sometimes realise only 30s. 9d. per ton, but the price commonly quoted is 31s. There are very few inquiries for forward delivery, and it is therefore difficult to say at what figure orders could be placed. Merchants ask 3d. to 6d. per ton more for forward than for present delivery, but makers decline to quote at all, The demand for forge iron is slack, and the price has fallen to 30s. 3d. per ton, or 3d. below the rate asked last week.

There is a further decline in the value of warrants. A considerable tonnage has changed hands at 31s. 3d. per ton. Stocks of pig iron in Messrs. Connal and Co.'s stores continue to increase both at Middlesbrough and Glasgow. At Middlesbrough the stock amounted on Monday last to 159,830 tons, being an increase during January of 17,157 tons. At Glasgow it was 681,081 tons, or 10,349 tons more than at the commencement of the year. The shipment of pig iron from the Tees has been much retarded by the severe weather. Only 47,696 tons were sent away during January, as compared with 60,648 tons during January, 1885, and 57,421 tons during December. The principal items were as follows:—Scotland took 20,437 tons; Wales, 5203 tons; Holland, 3320 tons; France, 3215 tons; Italy, 2846 tons; Belgium, 1775 tons; and America, 1300 tons.

The output of finished iron is smaller than ever, especially as regards plates. Scarcely any of the mills are kept going full time. There is no change in prices. The steel plate and angle mills are fairly well employed, but the strike at the shipyards will cause some of them to stop unless a settlement is quickly arrived at. Steel ship plates are £6 10s. per ton, and angles £6 5s., in trucks at makers' works.

The average net realised price of Durham coal during the three months, October, November, and December, was 4s. 7·62d. per ton. No alteration in wages is thereby involved.

The report of Mr. Waterhouse, accountant to the Board of Arbitration, relating to the months of November and December, 1885, has just been issued. The average realised price of manufactured iron of all kinds was only £4 15s. net at makers' works, which represents a fall of 2s. per ton. But this diminution of prices, already unprecedentedly low, is not the worst part of the story. The aggregate output has receded from 30,000 tons to about 22,000 tons per month. The 8000 tons deficiency is equivalent to the production of the two works at Middlesbrough which have temporarily stopped, and accounts for and justifies the action taken by the firms owning them. Curiously enough, the realised price of bars appears to have risen 1s. 6d. per ton, whilst the output has materially diminished. This seeming inconsistency is, however, capable of easy explanation. There are four firms sending returns who occupy themselves in making bar iron of all sections and various qualities. There are two others who occasionally enter the market and secure at minimum price any large contracts which may be obtainable, of common quality, suitable for railway tie-bars and similar purposes. When any such contracts are in progress, the average price of bar iron is naturally depressed below the normal level, and the output is increased. During the past two months no such contracts happen to have been current; hence the diminished output and increased price.

The annual meeting of the Board of Arbitration and an ordinary meeting of the Standing Committee were held at Darlington on Monday last. The officers and representatives of last year were in the main re-elected. There was no other business of public interest.

The distress at Middlesbrough through stoppage at some of the ironworks seems to be on the increase. The number of persons in receipt of out-door relief now stands at 5141. In the corresponding week of last year it was only 2295. The expenditure in relief has increased from £351 to £787 per week. In addition to this the workhouse now contains 793 paupers, which is an increase of 143 as compared with last year.

There seems to be considerable difficulty in managing the various stoneyards, and the men employed there do not seem to regard their occupation with any more satisfaction than do their employers the more thrifty portion of the public. It is to be feared that there are many hundreds if not thousands of families who are virtually starving in our Northern towns.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

The Scotch iron market has this week shown comparatively little activity. There have been fluctuations in prices, but a lower figure than before has again been touched, and there is no decided opinion even among those who take the most hopeful view of business that prices will not yet go lower still. The past week's shipments of pig iron were small, amounting to 6611 tons, as compared with 6051 in the preceding week, and 8833 in the corresponding week of 1883. The total shipments from Christmas to date are 27,940 tons, as against 39,594 in the same time last year, 46,833 in 1884, and 51,304 in 1883. The inquiry on the part of the United States is backward, and that from the Continent is even more unsatisfactory; while the home consumption both of our own and of iron imported from Cleveland is smaller than was anticipated. Up to date the imports of Middlesbrough pigs are 23,179 tons less than in the same period of last year, but as merchants have had a large amount in stock in Glasgow, it might be a mistake to assume that the falling off in the home consumption is anything like so large as the above figures would by themselves appear to indicate. The addition to the stock of Scotch pigs in Messrs. Connal and Co.'s Glasgow stores for the week is upwards of 4000 tons. There are 95 furnaces in blast, as against 94 at the corresponding date; 75 of these producing ordinary pig iron, 15 hematite, 4 basic, and 1 silicious iron.

Business was done in the warrant market on Friday at 39s. 7½d. cash. The market opened on Monday at 39s. 6d., and improved to 39s. 8d. cash. On Tuesday forenoon transactions took place at 39s. 8d. to 39s. 9½d., and back to 39s. 8½d. cash, while the afternoon quotations were 39s. 8d. to 39s. 6½d. cash, closing with buyers at 39s. 6d. cash. Business was done on Wednesday at 39s. 6d. to 39s. 7d., closing with sellers at 39s. 5d. cash. To-day—Thursday—the market was very depressed, with business down to 39s. 2d. cash, closing with sellers at that figure, buyers ½d. less.

Makers' iron, which is in limited demand, is again lower, as follows:—Gartsherrie, f.o.b. at Glasgow, per ton, No. 1, 44s. 6d.; No. 3, 42s. 6d.; Coltness, 48s. and 44s. 6d.; Langloan, 46s. and 43s. 6d.; Summerlee, 49s. 6d. and 43s. 6d.; Calder, 48s. and 42s. 6d.; Carnbroe, 44s. and 41s. 6d.; Clyde, 45s. and 41s.; Monkland, 40s. 6d. and 38s.; Quarter, 40s. and 37s. 6d.; Govan, at Broomielaw, 40s. 6d. and 38s.; Shotts, at Leith, 46s. and 45s. 6d.; Carron, at Grangemouth, 48s. 6d. and 45s. 6d.; Kinneil, at Bo'ness, 43s. 6d. and 42s. 6d.; Glengarnock, at Ardrossan, 44s. 6d. and 41s. 6d.; Eglinton, 40s. 6d. and 37s. 6d.; Dalmellington, 42s. 6d. and 39s. 6d.

In the malleable iron department some of the works are fairly busy with orders, a large proportion of which are for abroad; but in other cases there is little doing. The steel works continue well employed, mainly on shipbuilding contracts.

The past week's shipments of iron and steel manufactured goods from the Clyde embraced £1460 worth of machinery, £1473 sewing machines, £2734 steel goods, and £15,660 iron manufactures.

In the coal trade there is a great want of animation. The shipments of the past week embraced 19,143 tons from Glasgow, 1094 at Greenock, 6168 at Ayr, 1889 at Irvine, 7091 at Troon, 4245 at Leith, 2983 at Grangemouth, and 2500 at Bo'ness. The snowstorm has interfered to a considerable extent in some districts with the coal traffic, but this has caused less inconvenience on account of the reduced demand in the shipping department. For household coals the inquiry has necessarily been active, but the prices of all sorts are without material change. On the east coast the coal trade is very backward at present, as a result of the continental markets being shut.

The miners in most districts are reported more anxious to work full time than they were when the coal market was much more active. Very exaggerated statements have been made to the men by their leaders as to the prices obtained for coals at the ports, but correct information on the subject is being at the same time placed before the men through the medium of the newspapers.

Mr. Alex. Hill has read an interesting paper to the Mining Institute of Scotland, on "Mining as carried on in the Province of Huelva, Spain."

During the past month five vessels were launched from the Clyde shipyards, with an aggregate tonnage of 9150 tons, as compared with 10,760 tons in the same month last year, and 6340 tons in January, 1884. Several marine engineers have in hand considerable orders for engines for war vessels that are being built in Russia and other countries, and it is hoped that some of the engines about to be contracted for by the British Admiralty for the ironclads and cruisers now in course of construction will also come to the Clyde. It is estimated that there are at least 50,000 tons more shipping in hand just now than at this time last year. Notwithstanding this, however, a number of builders are doing very little.

The rivetters in the employment of Messrs. Russell and Co., Greenock and Port Glasgow, have come out on strike in consequence of a dispute as to piece wages.

WALES AND ADJOINING COUNTIES.

(*From our own Correspondent.*)

Reports from the coal valleys are still very variable; where one colliery is found to be turning out an average output, many will be noticed as scarcely working half time. Slackness of orders and stormy weather are given as prevailing causes. Ferndale only worked fourteen days last month, and this speaks volumes.

I noticed last week the number of Government contracts that are certain to come to Wales. One only has been booked since, and this by the Dowlais Iron Company, for the supply of Admiralty coals to Gibraltar. It is expected that a few more will be placed in the course of a week.

The variable alterations of the barometer have kept the colliery officials on the alert of late, and in one or two collieries explosions have been avoided by timely precautions. In the Cwm colliery, of Cyfarthfa, on Saturday, a fall, which may be due to a falling barometer or a throb of the earth currents, according to some scientific opinion, took place, killing three men outright and injuring another, it is feared, fatally. Numerous single accidents are also on record, and I fear that many sufferers have neglected the precaution of insuring in the Miners' Provident Fund. An interesting subject of discussion in coal matters is coming to the front. Cardiff now stands as the largest coaling port in the world. With a foreign export of nine and a-half million tons annually, the employment in coal mining alone of 60,000 men and boys, and an enormous capital invested in the industry, query should there not be a more direct government than is afforded by the Home Secretary. Ministers of Agriculture and Ministers of Mines would meet with popular opinion at present.

As an illustration of the great advance in particular collieries, I may cite Coedcae, which has come to the front as one of the finest collieries of the Rhondda, with a great area and steadily increasing output. I recollect—and not long ago—when the output at this place was 120 tons a day. It now turns out 13,000 tons per week.

Cardiff export last week was 125,000 tons only, showing a falling-off of 10,000 tons. Newport showed an increase of [illegible] tons; but the prevailing complaint is slackness.

Prices remain stationary, house and steam. Small steam can be bought as low as 4s.

The slackness of the Welsh industries has naturally told on the Taff Vale line. I see the dividend is to be 10 per cent., with 2 per cent. bonus. This is the lowest for a length of time. It has been 10 per cent., and 8 per cent. bonus.

The Rhymney will declare 10 per cent. I see that the agitation for linking the Rhymney and the Taff is still going on, and I have a strong impression that the general body of shareholders wish it, but lack unity and directness of action. Swansea industries are tolerably active. 25,000 tons of coal were sent away last week, and though patent fuel is still very sluggish, yet 2500 tons left last week, and it is hoped this trade is reviving.

The iron and steel trades are quiet. Nothing absolutely doing to call for any comment. Waiting, hoping, and stocking may be taken as describing the condition.

Tin-plate, too, is dull. Notice is out at Ynyspenllwch, but this is thought only to mean a reduction. The Gurnos Works will soon be re-started.

Prices are low, the failure of the combination having told more to the benefit of buyers than makers. Coke plates are now 13s. 9d. to 14s. Siemens vary according to brand. They can be had as low as 14s. 3d., and as high as 15s. 3d. Bessemers are quoted from 14s. up; ternes from 13s. 9d. to 15s. Stocks continue to increase, shipments having been few of late. A new company for making steel and tin-plates was registered this week for Swansea, so prospects of future trade are not regarded as bad.

The prospects of Newport are looking up. I announced some time ago the intention of Messrs. Nettlefold, the well-known Birmingham and Shropshire firm of iron, wire, and screw makers, to have a branch establishment there, and this is now fully decided. They have secured land from Lord Tredegar, and are confident upon manufacturing and transmitting material at far less cost than in the Midlands.

Messrs. Baldwin, sheet iron and steel makers, of Wilden and Swindon, are also going to open a branch works at Newport, instead of an extension as at first contemplated at Swindon.

These are signs of the future. The coalfield of the future is Newport district.

A pleasing event took place at Aberdare on Saturday last, when a deputation of colliers from Dowlais, Cyfarthfa, and Plymouth waited on Sir W. T. Lewis with an address of congratulation. It must have been highly gratifying, as the deputation represented many thousand colliers, and it had a practical earnest air about it, without the slightest fragment of display.

Colonial College and Training Farms.—The prospectus has been issued of the Colonial College and Training Farms, Limited, of Hollesley Ray, Suffolk, which is being organised under powerful influence for the training of youths intending to emigrate. The proposal is very strongly supported, and deserves wide encouragement. The offices of the Company are at 6A, Victoria-street, Westminster, S.W., Mr. Alex. Rivington being honorary secretary.

Naval Engineer Appointments.—The following appointments have been made at the Admiralty:—Edward A. E. Crowley, assistant engineer, to the Himalaya; Alfred J. Allen and Samuel J. Rock, chief engineers, additional, to the Excellent, for torpedo course in the Vernon, and hydraulic course in the Excellent; George B. Alton, engineer, to the Indus, additional, for service as Admiralty overseer at Messrs. Harland and Wolffe's, Belfast, during the construction of machinery of the Bramble and the Lizard; and Joseph Langmaid, engineer, to the Indus, additional for the training college for engineer students.

NEW COMPANIES.

THE following companies have just been registered:—

Simond's Round Forging Company, Limited.

This company was registered on the 26th ult. with a capital of £100,000, in £20 shares, to purchase and work patent rights relating to improvements in methods and machines for making irregularly-shaped metal articles that are circular in cross-sectional area. The subscribers are:—

	Shares.
*G. F. Simonds, Royal Hotel, Blackfriars, mechanical engineer	1
*C. T. Cayley, Brackley-street, E.C., mechanical engineer	1
*G. Chulow, 51, Belsize-avenue, card manufacturer	1
J. Allen, Seward-street, St. Luke's, Royal Mail contractor	1
J. Allen, jun., Duppas-hill, Croydon	1
W. Watts, Cowslip-road, George-lane, Essex, clerk	1
*W. R. Lake, 45, Southampton-buildings, consulting engineer	1

The number of directors is not to be less than three nor more than seven; qualification, fifty shares. The first are the subscribers denoted by an asterisk, and Lord Thurlow, who is appointed chairman at a remuneration of £1000 per annum. The other directors will be entitled to £1000 per annum, together with 10 per cent. of the net profits over 10 per cent. per annum. Mr. C. T. Cayley is appointed manager and managing director at a salary of £1000 per annum.

Woodhouse and Rawson Electric Supply Company of Great Britain, Limited.

This company was registered on the 25th ult. with a capital of £100,000, in £10 shares, to purchase the goodwill of the business of the supply department of Messrs. Woodhouse and Rawson, 11, Queen Victoria-street, so far as relates to the United Kingdom, and to become sole agents for the sale of all articles manufactured by the Woodhouse and Rawson Electric Manufacturing Company, Limited. The subscribers are:—

	Shares.
*O. E. Woodhouse, 11, Queen Victoria-street, electrical engineer	1
*F. L. Rawson, 11, Queen Victoria-street, electrical engineer	1
W. L. Madgen, 11, Queen Victoria-street, electrical engineer	1
Carl von Buch, 17, Cavendish-place, W., electrical engineer	1
J. H. Ward, 113, Lavender-street, S.W., clerk	1
*E. H. Burnett, 160, Cromwell-road, timber merchant	1
E. Manville, 38, Litherland-avenue, Maida Vale, electrical engineer	1

The number of directors is not to be less than three nor more than seven; qualification, 100 shares; the first are the subscribers denoted by an asterisk; the company in general meeting will determine remuneration. Messrs. O. E. Woodhouse and F. L. Rawson are appointed managing directors, and Mr. Carl von Buch is appointed first secretary.

Architectural Pottery Company, Limited.

It is proposed by this company to purchase the business carried on at Hamworthy, Poole, county of Dorset, under the style of the Architectural Pottery Company. The company was registered on the 23rd December with a capital of £50,000, in £5 shares, with the following as first subscribers:—

	Shares.
*T. R. Saunders, Bournemouth	1
R. R. Judd, Parkstone, Dorset, accountant	1
E. Stanbridge, Poole, Dorset, high bailiff of county court	1
G. Gibson, Poole, Dorset, secretary to a company	1
W. A. Stevens, 14, Edward-street, N.W., commission agent	1
B. G. March, 79, Queen-street, public accountant and auditor	1
*J. Richardson, 23, Leadenhall-street, merchant	1

The number of directors is not to be less than three nor more than five; qualification, fifty shares; the first are Messrs. A. T. Hawkins, John Bennett, E. R. Walker, and the subscribers denoted by an asterisk; remuneration, £400 per annum.

Automatic Window and Inventions Company, Limited.

This company was registered on the 21st ult. with a capital of £50,000, in £1 shares, to purchase and work the letters patent dated 21st August, 1884, No. 11,517, for improvements in railway carriage and other carriage windows, and also the letters patent dated 20th April, 1885, No. 4886, relating to further improvements. The purchase consideration is 25,000 shares. The subscribers are:—

	Shares.
Arnold Pye Smith, 16, Philpot-lane, manufacturer	1
J. C. Cottam, 39, Lombard-street, merchant	1
A. Jennings, 28, Gracechurch-street, merchant	1
W. S. Lockhart, C.E., 7, Fenchurch-street	1
William Shepherd, 31, Lombard-street, secretary to a company	1
William Wethered, 2, Phillimore-terrace, merchant	1
G. D. Jennings, 28, Gracechurch-street, merchant	1

Most of the regulations of Table A are adopted.

Brin's Oxygen Company, Limited.

This company was registered on the 26th ult. with a capital of £100,000, in £100 shares, to purchase certain patent rights and inventions, referred to in an unregistered agreement between Arthur Brin and Léon Quentin Brin of the first part, S. W. Cragg of the second part, Henry Sharp of the third part, and the company of the fourth part. The subscribers are:—

	Shares.
*Henry Sharp, Bournemouth, manufacturer	10
*J. Sharp, Chilworth, Surrey, electrician	10
Arthur Brin, C.E., Kensington-crescent	1
S. Sharp, Connaught Mansions, Victoria-street, electrical engineer	5
A. Cooper, Park-road, Twickenham, accountant	1
C. Sharp, Chilworth, Surrey, bar student	4
William Sharp, 9, Wallbrook, solicitor	1

The number of directors is not to be less than three nor more than seven; qualification, 30 A or 10 B shares, or corresponding stock. The first are Messrs. Henry Sharp and J. Sharp, and not more than five others, to be nominated by the subscribers. Minimum remuneration, £800 per annum, and a further amount equal to 10 per cent. of the profits in each year in which 10 per cent. dividend is paid.

Greenwich Ferry Company, Limited.

This company was registered on the 22nd ult. with a capital of £100,000, in £5 shares, to acquire steamboats, ferry-boats, floating bridges, &c., for the conveyance of passengers, horses, cattle, goods, and merchandise upon the Thames. The subscribers are:—

	Shares.
George Smith, 16, Kitto-road, Nunhead, stockbroker	1
G. J. Cross, Adelaide-road, Brockley, consulting engineer	1
H. S. Foster, Glenhurst, West Dulwich, law student	1
Colonel C. Steele, Shedfield, Southampton	1
C. Hight, 3, Copthall-buildings, chartered accountant	1
R. J. Smith, 2, Victoria Mansions, Westminster, contractor	1
D. N. Arnold, Endcliffe Mount, Sheffield, engineer	1

The number of directors is not to be less than three nor more than ten; qualification, £100 in stock or shares; the subscribers are to appoint the first; remuneration, £900 per annum, with an additional £150 for each director in excess of five.

Letts' Diaries Company, Limited.

On the 27th ult. this company was registered with a capital of £12,000, in £10 shares, to purchase the whole or any part of the business of Letts, Son, and Co., Limited. The subscribers are:—

	Shares.
T. D. Galpin, La Belle Sauvage, E.C., publisher	1
Robert Turner, La Belle Sauvage, E.C., publisher	1
*W. Hazell, 6, Kirby-street, Hatton-garden, printer	1
*W. J. Woods, Crouch-hill, publisher	1
*S. C. Galpin, Bristol House, Roehampton, S.W., publisher	1
*J. E. Viney, 6, Kirby-street, printer	1
*G. Watson, 52, Long-acre, printer	1
F. B. King, 6, Kirby-street, printer	1

The number of directors is not to be less than four nor more than eight; the first are the subscribers denoted by an asterisk and Mr. John Hamer, of Ladywell, Dartmouth Park-hill. One-half of the directors is to be appointed by Cassell and Co., Limited, and the remaining half by Hazell, Watson, and Viney, Limited, so long as they are members of the company. The remuneration of the directors will be determined by the company in general meeting.

Miller's Tanning Extract Company, Limited.

This is the conversion to a company of the business of tanning extract manufacturers, merchants, and timber merchants, carried on by the firm of J. and J. Miller and Co., at Millerton and Mortimore, in New Brunswick, Canada, and at the New Leather Market, Bermondsey. It was registered on the 26th ult. with a capital of £100,000, in £10 shares. The subscribers are:—

	Shares.
A. Lafone, Leather Market, leather factor	1
*Lord G. G. Campbell, R.N., 2, Bryanston-square	1
*F. Mortimore, Leather Market, merchant	1
A. W. Lafone, Leather Market, merchant	1
D. E. Miller, Leather Market, extract manufacturer	1
C. A. Duff Miller, Leather Market, extract manufacturer	1
*R. Cobb, 11, Lime-street, produce broker	1

The number of directors is not to be less than three nor more than seven; qualification, 100 shares; the first are the subscribers denoted by an asterisk; remuneration, £650 per annum, with a further £50 for each 1 per cent. dividend above 10 per cent. per annum.

Pendleton Spinning Company, Limited.

This company proposes to trade as spinners and manufacturers of cotton, silk, wool, flax, and other fibrous substances, and for such purposes will acquire the Windsor Mills, Pendleton, Lancaster, the property of Hall, McKerrow, and Co., Limited, together with turning power. It was registered on the 23rd ult. with a capital of £20,000, in £50 shares. The subscribers are:—

	Shares.
*J. Bridge, St. Mary's-gate, Manchester, commercial traveller	1
*J. B. McKerrow, 6, Nicholas-street, Manchester, manufacturer	1
*Max Baerlein, Salford, merchant	1
*Henry Lawton, Oldham, merchant	1
Thomas Hall, 6, Nicholas-street, Manchester, manufacturer	1
S. Cohn, 111, Portland-street, Manchester, merchant	1
H. Lightbourn, Hayfield Mills, Pendleton, paper-stainer	1

The number of directors is not to be less than three nor more than seven; qualification, five shares; the first are the subscribers denoted by an asterisk and Mr. R. Illingworth. The company in general meeting will determine remuneration.

George Newman and Co., Limited.

This company was constituted by articles of association on the 26th ult., and registered as a limited company on the 27th ult., with a capital of £50,000, in £10 shares, 2500 of which (fully paid up) are allotted. It proposes to carry on the business of builder and contractor in all branches. The members are:—

	Shares.
*G. Newman, 51, King-street, Deptford, builder	2500
*H. Newman, 61, Church-street, Deptford	1
W. Newman, Chingford, plumber	1
C. Newman, 61, Church-street, Deptford, clerk	1
D. Newman, Chingford, builder	1
J. H. Newman, South Norwood, builder	1
A. Morgan, 21, George-street, Deptford, builder	1
W. M. Sholter, 91, Grove-street, Deptford, clerk	1

The number of directors is not to be more than seven; the first are the two first subscribers and Mr. H. G. Wright, of Ingram House, 165, Fenchurch-street; the company in general meeting will determine remuneration.

THE PATENT JOURNAL.

Condensed from the Journal of the Commissioners of Patents.

Applications for Letters Patent.

*** When patents have been "communicated" the name and address of the communicating party are printed in italics.

26th January, 1886.

1123. Raising and Transmitting Grain, &c., A. Barclay and J. Walker, Glasgow.
1124. Bottles, Jars, and Tin-ware Vessels, T. Johns, Clifton.
1125. Distributing Electricity, W. H. Snell, London.
1126. Cements and Plasters, C. D. Alison, London.
1127. Shaving Brushes, J. H. Smith, Birmingham.
1128. Printing Figures or Marks Indicating Measured Lengths upon the Borders of Textile Fabrics, &c., F. and J. and P. Desbruéres, Manchester.
1129. Kilns, H. H. Redfern, Hanley.
1130. Sand-faced Bricks, &c., W. Johnson, Leeds.
1131. Ornamenting Metallic Bedsteads, T. Causnett and R. Leadley, Birmingham.
1132. Neck Part of Knobs, T. Causnett and R. Leadley, Birmingham.
1133. Easels, E. Tittle, Salford.
1134. Ornamenting Metallic Bedsteads, T. Causnett and R. Leadley, Birmingham.
1135 Fasteners for Gloves and Shoes, G. H. Bliss, Paris.
1136. Teaching Writing, Drawing, &c., R. Wallwork, Manchester.
1137. Tops or Caps for Scent Bottles, L. Spiers, Birmingham.
1138. Locks, A. K. Bergmann, Paris.
1139. Lever Locks and Latches, T. Walton, Birmingham.
1140. Locking Mechanism of Lock-up Spirit Frames, T. Hill, Sheffield.
1141. Lock Nuts, F. Chamberlain, London.
1142. Removable Horse Sharpeners, S. A. Ward, Sheffield.
1143. Key and other Rings, C. T. Willetts, Birmingham.
1144. Blind Roller, W. H. Keates, Bournemouth.
1145. Automatic Coupling and Uncoupling Apparatus, E J. Adams, London.
1146. Velocipedes, A. L. and A. J. G. Bricknell, London.
1147. Velocipedes, W. Phillips, London.
1148. Valvular Apparatus and Float Mechanism, S. H. Wright, Liverpool.
1149. Door Checks, H. Hartung, London.
1150. Electro-dynamic Motors, T. J. Handford.—(*F. J. Sprague, United States.*)
1151. Galvanic Batteries, W. W. Popplewell.—(*F. L. O. Lathrop, J. W. Carter, and C. Faber, U.S.*)
1152. Railway Signalling Apparatus, H. Williams and A. Williamson, London.
1153. Stoppering, &c., Bottles and like Receptacles, B. J. Grimes, London.
1154. Vehicle Seats, G. Downing.—(*P. A. Laravière and D. A. McCaskill, Canada.*)
1155. Brackets, W. Cluse, London.
1156. Securing Knobs or Handles to Doors, J. H. Burt, London.
1157. Motive Power Engines, W. Neil, Glasgow.
1158. Jet Bracelets, H. Warner, London.
1159. Cutting, Pinking, and Ornamenting Fabrics, &c., B. J. B. Mills.—(*F. Voland, France.*)
1160. Smelting Ores, W. P. Thompson.—(*A. H. Cowles, United States.*)
1161. Lining for the Walls of Electric Furnaces, W. P. Thompson.—(*E. H. and A. H. Cowles, U.S.*)
1162. Wringing and Mangling Machines, J. and R. W. Kenyon, and J. Barnes, Liverpool.
1163. Drying Floors for Bricks, H. R. Vaughan, Liverpool.
1164. Wire Rod Rolling Mills, P. M. Justice.—(*C. H. Morgan, United States.*)
1165. Hood Projector, C. Coleman, London.
1166. Gas Burners, F. Leslie, London.
1167. Trousers Pockets, W. J. Furnival, London.
1168. Automatic Door Closer and Check, D. T. Winter, London.
1169. Convertible Kitchen Ranges, A. Gillespie and G. Turnbull, London.
1170. Cricket Bats, H. Woodham, London.
1171. Composition for Sharpening Tools, F. Balbi, London.
1172. Life Boats, A. M. Wood, London.
1173. Machines for Filling Bottles, &c., F. Foster and J. H. Hamilton, London.
1174. Mechanism for Adjusting the Seats of Two-wheeled Carriages, J. E. Standfield, London.
1175. Brake Gear for Wagonettes, J. E. Standfield, London.
1176. Railway Chairs, E. Massey and J. H. Simcock, London.
1177. Metallic Riggers, A. Goodwin and A. Goodwin, jun., London.
1178. Paper, J. H. Oberhaensli, London.
1179. Horseshoes, &c., M. J. Rowley and J. G. Johnson, London.
1180. Breech-loading Fire-arms, L. Stackfleth, London.
1181. Lathes, M. F. Starke and M. Weinrebe, London.
1182. India-rubber Boots and Shoes, W. D. Hutchinson, London.
1183. Supporting Lanterns, &c., R. E. B. Crompton, London.
1184. Water Meters, A. J. Boult.—(*J. G. Richert, Sweden.*)
1185. Syphons for Flushing Cisterns, A. J. Boult.—(*J. G. Richert, Sweden.*)
1186. Automatically Extinguishing Gas Lamps, A. Le-Grand, London.
1187. Stopping and Starting Tram-cars, A. Le-Grand, London.
1188. Applying Cork Rings to Bottles, S. A. Bull, London.
1189. Car Couplers, N. W. Hawkenson, London.
1190. Rolls for Reducing Old Rails to Flat Bars, E. D. Wassell, Pittsburgh, U S.
1191. Bushes for the Bung-holes of Casks, W. R. Lake.—(*W. Kromer, Germany.*)
1192. Insulating Stands, O. E. Woodhouse and F. L. Rawson, London.
1193. Incandescent Electric Lamps, O. E. Woodhouse and F. L. Rawson, London.
1194. Incandescence Gas Lights, F. L. Rawson, London.
1195. Incandescence Gas Lights, F. L. Rawson and T. V. Hughes, London.
1196. Actuating Mechanism for Electro-static Generators, J. G. Lorrain, London.

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1197. Signalling, F. E. Stuart, London.
1198. Sporting Guns, W. Ford, Birmingham.
1199. Suspenders for Pictures, C S. Snell, London.
1200. Infants' Diapers and Underclothing, T. Roberts, Manchester.
1201. Spring for Velocipedes, A. Peddie, London.
1202. Automatically Inserting Press Papers between the Folds of Cloth, J. Marshall, Glasgow.
1203. Saving Life at Sea, A. Turner, Manchester.
1204. Curled or Looped Woven Fabric, H. Lister, Halifax.
1205. Seal Skin, &c., Piled Fabrics, H. Lister, Halifax.
1206. Chimney Cowl, G. Whitehead, Rochdale.
1207. Cork-cutting Machine, J. F. Russell, London.
1208. Shoes for Horses, J. Monk, Halifax.
1209. Racquets for Lawn-tennis, C. R. Heap, London.
1210. Mercurial Gauges, H. J. H. King, Newmarket.
1211. Splitting Firewood, W. B. Brooker, Bootle.
1212. Railway Couplings for the Protection of Life, W. H. Adcock, Fazely.
1213. Automatically Stripping Out Press Papers from the Folds of Woven Fabrics, J. Marshall, Glasgow.
1214. Reservoir Pen Holders, M. Myers and E. Hunt, Birmingham.
1215. Combination Cramp, Cutter, and Compass, T. Dredge, Birmingham.
1216. Cupboard Fastenings, T. Causnett and R. Leadley, Birmingham.
1217. Punched or Perforated Covered Jars, J. Roberts, Newcastle-on-Tyne.
1218. Basin for Drain Gullies, C. Glossop, Sheffield.
1219. Securing Lengths of Flexible Hose Together C. Darrah, jun., London.
1220. Electric Clocks, J. Cassey and J. F. Dixon, Birmingham.
1221. Safety Appliances for Travelling Cranes, A. Hewlett and J. Laithwaite, Liverpool.
1222. Treating Malt Extracts, E. R. Southby, London.
1223. Attaching Screws to Ironwork, T. S. Price, London.
1224. Sewing Machines, J. Laird, Belfast.
1225. Menu Cards or Tablets, C. Keywort, London.
1226. Charging and Drawing Gas Retorts, J. West, London.
1227. Cover or Lid for Jugs, W. H. Shaw, Staffordshire.
1228. Furnaces, H. Thompson, London.
1229. Blowing House Fires, E. Brookes, London.
1230. Securing Door Knobs on their Spindles, J. W Radford, London.
1231. Self Hair-cutting Apparatus, H. S. King.—(*H. Manners, India.*)
1232. Ambulance Stretchers, T. Whitelock, London.
1233. Flushing Syphons, W. Bartholomew and E. A. Reynolds, London.
1234. Ointment for Preventing Mosquito Bites, M. Shirer, London.
1235. Incandescent Gas Light, C. von Buch, London.
1236. Adjusting Weights for Weighing, C. F. Clark London.
1237. Pipes for Smoking, S. Watkins, London.
1238. Curling or Coiling Hair, M. Moore, London.
1239. Embossed Material for Decorating Walls, M. Conrath, London.
1240. Embossing Rolls, M. Conrath, London.
1241. Obtaining Magnesia, A. Fould and P. Genreau, London.
1242. Hydraulic Apparatus, M. B. Fontaine and E. Widmann, London.
1243. Refractory Bricks, &c., A. Fould and P. Genreau, London.
1244. Tramway and other Road Engines, R. C. Parsons, London.
1245. Press for Tennis and other Bats, A. J. Altman, London.
1246. Thermo-electric Piles, R. F. Venner, London.
1247. Valves for Steam or other Engines, H. Harford and C. F. Sutcliffe, London.
1248. Wicks, C. H. Fitzmaurice, London.
1249. Coffee Mills, G. A. Wilkins, London.
1250. Electrical Contact Apparatus, C. O. Varley, London.
1251. Transmission of Motive-power, W. R. Lake.—(*F. Fossati, Italy.*)
1252. Railway Couplings, W. Dagnall, London.
1253. Dental Engine, A. Jamieson, London.
1254. Preventing Colliery Explosions, A. Kellar and W. Blakemore, London.
1255. Pocket Flasks, &c., H. A. Silver and W. S. Bennett, London.

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1256. Carding Machines, W. Cunningham, Glasgow.
1257. Lawn-tennis Racquets or Bats, W. Sykes Wakefield.
1258. Register for Cisterns, S. Bunting, Dublin.
1259. Treatment of Sewage, S. D. Cox and J. Cox, Bexley Heath.
1260. Warming the Compartments of Railway Carriages, R. Ashton, Heaton Mersey.
1261. Filtering, &c., Sewage, &c., F. L. Jeyes, Westminster.
1262. Tools for Forming Grooves in Bottle Mouths, D. Rylands and B. Stoner, Barnsley.
1263. Lamps, J. B. Fenby, Sutton Coldfield.
1264. Writing with Fluid Ink, G. Messervy, Jersey.
1265. Buckles, J. Burgess, Manchester.
1266. Filling Syphon and other Bottles, W. Bruce and T. Ashmore, Liverpool.
1267. Horseshoes. W. Trobe, jun., South Shields.
1268. Clocks, J. Fellheimer.—(*D. Chase, United States.*)
1269. Checking, &c., the Number of Persons Entering and Leaving Tram-cars, &c., W. H. Gittens and W. Hunter, Liverpool.
1270. Hair-pins, F. Goodman, London.
1271. Indicating the Direction of Working of Marine Engines, C. MacLeod, Liverpool.
1272. Non-slipping Conical Tuning Pin for Pianofortes, J. S. Brenchley, London.
1273. Couplings for Railway Rolling Stock, C. Goddard, London.
1274. Envelopes, W. and J. S. Hughes, Portmadoc.—*23rd October*, 1885.
1275. A Tree Pruner, G., R. H., and A. H. Coppin, Addington.
1276. Brooms and Brushes, A. Reside, London.
1277. Utilising Clockwork as a Motive Power, E. Sauze, London.
1278. Preparing Flax for Spinning, J. C. Mewburn.—(*C. Droulers-Vernier, France.*)
1279. Scandinavian Padlocks, J., D., and A. Minors, London.
1280. Gauging Machines, B. Wright, London.
1281. Wire Frame for Bags, D. Allport, London.
1282. Securing Door Knobs to their Spindles, J. B. O'Callaghan, London.
1283. Securing Chairs to Metallic Sleepers, J. G. Bell, London.
1284. Regulating Electrical Currents, J. A. Kingdon, London.
1285. Candle Lamps, C. W. Blackman, London.
1286. Cases or Covers for Books, R. Leighton and A. E. Adlard, London.
1287. Portable Brushes, F. Mitchell, London.
1288. Obtaining Compounds of Cobalt, G. Perry.—(*M. Perry, New South Wales.*)
1289. Obtaining Compounds of Cobalt, G. Perry.—(*M. Perry, New South Wales.*)
1290. Attachment to Fire-arms, G. Flaischlen, London.
1291. Holders for Filing Papers, F. Müller, London.
1292. Telephones, H. Edmunds.—(*S. Thornberry, United States.*)
1293. Finings for Malt, &c., Liquors, C. J. Pickthall, London.

29th Januasy, 1886.

1294. Constructing Rackets for Tennis, &c., F. L. Jeyes, London.
1295. Pins for Brooches, J. W. Evans, Birmingham.
1296. Jack Cranes, C. Priestland, Aston.
1297. Raising the Covers of Biscuit Boxes, &c., E. T. and H. F. Woolley, Birmingham.
1298. Ship-steering Apparatus, W. Hewitt, R. Roger, and H. T. Robson, Stockton-on-Tees.
1299. Ring-spinning Frames, S. Tweedale, Halifax.
1300. Looms for Weaving, W. Thompson and R. Heaps, Halifax.
1301. Locking Bicycles, &c., C. Church, London.
1302. Brackets for Holding Glass Tablets, &c., J. Evans, jun, Birmingham.
1303. Driving Chain for Velocipedes, W. Deakin, Birmingham.
1304. Discharging Water from Ships, &c., C. and H. Nicholas, Landport.
1305. Couplings for Railway Wagons, J. Beddall and F. W. Small, Openshaw.
1306. Raising and Lowering Globe and Chimney Galleries of Paraffin, &c., Lamp Burners, H. A. Walker and J. A. Ellis, Erdington.
1307. Apparatus to be Fastened to the Ordinary Shoe of a Horse to Prevent Slipping, A. Ashby and G. F. Gibbs, Luton.

1308. LOCK-FURNITURE, G. and P. Hookham, Birmingham.
1309. RESISTANCE BOXES, G. A. Nussbaum. London.
1310. TELEPHONE TRANSMITTERS, W. P. Thompson.—(*E. T. Gilliland, United States.*)
1311. UMBRELLA STANDS, C. West, London.
1312. RAILWAY WAGON, &c., COUPLINGS, T. Williams, Stockton-on-Tees.
1313. INCANDESCENT LAMP HOLDERS, W. A. S. Benson, London.
1314. PASSAGES for FLUIDS, J. C. Merryweather and C. J. W. Jakeman, London.
1315. WHEELS, J. C. Merryweather and C. J. W. Jakeman, London.
1316. WASHING MACHINES, F. Welp, London.
1317. ROTARY ENGINES, C. J. Rusher, London.
1318. AUTOMATIC CANDLE EXTINGUISHER, L. Blumfeld.—(*C. Erhard, Germany.*)
1319. EXCLUDING DRAUGHTS from DOORS, &c., J. Pickstock, London.
1320. SECONDARY BATTERIES, A. Reckenzaun, London.
1321. AUTOMATIC COUPLING of RAILWAY CARRIAGES, G. W. Moon, London.
1322. PORTABLE ELECTRIC BURGLAR ALARMS and BELLS, L. C. Dettmar, London.
1323. LAWN-TENNIS NETS, J. W. Bennett, London.
1324. EXTRACTING FIBRES from FIBROUS PLANTS, J. C. Mewburn.—(*E. Lepage, France.*)
1325. COOKING RANGES, R. Hunter and W. Moffatt, Glasgow.
1326. COMBINED SIGHT ELEVATORS and WIND GAUGES, E. Harrison and W. J. Jeffery, London.
1327. INDICATING the OVERHEATING of BEARINGS, R. Richards, London.
1328. STOPPERS for BOTTLES, &c., G. F. Redfern.—(*C. Korthaus, Germany*)
1329. FORMING MOULDS for CASTING, F. Butterfield, London.
1330. PRESERVING MILK and CREAM, W. McDonnell, London.
1331. SEWING MACHINE STANDS, J. Wertheim, London.
1332. SUPPORTING WINDOW SASHES, E. J. Hill, London.
1333. SINGLE and DUPLEX GAS BURNERS, T. Heron, London.
1334. TELL-TALE TIMEKEEPERS, J. Millar, London.
1335. TRUSSING CASKS, C. Hewitt, London.
1336. SECURING in PLACE BOLTS, NUTS, &c., H. A. Gadsden, London.
1337. ELECTRICAL SWITCHES, F. L. Rawson and J. H. Davies, London.
1338. CAR WHEEL TRUING MACHINES, M. E. Dayton, London.
1339. RAILWAY BUFFERS, F. J. Talbot, London.
1340. DYNAMO-ELECTRIC MACHINES, G. C. Fricker, Putney.
1341. ADJUSTABLE GLOBE or SHADE HOLDERS for LAMPS, T. Heron, London.
1342. ANNEALING or TEMPERING METALLIC WIRE, A. K. Huntington, London.
1343. COUPLING for RAILWAY GOODS TRUCKS, S. Pettit and G. W. Pitt, London.
1344. DARNING STOCKINGS, &c., W. L. Wise.—(*P. E. Foucar, Germany.*)

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1345. ANEMOMETER INDEPENDENT of FRICTION, W. H. Dines, Hersham.
1346. PYRAMID DRAUGHTS, J. Hyde, Acton.
1347. AUTOMATIC COUPLINGS for RAILWAY VEHICLES, H. S. Stewart, London.
1348. ADJUSTING the SEATS of TRICYCLES, H. W. Greenfield, London.
1349. HOLDER for GAS GLOBES and FITTINGS, H. Harper, Birmingham.
1350. LETTER-PRESS PRINTERS' CHASES, J. B. Ellis, London.
1351. PREVENTING DOWN-DRAUGHTS in CHIMNEYS, H. J. B. Holland, Blackburn.
1352. FURNACES, R. Scott, Newcastle-on-Tyne.
1353. MAGIC-LANTERN SLIDE FITTINGS, A. Phillips, jun., Manchester.
1854. ELECTRODE for SECONDARY BATTERIES, H. J. Allison.—(*E. M. Gardner, United States.*)
1355. FIGURED WOVEN FABRICS, E. Makin, jun., and H. W. Makin, Manchester.
1356. DISINFECTING WEARING APPAREL, A. Bradley, Salford.
1357. CONVERTIBLE DESKS, W. and F. H. Fisher, Birmingham.
1358. BICYCLES, S. Lee, London.
1359. COATING and CLEANING METAL PLATES, &c., J. R. Turnock, Loughor.
1360. RAILWAY CHAIRS, B. Rhodes, Bradford.
1361. FORMING DESIGNS on WOVEN FABRICS, J. and A. E. Walker, Halifax.
1362. COUPLING RAILWAY TRUCKS, &c., B. Schofield, Halifax.
1363. HORSE RUGS, W. and J. Terry, Halifax.
1364. WATERPROOF GARMENTS, L. Mistovski, Manchester.
1365. INSTANTANEOUS PHOTOGRAPHIC DROP-SHUTTER, T. Forrest, Pontypridd.
1366. OIL LAMPS, D. B. Morison, Hartlepool.
1367. INODOROUS GAS CALORIFERE, G. Kinnaird, Glasgow.
1368. CRAMPING the CORNERS of PICTURE FRAMES, T. S. Payne, West Croydon.
1369. EMPTYING CESSPOOLS, F. Piattini, London.
1370. HAND-GUARD for BATSMEN in CRICKET, J. Jeffery, London.
1371. RAISING WATER, &c., S. H. Wright, Liverpool.
1372. FIREPLACES, &c., J. S. Watson and H. S. Moorwood, Sheffield.
1373. MALT SHOVELS, T. Zschack, London.
1374. HANDLES for PERAMBULATORS, &c., C. Groom, London.
1375. GALVANIC BATTERIES, R. M. Baily, jun., and A. Grundy, London.
1376. COOKING UTENSIL, F. J. Bird, London.
1377. CINDER SIFTER, F. J. Bird, London.
1378. CARD and LETTER STATIONERY RACK, F. J. Bird, London.
1379. WRITING INK VESSELS and STANDS, D. Paton, London.
1380. IRONS, HINGES, and FASTENINGS, J. J. Mazellet, London.
1381. RESERVOIR PEN, J. D. Perrett, Glasgow.
1382. CLEARING SHIPS' MOORING and TELEGRAPH CABLES, H. J. Eck and E. Archer, Clapham.
1383. TWISTING or DOUBLING SLIVERS, YARNS, &c., J. W. Shepherd, W. Ayrton, and R. Clegg, Manchester.
1384. MANHOLE DOOR, H. J. Conolly, S. S. Phillips, and H. F. Green, London.
1385. FASTENING the ENDS of BALE HOOPS, J. Watson, London.
1386. SHEET METAL TUBULAR HANDLES of SAUCEPANS, &c., C. F. Clark and J. L. Dubois, London.
1387. WINDOW, &c., CLEANERS, C. Price, London.
1388. FRINGING TEXTILE FABRICS, J. Booth and J. Woodhouse, London.
1389. GRINDING or POLISHING RODS, TUBES, &c., W. S. Boult and J. C. W. Stanley, London.
1390. PAPER BARREL CASINGS, W. S. Boult, London.
1391. FEEDING FURNACES with FUEL, H. Maus, London.
1392. RADIAL PARALLEL TRAVELLER, G. B. Cutler, London.
1393. HORSESHOES, H. J. Haddan.—(*A. E. Wiemann, Austria.*)
1394. MOTOR ENGINES, W. D. and S. Priestman, Hull.
1395. GOVERNORS for MOTIVE POWER ENGINES, T. Heather, London.
1396. COUPLING RAILWAY WAGONS, H. H. A. Schwarz, London.
1397. LACING MACHINES, H. B. Payne and W. Campion, London.
1398. WIRE FENCING, E. Fox, London.
1399. PRINTING, &c., KNITTED FABRICS, G. H. Nussey, London.
1400. MANUFACTURING, &c., DRY GAS METERS, G. Welch, London.
1401. PNEUMATIC COUPLERS for ORGANS, H. Booth, London.
1402. SNOW PLOUGH, R. C. C. White, London.
1403. JEWELLERY, F. S. Banks, London.
1404. SCISSORS, &c., M. Pulvermann.—(*Messrs. Gerresheim and Son, Germany.*)
1405. PREVENTING CRUSHING at THEATRES, J. H. Taylor, London.
1406. APPARATUS for CLEANING STREETS, B. G. D. Cooke, London.
1407. CARTRIDGE CASES, B. G. D. Cooke, London.
1408. VENTILATING SEWERS, W. Webb, Twickenham.
1409. WHEELS for RAILWAY PURPOSES, O. Jones, London.
1410. INCANDESCENT ELECTRIC LAMPS, C. Bake, London.
1411. BREECH-LOADING FIRE-ARMS, T. Nordenfelt, London.
1412. DOOR MATS, P. Fraser, Glasgow.

1st February, 1886.

1413. OPENING GATES by the AGENCY of WATER, &c., H. Barcroft, Belfast.
1414. GLASS TILES, J. Haley, Manchester.
1415. PRIMARY ELECTRIC BATTERIES, N. J. Contarini and T. Wrigley, London.
1416. FASTENERS for GATES, J. Fletcher, Durham.
1417. MOUNTING STEREOTYPE PLATES, M. A. Gauntlett, Brighton.
1418. COMBINATION SEAT COVER and APRON, W. Hussey, Birmingham.
1419. BALL BEARINGS, A. T. Shellard, Bristol.
1420. COATING of STEAM PIPES, &c., J. Payne, Cardiff.
1421. GOVERNING MARINE SCREW-PROPELLER ENGINES, G. T. Grey and G. Burnett, Durham.
1422. BROOCHES, S. Pearce, Birmingham.
1423. SKIPS for PACKING, A. May, Glossop.
1424. APPARATUS for WASHING WOVEN FABRICS, W. Birch, Manchester.
1425. NUMERICAL INDICATOR, T. P. Hewitt, Prescot.
1426. PARCEL CARRIER, H. A. Done, Sutton Coldfield.
1427. STEEL ANVILS, W. Chrimes, jun., Dudley.
1428. APPARATUS for STOPPING and STARTING VEHICLES, J. Monteith, Glasgow.
1429. REFLECTOR for BILLIARD GAS LIGHTS, T. Thorp, Whitefield.
1430. GAS REGULATORS, R. Hargreaves and J. Bardsley, Manchester.
1431. AUTOMATIC WATER DISCHARGING and FIRE-ALARM APPARATUS, G. Mills, Manchester.
1432. OPENING the LENSES in PHOTOGRAPHY, F. C. Moore, Leeds.
1433. GAS ENGINES, G. McGhee, Glasgow.
1434. HORSESHOE for PREVENTING SLIPPING, J. Taylor, Ardwick.
1435. SELF-MEASURING APPLIANCE, S. A. Cooke, London.
1436. SMOKE CONSUMING FURNACES, H. Rösicke, London.
1437. BOOTS and SHOES, W. Yarwood, London.
1438. RAILS, C. D. Norton, London.
1439. PUMPS, J. Atkinson, London.
1440. TEMPERING STEEL, P. Adie, London.
1441. INDEXING by CARDS, J. B. Burr, London.
1442. BUTTER, W. A. Murray, London.
1443. FEEDING CLOVER HULLERS, M. E. Perring, Michigan, U.S.
1444. FIRE-ESCAPE, M. Ross, Glasgow.
1445. MEANS for INDICATING when a LETTER has been OPENED, L. A. Groth.—(*M. P. Herfurth, Saxony.*)
1446. METAL CASEMENTS, J. E. Williams, London.
1447. PURIFYING GRAIN, A. G. Brookes.—(*G. F. A. Neiderer and J. H. A. Kahl, Germany.*)
1448. TIPS of SPECTACLES, W. Baldwin, London.
1449. BORING, &c., MACHINES, R. Stanley, London.
1450. LOCK, P. Everitt, London.
1451. GUIDE-PLATES, W. Atkinson, Bradford.
1452. OPENING. &c., FANLIGHTS, J. W. Shepherd, Bradford.
1453. REFLECTORS, L. Sepulchre, London.
1454. TYPE-WRITERS, R. E. Morris, London.
1455. REMOVABLE COLLARS for any-sized WARP BEAMS, W. and G. R. Baker, London.
1456. FASTENERS for HAMPERS, &c., W. P. Ellmore, London.
1457. HEATING KILNS for DRYING MALT, &c., A. S. Tomkins and F. A. Cracknall, London.
1458 ELECTRO-TELEGRAPHIC APPARATUS, J. J. Ebel, New Charlton.
1459. ILLUMINATING GAS and VOLATILE LIQUID HYDROCARBONS, J. L. Balfour and J. Lane, London.
1460. STANDS for HOLDING LETTERS, &c., C. Johnson, London.
1461. TREATMENT of BEER RETURNS, &c., F. Faulkner and G. R. Wilson, London.
1462. BREEDING CAGE for DOMESTIC BIRDS, J. Agombar, London.
1463. HOLDERS for PENCILS, &c., K. Strössenreuther, London.
1464. MIXING, &c., COMBUSTIBLE CHARGES OPERATING LIQUID HYDROCARBON ENGINES, J. J. R. Humes, London.
1465. BLUING WATER for LAUNDRY, &c., PURPOSES, H. Horner, London.
1466. LADIES' WATERPROOF GARMENTS, H. Frankenburg, Manchester.
1467. SAFETY FASTENINGS for RAILWAY CARRIAGE DOORS, &c., M. and T. Thomas, London.
1468. AUTOMATICALLY WORKING the POINTS, &c., on RAILWAYS, D. Hanna, London.
1469. TELEGRAPHIC PRINTING APPARATUS, E. Edwards.—(*L. A. E. Parment, France.*)
1470. RECOVERY of NICKEL from SCRAPS of METAL PLATED or OTHERWISE, H. H. Lake.—(*La Société de Laminage du Nickel, France.*)
1471. COUPLINGS on RAILWAY CARRIAGES, &c., W. and J. Boucher, London.
1472. BALING PRESSES, H. G. Hansen and F. Mackenzie, London.
1473. COVERING of METAL with NICKEL, &c., H. H. Lake.—(*La Société de Laminage du Nickel, France.*)
1474. FIRE-EXTINGUISHING APPARATUS, S. Smirke, London.
1475. LAMPS for BURNING PARAFFINE OIL, E. Patterson and W. H. Strype, London.
1476. CHOPPING or MINCING MACHINE, J. J. Lane, London.
1477. SHORT CURTAIN HOLDERS for WINDOWS, J. H. Weston, London.
1478. CONTROLLING the FLIGHT of BIRDS, A. M. Clark.—(*R. Dennin, France.*)
1479. FASTENER for BRACELETS, &c., E. Taylor and S. Garside, London.

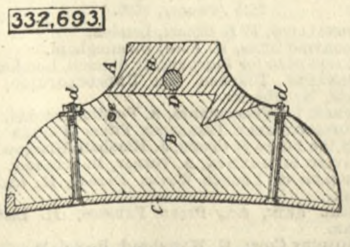
SELECTED AMERICAN PATENTS.

(*From the United States' Patent Office official Gazette.*)

332,693. BRAKE BLOCK, *Robert S. C. Herman, Gardenville, Md.—Filed May* 10*th*, 1884.

Claim.—(1) A brake block consisting of a brake shoe having ears *b*, which protect the sides of the rubber B, provided with a facing piece, and said rubber held in place by a set screw and supported on a projection *c*, which also receives the thrust, all constructed and arranged substantially as specified. (2) The combination of a brake shoe A, having ears *b* and angular projection *c*, with a rubber B having facing piece C, and held in place by a set screw *e* and attached to the brake bar D, all constructed and arranged substantially as and for the purpose set forth.

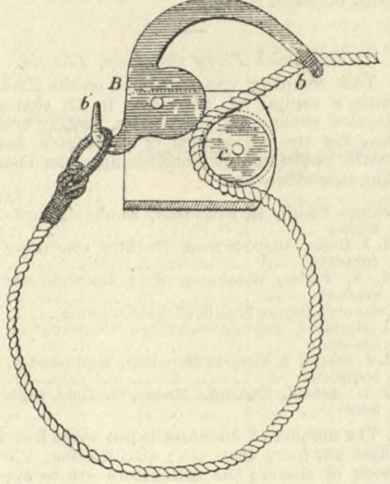
332,693.



332,619. FODDER BINDER, *Charles E. Moles, Whilmot, Ohio.—Filed October* 21*st*, 1884.

Claim.—In a temporary binder for straw, grain, &c., cam lever B, having a hook b^1 at one end and the eye *b* at the other, in combination with the pulley *c* and a cord having a loop or ring, substantially as and for the purpose described.

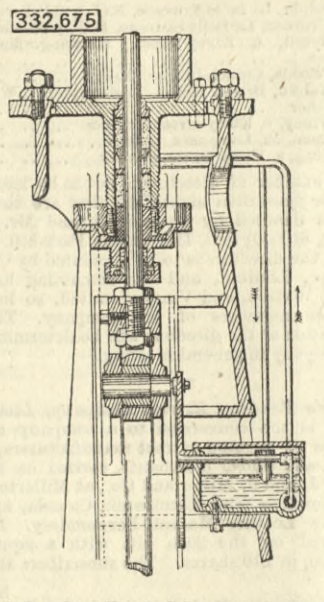
332,619.



332,675. STUFFING-BOX FOR PISTON-RODS OF ICE MACHINES, &c., *George F. Ott, Philadelphia, Pa.—Filed November* 11*th*, 1885.

Claim.—(1) The combination, substantially as before set forth, of the stuffing-box having an oil cavity in the packing, a pump for forcing oil into said cavity, and a safety valve connected with said oil cavity. (2) The combination, substantially as before set forth, of the stuffing-box, the skeleton separator ring in the packing, a pump for forcing oil into the cavity formed by said separator ring in the packing, an oil well, and a safety valve within the oil well and connected with the said cavity in the packing.

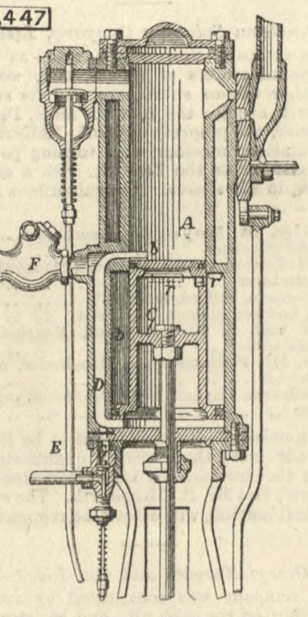
332,675



332,447. GAS ENGINE, *Cephas Shelburne, Richmond, Va.—Filed April* 7*th*, 1885.

Claim.—(1) In a gas motor engine, the combination of the cylinder A having the enlarged end, the piston C having the enlarged head working in the enlarged end of the cylinder, unobstructed port *r* in the cylinder, communicating with the outer air, and passage D provided with air and gas valves F and G. (2) In a gas motor engine, the combination of the cylinder A having the enlarged end, the piston C having the enlarged head working in the enlarged end of the cylinder, port *r* in the cylinder, communicating with the outer air, passage D, and ports *b* b^2, communicating with the enlarged and reduced portions of the cylinder, air valve F at one end of passage D, gas valve G at opposite end thereof, perforated plate *p* between the gas valve G and the port b^2, and discharge valve E, adapted to be opened just before the piston has uncovered the port *b*, substantially as described. (3) The combination, in a gas engine, of the cylinder A, piston C, air-jacket B^1, and unobstructed ports *r* r^2 for keeping up a constant current of air in and around the piston, as and for the purpose specified.

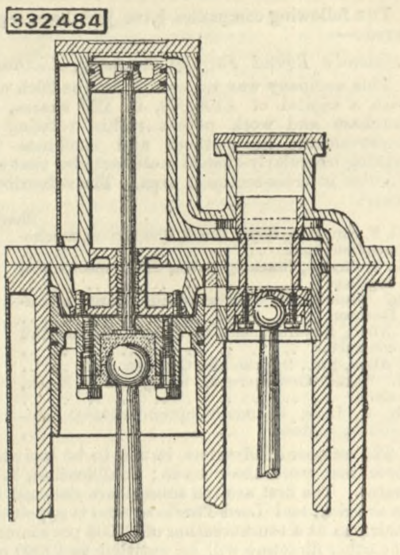
332,447



332,484. COMPOUND ENGINE, *Peter Brotherhood, Lambeth, Surrey, England.—Filed February* 12*th*, 1885.

Claim.—The combination of a small or high-pressure cylinder with a larger or expansion cylinder, single-acting and in line with the small cylinder, and a slide valve and ports so arranged that while the full pressure acts constantly on the back of the smaller piston it acts on its front during the back stroke, the larger cylinder then discharging the exhaust, and during the forward stroke the fluid that had acted in front of the smaller piston expands into the larger cylinder acting on the larger piston, substantially as herein described.

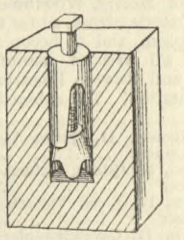
332,484



332,701. ANCHOR BOLT, *William S. Craig, Springfield, Ohio.—Filed April* 14*th*, 1885.

Claim.—(1) The combination, with the cylindrica tapered piece, of the cylindrical sleeve having three or more longitudinal openings and a similar number of legs adapted to be expanded by said tapered piece, and means for forcing said tapered piece into said sleeve, substantially as specified. (2) The combination, with the sleeve having the longitudinal openings therein, of the tapered piece hollowed out and notched at the bottom thereof, and a bolt adapted to extend through said sleeve and screw into said tapered piece, which is correspondingly tapped, substantially as specified.

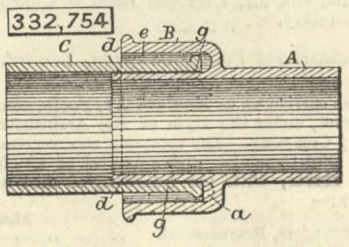
332,701



332,754. PIPE JOINT, *George R. Scott, Washington, D.C.—Filed November* 3*rd*, 1885.

Claim.—(1) In a pipe joint, the pipe A, having a continuation D, and a slightly shorter hub B surrounding it, thus forming a recess in which are contained the ribs *a*, in combination with the pipe C, telescoping over the continuation D of the pipe A, substantially as and for the purpose set forth. (2) In a pipe joint, the pipe A, having a continuation D, and a slightly shorter hub B, with the ribs *a*, in combination with the pipe C, and a rubber or packing ring *d*, substantially as and for the purpose described.

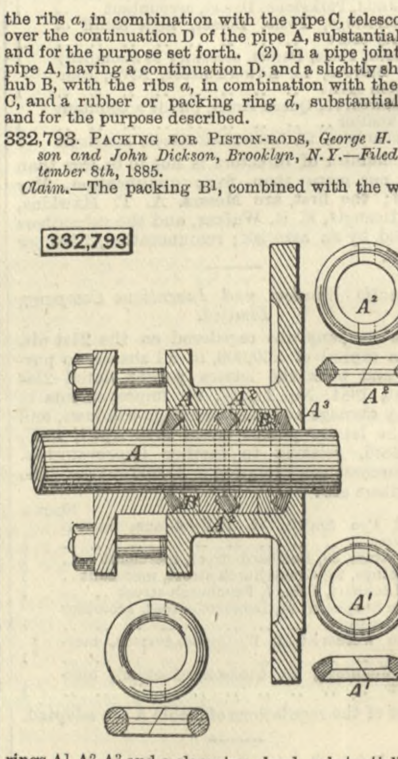
332,754



332,793. PACKING FOR PISTON-RODS, *George H. Dickson and John Dickson, Brooklyn, N.Y.—Filed September* 8*th*, 1885.

Claim.—The packing B^1, combined with the wedge rings A^1 A^2 A^3 and a clamping gland, substantially as and for the purpose specified.

332,793



[SUPPLEMENT TO THE ENGINEER, FEBRUARY 5, 1886.]

CONVERSION TABLES FOR FRENCH AND ENGLISH MEASURES.—No. I. LENGTH.

METRES AND FEET; CENTIMETRES AND INCHES; KILOMETRES AND MILES.

No.	Metres = Feet.	Feet = Metres	Cm. = Inches.	Inches = Cm.	Kiloms. = Miles.	Miles = Kiloms.
100	328·1	30·5	39·4	254·0	62·1	160·9
1	331·4	30·8	39·8	256·5	62·8	162·5
2	334·6	31·1	40·1	259·1	63·4	164·1
3	337·9	31·4	40·5	261·6	64·0	165·8
4	341·2	31·7	40·9	264·1	64·6	167·4
5	344·5	32·0	41·3	266·7	65·2	169·0
6	347·8	32·3	41·7	269·2	65·9	170·6
7	351·1	32·6	42·1	271·8	66·5	172·2
8	354·3	32·9	42·5	274·3	67·1	173·8
9	357·6	33·2	42·9	276·8	67·7	175·4
110	360·9	33·5	43·3	279·4	68·4	177·0
1	364·2	33·8	43·7	281·9	69·0	178·6
2	367·5	34·1	44·1	284·5	69·6	180·2
3	370·7	34·4	44·5	287·0	70·2	181·9
4	374·0	34·7	44·9	289·5	70·9	183·5
5	377·3	35·0	45·3	292·1	71·5	185·1
6	380·6	35·3	45·7	294·6	72·1	186·7
7	383·9	35·6	46·1	297·2	72·7	188·3
8	387·1	35·9	46·4	299·7	73·3	189·9
9	390·4	36·3	46·8	302·2	73·9	191·5
120	393·7	36·6	47·2	304·8	74·6	193·1
1	397·0	36·9	47·6	307·3	75·2	194·7
2	400·3	37·2	48·0	309·9	75·8	196·3
3	403·5	37·5	48·4	312·4	76·4	197·9
4	406·8	37·8	48·8	314·9	77·1	199·6
5	410·1	38·1	49·2	317·5	77·7	201·2
6	413·4	38·4	49·6	320·0	78·3	202·8
7	416·7	38·7	50·0	322·6	78·9	204·4
8	419·9	39·0	50·4	325·1	79·5	206·0
9	423·2	39·3	50·8	327·6	80·2	207·6
130	426·5	39·6	51·2	330·2	80·8	209·2
1	429·8	39·9	51·6	332·7	81·4	210·8
2	433·1	40·2	52·0	335·3	82·0	212·4
3	436·4	40·5	52·4	337·8	82·6	214·0
4	439·6	40·8	52·8	340·3	83·3	215·7
5	442·9	41·1	53·2	342·9	83·9	217·3
6	446·2	41·4	53·5	345·4	84·5	218·9
7	449·5	41·7	53·9	348·0	85·1	220·5
8	452·8	42·1	54·3	350·5	85·8	222·1
9	456·0	42·4	54·7	353·0	86·4	223·7
140	459·3	42·7	55·1	355·6	87·0	225·3
1	462·6	43·0	55·5	358·1	87·6	226·9
2	465·9	43·3	55·9	360·7	88·2	228·5
3	469·2	43·6	56·3	363·2	88·8	230·1
4	472·4	43·9	56·7	365·7	89·5	231·7
5	475·7	44·2	57·1	368·3	90·1	233·3
6	479·0	44·5	57·5	370·8	90·7	235·0
7	482·3	44·8	57·9	373·4	91·3	236·6
8	485·6	45·1	58·3	375·9	92·0	238·2
9	488·8	45·4	58·7	378·4	92·6	239·8
150	492·1	45·7	59·1	381·0	93·2	241·4
1	495·4	46·0	59·4	383·5	93·8	243·0
2	498·7	46·3	59·8	386·1	94·4	244·6
3	502·0	46·6	60·2	388·6	95·1	246·2
4	505·3	46·9	60·6	391·1	95·7	247·8
5	508·5	47·2	61·0	393·7	96·3	249·4
6	511·8	47·5	61·4	396·2	96·9	251·1
7	515·1	47·8	61·8	398·8	97·6	252·7
8	518·4	48·1	62·2	401·3	98·2	254·3
9	521·7	48·4	62·6	403·8	98·8	255·9
160	524·9	48·8	63·0	406·4	99·4	257·5
1	528·2	49·1	63·4	408·9	100·0	259·1
2	531·5	49·4	63·8	411·5	100·7	260·7
3	534·8	49·7	64·2	414·0	101·3	262·3
4	538·1	50·0	64·6	416·5	101·9	263·9
5	541·3	50·3	65·0	419·1	102·5	265·5
6	544·6	50·6	65·3	421·6	103·1	267·1
7	547·9	50·9	65·7	424·2	103·8	268·8
8	551·2	51·2	66·1	426·7	104·4	270·4
9	554·5	51·5	66·5	429·2	105·0	272·0
170	557·8	51·8	66·9	431·8	105·6	273·6
1	561·0	52·1	67·3	434·3	106·3	275·2
2	564·3	52·4	67·7	436·9	106·9	276·8
3	567·6	52·7	68·1	439·4	107·5	278·4
4	570·9	53·0	68·5	441·9	108·1	280·0
5	574·2	53·3	68·9	444·5	108·7	281·6
6	577·4	53·6	69·3	447·0	109·4	283·2
7	580·7	53·9	69·7	449·6	110·0	284·8
8	584·0	54·2	70·1	452·1	110·6	286·5
9	587·3	54·6	70·5	454·6	111·2	288·1
180	590·6	54·9	70·9	457·2	111·8	289·7
1	593·8	55·2	71·3	459·7	112·5	291·3
2	597·1	55·5	71·6	462·3	113·1	292·9
3	600·4	55·8	72·0	464·8	113·7	294·5
4	603·7	56·1	72·4	467·3	114·3	296·1
5	607·0	56·4	72·8	469·9	115·0	297·7
6	610·2	56·7	73·2	472·4	115·6	299·3
7	613·5	57·0	73·6	475·0	116·2	300·9
8	616·8	57·3	74·0	477·5	116·8	302·5
9	620·1	57·6	74·4	480·0	117·4	304·2
190	623·4	57·9	74·8	482·6	118·1	305·8
1	626·6	58·2	75·2	485·1	118·7	307·4
2	629·9	58·5	75·6	487·7	119·3	309·0
3	633·2	58·8	76·0	490·2	119·9	310·6
4	636·5	59·1	76·4	492·7	120·5	312·2
5	639·8	59·4	76·8	495·3	121·2	313·8
6	643·1	59·7	77·2	497·8	121·8	315·4
7	646·3	60·0	77·6	500·4	122·4	317·0
8	649·6	60·3	77·9	502·9	123·0	318·6
9	652·9	60·6	78·3	505·4	123·7	320·3
200	656·2	61·0	78·7	508·0	124·3	321·9
1	659·5	61·3	79·1	510·5	124·9	323·5
2	662·7	61·6	79·5	513·1	125·5	325·1
3	666·0	61·9	79·9	515·6	126·1	326·7
4	669·3	62·2	80·3	518·1	126·8	328·3
5	672·6	62·5	80·7	520·7	127·4	329·9
6	675·9	62·8	81·1	523·2	128·0	331·5
7	679·1	63·1	81·5	525·8	128·6	333·1
8	682·4	63·4	81·9	528·3	129·2	334·7
9	685·7	63·7	82·3	530·8	129·9	336·3
210	689·0	64·0	82·7	533·4	130·5	338·0
1	692·3	64·3	83·1	535·9	131·1	339·6
2	695·5	64·6	83·5	538·5	131·7	341·2

No	Metres = Feet.	Feet = Metres	Cm. = Inches.	Inches = Cm.	Kiloms. = Miles.	Mile = Kiloms.
3	698·8	64·9	83·8	541·0	132·4	342·8
4	702·1	65·2	84·2	543·5	133·0	344·4
5	705·4	65·5	84·6	546·1	133·6	346·0
6	708·8	65·8	85·0	548·6	134·2	347·6
7	711·9	66·1	85·4	551·2	134·8	349·2
8	715·2	66·4	85·8	553·7	135·5	350·8
9	718·5	66·7	86·2	556·2	136·1	352·4
220	721·8	67·1	86·6	558·8	136·7	354·0
1	725·1	67·4	87·0	561·3	137·3	355·7
2	728·4	67·7	87·4	563·9	137·9	357·3
3	731·6	68·0	87·8	566·4	138·6	358·9
4	734·9	68·3	88·2	568·9	139·2	360·5
5	738·2	68·6	88·6	571·5	139·8	362·1
6	741·5	68·9	89·0	574·0	140·4	363·7
7	744·8	69·2	89·4	576·6	141·0	365·3
8	748·0	69·5	89·8	579·1	141·7	366·9
9	751·3	69·8	90·2	581·7	142·3	368·5
230	754·6	70·1	90·6	584·2	142·9	370·1
1	757·9	70·4	90·9	586·7	143·5	371·8
2	761·2	70·7	91·3	589·3	144·2	373·4
3	764·4	71·0	91·7	591·8	144·8	375·0
4	767·7	71·3	92·1	594·3	145·4	376·6
5	771·0	71·6	92·5	596·9	146·0	378·2
6	774·3	71·9	92·9	599·4	146·6	379·8
7	777·6	72·2	93·3	602·0	147·3	381·4
8	780·8	72·5	93·7	604·5	147·9	383·0
9	784·1	72·8	94·1	607·0	148·5	384·6
240	787·4	73·1	94·5	609·6	149·1	386·2
1	790·7	73·4	94·9	612·1	149·7	387·8
2	794·0	73·7	95·3	614·7	150·4	389·4
3	797·3	74·1	95·7	617·2	151·0	391·1
4	800·5	74·4	96·1	619·7	151·6	392·7
5	803·8	74·7	96·5	622·3	152·2	394·3
6	807·1	75·0	96·8	624·8	152·9	395·9
7	810·4	75·3	97·2	627·4	153·5	397·5
8	813·7	75·6	97·6	629·9	154·1	399·1
9	816·9	75·9	98·0	632·4	154·7	400·7
250	820·2	76·2	98·4	635·0	155·3	402·3
1	823·5	76·5	98·8	637·5	156·0	403·9
2	826·8	76·8	99·2	640·1	156·6	405·5
3	830·1	77·1	99·6	642·6	157·2	407·2
4	833·3	77·4	100·0	645·1	157·8	408·8
5	836·6	77·7	100·4	647·7	158·5	410·4
6	839·9	78·0	100·8	650·2	159·1	412·0
7	843·2	78·3	101·2	652·8	159·7	413·6
8	846·5	78·6	101·6	655·3	160·3	415·2
9	849·7	78·9	102·0	657·8	160·9	416·8
260	853·0	79·2	102·4	660·4	161·6	418·4
1	856·3	79·5	102·8	662·9	162·2	420·0
2	859·6	79·8	103·1	665·5	162·8	421·6
3	862·9	80·2	103·5	668·0	163·4	423·2
4	866·2	80·5	103·9	670·5	164·1	424·9
5	869·4	80·8	104·3	673·1	164·7	426·5
6	872·7	81·1	104·7	675·6	165·3	428·1
7	876·0	81·4	105·1	678·2	165·9	429·7
8	879·3	81·7	105·5	680·7	166·5	431·3
9	882·6	82·0	105·9	683·2	167·2	432·9
270	885·8	82·3	106·3	685·8	167·8	434·5
1	889·1	82·6	106·7	688·3	168·4	436·1
2	892·4	82·9	107·1	690·9	169·0	437·7
3	895·7	83·2	107·5	693·4	169·6	439·3
4	899·0	83·5	107·9	695·9	170·3	441·0
5	902·2	83·8	108·3	698·5	170·9	442·6
6	905·4	84·1	108·7	701·0	171·5	444·2
7	908·7	84·4	109·1	703·6	172·1	445·8
8	912·0	84·7	109·4	706·1	172·7	447·4
9	915·4	85·0	109·8	708·6	173·4	449·0
280	918·7	85·3	110·2	711·2	174·0	450·6
1	921·9	85·6	110·6	713·7	174·6	452·2
2	925·2	85·9	111·0	716·3	175·2	453·8
3	928·5	86·2	111·4	718·8	175·8	455·4
4	931·8	86·6	111·8	721·3	176·5	457·0
5	935·1	86·9	112·2	723·9	177·1	458·7
6	938·3	87·2	112·6	726·4	177·7	460·3
7	941·6	87·5	113·0	729·0	178·3	461·9
8	944·9	87·8	113·4	731·5	179·0	463·5
9	948·2	88·1	113·8	734·0	179·6	465·1
290	951·5	88·4	114·2	736·6	180·2	466·7
1	954·7	88·7	114·6	739·1	180·8	468·3
2	958·0	89·0	115·0	741·7	181·4	469·9
3	961·3	89·3	115·3	744·2	182·1	471·5
4	964·6	89·6	115·7	746·7	182·7	473·1
5	967·9	89·9	116·1	749·3	183·3	474·7
6	971·1	90·2	116·5	751·8	183·9	476·4
7	974·4	90·5	116·9	754·4	184·6	478·0
8	977·7	90·8	117·3	756·9	185·2	479·6
9	981·0	91·1	117·7	759·4	185·8	481·2
300	984·3	91·4	118·1	762·0	186·4	482·8
1	987·6	91·7	118·5	764·5	187·0	484·4
2	990·8	92·0	118·9	767·1	187·6	486·0
3	994·1	92·3	119·3	769·6	188·3	487·6
4	997·4	92·7	119·7	772·1	188·9	489·2
5	1000·	93·0	120·1	774·7	189·5	490·8
6	1004·	93·3	120·5	777·2	190·1	492·4
7	1007·	93·6	120·9	779·8	190·8	494·1
8	1010·	93·9	121·3	782·3	191·4	495·7
9	1013·	94·2	121·7	784·8	192·0	497·3
310	1017·	94·5	122·1	787·4	192·6	498·9
1	1020·	94·8	122·4	789·9	193·2	500·5
2	1023·	95·1	122·8	792·5	193·9	502·1
3	1026·	95·4	123·2	795·0	194·5	503·7
4	1030·	95·7	123·6	797·5	195·1	505·3
5	1033·	96·0	124·0	800·1	195·7	506·9
6	1036·	96·3	124·4	802·6	196·4	508·5
7	1040·	96·6	124·8	805·2	197·0	510·2
8	1043·	96·9	125·2	807·7	197·6	511·8
9	1046·	97·2	125·6	810·2	198·2	513·4
320	1049·	97·5	126·0	812·8	198·8	515·0
1	1053·	97·8	126·4	815·3	199·5	516·6
2	1056·	98·1	126·8	817·9	200·1	518·2
3	1059·	98·4	127·2	820·4	200·7	519·8
4	1063·	98·7	127·6	822·9	201·3	521·4
5	1066·	99·0	128·0	825·5	201·9	523·0

No.	Metres = Feet.	Feet = Metres.	Cm. = Inches.	Inches = Cm.	Kiloms. = Miles.	Miles = Kiloms.
6	1069·	99·3	128·3	828·0	202·6	524·6
7	1072·	99·7	128·7	830·6	203·2	526·2
8	1076·	100·0	129·1	833·1	203·8	527·9
9	1079·	100·3	129·5	835·6	204·4	529·5
330	1082·	100·6	129·9	838·2	205·1	531·1
1	1086·	100·9	130·3	840·7	205·7	532·7
2	1089·	101·2	130·7	843·3	206·3	534·3
3	1092·	101·5	131·1	845·8	206·9	535·9
4	1095·	101·8	131·5	848·3	207·5	537·5
5	1099·	102·1	131·9	850·9	208·2	539·1
6	1102·	102·4	132·3	853·4	208·8	540·7
7	1105·	102·7	132·7	856·0	209·4	542·3
8	1108·	103·0	133·1	858·5	210·0	544·0
9	1112·	103·3	133·5	861·0	210·6	545·6
340	1115·	103·6	133·9	863·6	211·3	547·2
1	1118·	103·9	134·2	866·1	211·9	548·8
2	1122·	104·2	134·6	868·7	212·5	550·4
3	1125·	104·5	135·0	871·2	213·1	552·0
4	1128·	104·8	135·4	873·7	213·8	553·6
5	1131·	105·1	135·8	876·3	214·4	555·2
6	1135·	105·4	136·2	878·8	215·0	556·8
7	1138·	105·7	136·6	881·4	215·6	558·4
8	1141·	106·1	137·0	883·9	216·3	560·0
9	1145·	106·4	137·4	886·4	216·9	561·7
350	1148·	106·7	137·8	889·0	217·5	563·3
1	1151·	107·0	138·2	891·5	218·1	564·9
2	1154·	107·3	138·6	894·1	218·7	566·5
3	1158·	107·6	139·0	896·6	219·3	568·1
4	1161·	107·9	139·4	899·1	220·0	569·7
5	1164·	108·2	139·8	901·7	220·6	571·3
6	1168·	108·5	140·2	904·2	221·2	572·9
7	1171·	108·8	140·5	906·8	221·8	574·5
8	1174·	109·1	140·9	909·3	222·5	576·1
9	1177·	109·4	141·3	911·8	223·1	577·7
360	1181·	109·7	141·7	914·4	223·7	579·3
1	1184·	110·0	142·1	916·9	224·3	581·0
2	1187·	110·3	142·5	919·5	224·9	582·6
3	1191·	110·6	142·9	922·0	225·6	584·2
4	1194·	110·9	143·3	924·5	226·2	585·8
5	1197·	111·2	143·7	927·1	226·8	587·4
6	1200·	111·5	144·1	929·6	227·4	589·0
7	1204·	111·8	144·5	932·2	228·0	590·6
8	1207·	112·2	144·9	934·7	228·7	592·2
9	1210·	112·5	145·3	937·2	229·3	593·8
370	1213·	112·8	145·7	939·8	229·9	595·4
1	1217·	113·1	146·1	942·3	230·5	597·1
2	1220·	113·4	146·5	944·9	231·2	598·7
3	1223·	113·7	146·9	947·4	231·8	600·3
4	1227·	114·0	147·3	949·9	232·4	601·9
5	1230·	114·3	147·6	952·5	233·0	603·5
6	1233·	114·6	148·0	955·0	233·6	605·1
7	1236·	114·9	148·4	957·6	234·3	606·7
8	1240·	115·2	148·8	960·1	234·9	608·3
9	1243·	115·5	149·2	962·6	235·5	609·9
380	1246·	115·8	149·6	965·2	236·1	611·5
1	1250·	116·1	150·0	967·7	236·7	613·1
2	1253·	116·4	150·4	970·3	237·4	614·8
3	1256·	116·7	150·8	972·8	238·0	616·4
4	1259·	117·0	151·2	975·3	238·6	618·0
5	1263·	117·3	151·6	977·9	239·2	619·6
6	1266·	117·6	152·0	980·4	239·9	621·2
7	1269·	117·9	152·4	983·0	240·5	622·8
8	1273·	118·2	152·8	985·5	241·1	624·4
9	1276·	118·6	153·2	988·0	241·7	626·0
390	1279·	118·9	153·5	990·6	242·3	627·6
1	1282·	119·2	153·9	993·1	243·0	629·2
2	1286·	119·5	154·3	995·7	243·6	630·9
3	1289·	119·8	154·7	998·2	244·2	632·5
4	1292·	120·1	155·1	1000·	244·8	634·1
5	1296·	120·4	155·5	1003·	245·5	635·7
6	1299·	120·7	155·9	1005·	246·1	637·3
7	1302·	121·0	156·3	1008·	246·7	638·9
8	1305·	121·3	156·7	1010·	247·3	640·5
9	1309·	121·6	157·1	1013·	247·9	642·1
400	1312·	121·9	157·5	1016·	248·5	643·7
1	1315·	122·2	157·9	1018·	249·2	645·3
2	1318·	122·5	158·3	1021·	249·8	646·9
3	1322·	122·8	158·7	1023·	250·4	648·6
4	1325·	123·1	159·1	1026·	251·0	650·2
5	1328·	123·4	159·5	1028·	251·7	651·8
6	1332·	123·7	159·8	1031·	252·3	653·4
7	1335·	124·0	160·2	1033·	252·9	655·0
8	1338·	124·3	160·6	1036·	253·5	656·6
9	1341·	124·7	161·0	1038·	254·1	658·2
410	1345·	125·0	161·4	1041·	254·8	659·8
1	1348·	125·3	161·8	1043·	255·4	661·4
2	1351·	125·6	162·2	1046·	256·0	663·0
3	1355·	125·9	162·6	1049·	256·6	664·7
4	1358·	126·2	163·0	1051·	257·2	666·3
5	1361·	126·5	163·4	1054·	257·9	667·9
6	1364·	126·8	163·8	1056·	258·5	669·5
7	1368·	127·1	164·2	1059·	259·1	671·1
8	1371·	127·4	164·6	1061·	259·7	672·7
9	1374·	127·7	165·0	1064·	260·4	674·3
420	1378·	128·0	165·4	1066·	261·0	675·9
1	1381·	128·3	165·7	1069·	261·6	677·5
2	1384·	128·6	166·1	1071·	262·2	679·1
3	1387·	128·9	166·5	1074·	262·8	680·7
4	1391·	129·2	166·9	1076·	263·5	682·3
5	1394·	129·5	167·3	1079·	264·1	684·0
6	1397·	129·8	167·7	1082·	264·7	685·6
7	1400·	130·1	168·1	1084·	265·3	687·2
8	1404·	130·4	168·5	1087·	265·9	688·8
9	1407·	130·7	168·9	1089·	266·6	690·4
430	1410·	131·1	169·3	1092·	267·2	692·0
1	1414·	131·4	169·7	1094·	267·8	693·6
2	1417·	131·7	170·1	1097·	268·4	695·2
3	1420·	132·0	170·5	1099·	269·1	696·8
4	1423·	132·3	170·9	1102·	269·7	698·4
5	1427·	132·6	171·3	1104·	270·3	700·1
6	1430·	132·9	171·7	1107·	270·9	701·7
7	1433·	133·2	172·1	1110·	271·5	703·3
8	1437·	133·5	172·5	1112·	272·2	704·9

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9	1440·	133·8	172·9	1115·	272·8	706·5
440	1443·	134·1	173·2	1117·	273·4	708·1
1	1446·	134·4	173·6	1120·	274·0	709·7
2	1450·	134·7	174·0	1122·	274·6	711·3
3	1453·	135·0	174·4	1125·	275·3	712·9
4	1456·	135·3	174·8	1127·	275·9	714·5
5	1460·	135·6	175·2	1130·	276·5	716·1
6	1463·	135·9	175·6	1132·	277·1	717·8
7	1466·	136·2	176·0	1135·	277·8	719·4
8	1469·	136·5	176·4	1137·	278·4	721·0
9	1473·	136·8	176·8	1140·	279·0	722·6
450	1476·	137·1	177·2	1143·	279·6	724·2
1	1479·	137·4	177·6	1145·	280·2	725·8
2	1483·	137·7	178·0	1148·	280·9	727·4
3	1486·	138·1	178·4	1150·	281·5	729·0
4	1489·	138·4	178·8	1153·	282·1	730·6
5	1492·	138·7	179·1	1155·	282·7	732·2
6	1496·	139·0	179·5	1158·	283·4	733·9
7	1499·	139·3	179·9	1160·	284·0	735·5
8	1502·	139·6	180·3	1163·	284·6	737·1
9	1505·	139·9	180·7	1165·	285·2	738·7
460	1509·	140·2	181·1	1168·	285·8	740·3
1	1512·	140·5	181·5	1170·	286·5	741·9
2	1515·	140·8	181·9	1173·	287·1	743·5
3	1519·	141·1	182·3	1176·	287·7	745·1
4	1522·	141·4	182·7	1178·	288·3	746·7
5	1525·	141·7	183·1	1181·	288·9	748·3
6	1528·	142·0	183·5	1183·	289·6	749·9
7	1532·	142·3	183·9	1186·	290·2	751·5
8	1535·	142·6	184·3	1188·	290·8	753·2
9	1538·	142·9	184·7	1191·	291·4	754·8
470	1542·	143·2	185·0	1193·	292·1	756·4
1	1545·	143·5	185·4	1196·	292·7	758·0
2	1548·	143·8	185·8	1198·	293·3	759·6
3	1551·	144·2	186·2	1201·	293·9	761·2
4	1555·	144·5	186·6	1203·	294·5	762·8
5	1558·	144·8	187·0	1206·	295·2	764·4
6	1561·	145·1	187·4	1209·	295·8	766·0
7	1565·	145·4	187·8	1211·	296·4	767·6
8	1568·	145·7	188·2	1214·	297·0	769·3
9	1571·	146·0	188·6	1216·	297·6	770·9
480	1574·	146·3	189·0	1219·	298·3	772·5
1	1578·	146·6	189·4	1221·	298·9	774·1
2	1581·	146·9	189·8	1224·	299·5	775·7
3	1584·	147·2	190·2	1226·	300·1	777·3
4	1588·	147·5	190·6	1229·	300·7	778·9
5	1591·	147·8	190·9	1231·	301·4	780·5
6	1594·	148·1	191·3	1234·	302·0	782·1
7	1597·	148·4	191·7	1237·	302·6	783·7
8	1601·	148·7	192·1	1239·	303·2	785·3
9	1604·	149·0	192·5	1242·	303·8	787·0
490	1607·	149·3	192·9	1244·	304·5	788·6
1	1610·	149·6	193·3	1247·	305·1	790·2
2	1614·	149·9	193·7	1249·	305·7	791·8
3	1617·	150·2	194·1	1252·	306·3	793·4
4	1620·	150·6	194·5	1254·	307·0	795·0
5	1624·	150·9	194·9	1257·	307·6	796·6
6	1627·	151·2	195·3	1259·	308·2	798·2
7	1630·	151·5	195·7	1262·	308·8	799·8
8	1633·	151·8	196·1	1264·	309·4	801·4
9	1637·	152·1	196·5	1267·	310·1	803·1
500	1640·	152·4	196·9	1270·	310·7	804·7
1	1643·	152·7	197·2	1272·	311·3	806·3
2	1647·	153·0	197·6	1275·	311·9	807·9
3	1650·	153·3	198·0	1277·	312·5	809·5
4	1653·	153·6	198·4	1280·	313·2	811·1
5	1656·	153·9	198·8	1282·	313·8	812·7
6	1660·	154·2	199·2	1285·	314·4	814·3
7	1663·	154·5	199·6	1287·	315·0	815·9
8	1666·	154·8	200·0	1290·	315·7	817·5
9	1670·	155·1	200·4	1292·	316·3	819·1
510	1673·	155·4	200·8	1295·	316·9	820·8
1	1676·	155·7	201·2	1297·	317·5	822·4
2	1679·	156·0	201·6	1300·	318·1	824·0
3	1683·	156·3	202·0	1303·	318·8	825·6
4	1686·	156·7	202·4	1305·	319·4	827·2
5	1689·	157·0	202·8	1308·	320·0	828·8
6	1692·	157·3	203·2	1310·	320·6	830·4
7	1696·	157·6	203·5	1313·	321·3	832·0
8	1699·	157·9	203·9	1315·	321·9	833·6
9	1702·	158·2	204·3	1318·	322·5	835·2
520	1706·	158·5	204·7	1320·	323·1	836·8
1	1709·	158·8	205·1	1323·	323·7	838·4
2	1712·	159·1	205·5	1325·	324·4	840·1
3	1715·	159·4	205·9	1328·	325·0	841·7
4	1719·	159·7	206·3	1330·	325·6	843·3
5	1722·	160·0	206·7	1333·	326·2	844·9
6	1725·	160·3	207·1	1336·	326·8	846·5
7	1729·	160·6	207·5	1338·	327·5	848·1
8	1732·	160·9	207·9	1341·	328·1	849·7
9	1735·	161·2	208·3	1343·	328·7	851·3
530	1738·	161·5	208·7	1346·	329·3	852·9
1	1742·	161·8	209·1	1348·	330·0	854·5
2	1745·	162·1	209·4	1351·	330·6	856·2
3	1748·	162·4	209·8	1353·	331·2	857·8
4	1752·	162·8	210·2	1356·	331·8	859·4
5	1755·	163·1	210·6	1358·	332·4	861·0
6	1758·	163·4	211·0	1361·	333·1	862·6
7	1761·	163·7	211·4	1363·	333·7	864·2
8	1765·	164·0	211·8	1366·	334·3	865·8
9	1768·	164·3	212·2	1369·	334·9	867·4
540	1771·	164·6	212·6	1371·	335·5	869·0
1	1775·	164·9	213·0	1374·	336·2	870·6
2	1778·	165·2	213·4	1376·	336·8	872·2
3	1781·	165·5	213·8	1379·	337·4	873·9
4	1784·	165·8	214·2	1381·	338·0	875·5
5	1788·	166·1	214·6	1384·	338·7	877·1
6	1791·	166·4	215·0	1386·	339·3	878·7
7	1794·	166·7	215·4	1389·	339·9	880·3
8	1797·	167·0	215·8	1391·	340·5	881·9
9	1801·	167·3	216·2	1394·	341·1	883·5
550	1804·	167·6	216·5	1397·	341·8	885·1
1	1807·	167·9	216·9	1399·	342·4	886·7

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2	1811·	168·2	217·3	1402·	343·0	888·3
3	1814·	168·5	217·7	1404·	343·6	890·0
4	1817·	168·8	218·1	1407·	344·2	891·6
5	1820·	169·1	218·5	1409·	344·9	893·2
6	1824·	169·4	218·9	1412·	345·5	894·8
7	1827·	169·8	219·3	1414·	346·1	896·4
8	1830·	170·1	219·7	1417·	346·7	898·0
9	1834·	170·4	220·1	1419·	347·4	899·6
560	1837·	170·7	220·5	1422·	348·0	901·2
1	1840·	171·0	220·9	1424·	348·6	902·8
2	1843·	171·3	221·3	1427·	349·2	904·4
3	1847·	171·6	221·7	1430·	349·8	906·0
4	1850·	171·9	222·1	1432·	350·4	907·6
5	1853·	172·2	222·4	1435·	351·1	909·3
6	1857·	172·5	222·8	1437·	351·7	910·9
7	1860·	172·8	223·2	1440·	352·3	912·5
8	1863·	173·1	223·6	1442·	352·9	914·1
9	1866·	173·4	224·0	1445·	353·6	915·7
570	1870·	173·7	224·4	1447·	354·2	917·3
1	1873·	174·0	224·8	1450·	354·8	918·9
2	1876·	174·3	225·2	1452·	355·4	920·5
3	1880·	174·6	225·6	1455·	356·0	922·1
4	1883·	175·0	226·0	1457·	356·7	923·7
5	1886·	175·3	226·4	1460·	357·3	925·4
6	1889·	175·6	226·8	1463·	357·9	927·0
7	1893·	175·9	227·2	1465·	358·5	928·6
8	1896·	176·2	227·6	1468·	359·2	930·2
9	1899·	176·5	228·0	1470·	359·8	931·8
580	1902·	176·8	228·4	1473·	360·4	933·4
1	1906·	177·1	228·7	1475·	361·0	935·0
2	1909·	177·4	229·1	1478·	361·6	936·6
3	1912·	177·7	229·5	1480·	362·3	938·2
4	1916·	178·0	229·9	1483·	362·9	939·8
5	1919·	178·3	230·3	1485·	363·5	941·4
6	1922·	178·6	230·7	1488·	364·1	943·1
7	1925·	178·9	231·1	1490·	364·7	944·7
8	1929·	179·2	231·5	1493·	365·4	946·3
9	1932·	179·5	231·9	1496·	366·0	947·9
590	1935·	179·8	232·3	1498·	366·6	949·5
1	1939·	180·1	232·7	1501·	367·2	951·1
2	1942·	180·4	233·1	1503·	367·9	952·7
3	1945·	180·7	233·5	1506·	368·5	954·3
4	1948·	181·0	233·9	1508·	369·1	955·9
5	1952·	181·4	234·3	1511·	369·7	957·5
6	1955·	181·7	234·7	1513·	370·3	959·2
7	1958·	182·0	235·0	1516·	371·0	960·8
8	1962·	182·3	235·4	1518·	371·6	962·4
9	1965·	182·6	235·8	1521·	372·2	964·0
600	1968·	182·9	236·2	1524·	372·8	965·6
1	1971·	183·2	236·6	1526·	373·4	967·2
2	1975·	183·5	237·0	1529·	374·1	968·8
3	1978·	183·8	237·4	1531·	374·7	970·4
4	1981·	184·1	237·8	1534·	375·3	972·0
5	1984·	184·4	238·2	1536·	375·9	973·6
6	1988·	184·7	238·6	1539·	376·6	975·2
7	1991·	185·0	239·0	1541·	377·2	976·9
8	1994·	185·3	239·4	1544·	377·8	978·5
9	1998·	185·6	239·8	1546·	378·4	980·1
610	2001·	185·9	240·2	1549·	379·0	981·7
1	2004·	186·2	240·6	1551·	379·7	983·3
2	2007·	186·5	240·9	1554·	380·3	984·9
3	2011·	186·8	241·3	1557·	380·9	986·5
4	2014·	187·1	241·7	1559·	381·5	988·1
5	2017·	187·4	242·1	1562·	382·2	989·7
6	2021·	187·7	242·5	1564·	382·8	991·3
7	2024·	188·0	242·9	1567·	383·4	993·0
8	2027·	188·4	243·3	1569·	384·0	994·6
9	2030·	188·7	243·7	1572·	384·6	996·2
620	2034·	189·0	244·1	1574·	385·3	997·8
1	2037·	189·3	244·5	1577·	385·9	999·4
2	2040·	189·6	244·9	1579·	386·5	1001·
3	2044·	189·9	245·3	1582·	387·1	1002·
4	2047·	190·2	245·7	1584·	387·7	1004·
5	2050·	190·5	246·1	1587·	388·4	1005·
6	2053·	190·8	246·5	1590·	389·0	1007·
7	2057·	191·1	246·9	1592·	389·6	1009·
8	2060·	191·4	247·3	1595·	390·2	1010·
9	2063·	191·7	247·7	1597·	390·8	1012·
630	2067·	192·0	248·0	1600·	391·5	1013·
1	2070·	192·3	248·4	1602·	392·1	1015·
2	2073·	192·6	248·8	1605·	392·7	1017·
3	2076·	192·9	249·2	1607·	393·3	1018·
4	2080·	193·2	249·6	1610·	394·0	1020·
5	2083·	193·5	250·0	1612·	394·6	1021·
6	2086·	193·8	250·4	1615·	395·2	1023·
7	2089·	194·1	250·8	1617·	395·8	1025·
8	2093·	194·4	251·2	1620·	396·4	1026·
9	2096·	194·7	251·6	1623·	397·1	1028·
640	2099·	195·1	252·0	1625·	397·7	1030·
1	2103·	195·4	252·4	1628·	398·3	1031·
2	2106·	195·7	252·8	1630·	398·9	1033·
3	2109·	196·0	253·2	1633·	399·6	1034·
4	2112·	196·3	253·6	1635·	400·2	1036·
5	2116·	196·6	253·9	1638·	400·8	1038·
6	2119·	196·9	254·3	1640·	401·4	1039·
7	2122·	197·2	254·7	1643·	402·0	1041·
8	2126·	197·5	255·1	1645·	402·6	1042·
9	2129·	197·8	255·5	1648·	403·3	1044·
650	2132·	198·1	255·9	1651·	403·9	1046·
1	2135·	198·4	256·3	1653·	404·5	1047·
2	2139·	198·7	256·7	1656·	405·1	1049·
3	2142·	199·0	257·1	1658·	405·8	1050·
4	2145·	199·3	257·5	1661·	406·4	1052·
5	2149·	199·6	257·9	1663·	407·0	1054·
6	2152·	199·9	258·3	1666·	407·6	1055·
7	2155·	200·2	258·7	1668·	408·2	1057·
8	2158·	200·5	259·1	1671·	408·9	1058·
9	2162·	200·9	259·5	1673·	409·5	1060·
660	2165·	201·2	259·8	1676·	410·1	1062·
1	2168·	201·5	260·2	1678·	410·7	1063·
2	2172·	201·8	260·6	1681·	411·3	1065·
3	2175·	202·1	261·0	1684·	412·0	1067·

No.	Metres = Feet.	Feet = Metres.	Cm. = Inches.	Inches = Cm.	Kiloms. = Miles.	Miles = Kiloms.
4	2178·	202·4	261·4	1686·	412·6	1068·
5	2181·	202·7	261·8	1689·	413·2	1070·
6	2185·	203·0	262·2	1691·	413·8	1071·
7	2188·	203·3	262·6	1694·	414·5	1073·
8	2191·	203·6	263·0	1696·	415·1	1075·
9	2194·	203·9	263·4	1699·	415·7	1076·
670	2198·	204·2	263·8	1701·	416·3	1078·
1	2201·	204·5	264·2	1704·	416·9	1079·
2	2204·	204·8	264·6	1706·	417·6	1081·
3	2208·	205·1	265·0	1709·	418·2	1083·
4	2211·	205·4	265·4	1711.	418·8	1084·
5	2214·	205·7	265·8	1714·	419·4	1086·
6	2217·	206·0	266·1	1717·	420·1	1087·
7	2221·	206·3	266·5	1719·	420·7	1089·
8	2224·	206·6	266·9	1722·	421·3	1091·
9	2227·	207·0	267·3	1724·	421·9	1092·
680	2231·	207·3	267·7	1727·	422·5	1094·
1	2234·	207·6	268·1	1729.	423·2	1095.
2	2237·	207·9	268·5	1732.	423·8	1097.
3	2240·	208·2	268·9	1734·	424·4	1099·
4	2244·	208·5	269·3	1737·	425·0	1100·
5	2247·	208·8	269·7	1739·	425·6	1102·
6	2250·	209·1	270·1	1742·	426·3	1104.
7	2254·	209·4	270·5	1744·	426·9	1105·
8	2257·	209·7	270·9	1747·	427·5	1107·
9	2260·	210·0	271·3	1750·	428·1	1108·
690	2263·	210·3	271·7	1752·	428·8	1110·
1	2267·	210·6	272·1	1755·	429·4	1112·
2	2270·	210·9	272·4	1757·	430·0	1113·
3	2273·	211·2	272·8	1760·	430·6	1115·
4	2276·	211·5	273·2	1762·	431·2	1116·
5	2280·	211·8	273·6	1765·	431·9	1118·
6	2283·	212·1	274·0	1767·	432·5	1120·
7	2286·	212·4	274·4	1770·	433·1	1121·
8	2290·	212·7	274·8	1772·	433·7	1123·
9	2293·	213·1	275·2	1775·	434·4	1124·
700	2296·	213·4	275·6	1778·	435·0	1126·
1	2299·	213·7	276·0	1780·	435·6	1128·
2	2303·	214·0	276·4	1783·	436·2	1129·
3	2306·	214·3	276·8	1785·	436·8	1131·
4	2309·	214·6	277·2	1788·	437·4	1133·
5	2313·	214·9	277·6	1790·	438·1	1134·
6	2316·	215·2	278·0	1793·	438·7	1136·
7	2319·	215·5	278·3	1795·	439·3	1137·
8	2322·	215·8	278·7	1798·	439·9	1139·
9	2326·	216·1	279·1	1800·	440·6	1141·
710	2329·	216·4	279·5	1803·	441·2	1142·
1	2332·	216·7	279·9	1805·	441·8	1144·
2	2336·	217·0	280·3	1808·	442·4	1145·
3	2339·	217·3	280·7	1811·	443·0	1147·
4	2342·	217·6	281·1	1813·	443·7	1149·
5	2345·	217·9	281·5	1816·	444·3	1150·
6	2349·	218·2	281·9	1818·	444·9	1152·
7	2352·	218·5	282·3	1821·	445·5	1153·
8	2355·	218·8	282·7	1823·	446·2	1155·
9	2359·	219·1	283·1	1826·	446·8	1157·
720	2362·	219·4	283·5	1828·	447·4	1158·
1	2365·	219·7	283·9	1831·	448·0	1160·
2	2368·	220·0	284·3	1833·	448·6	1161·
3	2372·	220·4	284·7	1836·	449·2	1163·
4	2375·	220·7	285·1	1838·	449·9	1165·
5	2378·	221·0	285·4	1841·	450·5	1166·
6	2381·	221·3	285·8	1844·	451·1	1168·
7	2385·	221·6	286·2	1846·	451·7	1170·
8	2388·	221·9	286·6	1849·	452·4	1171·
9	2391·	222·2	287·0	1851·	453·0	1173·
730	2395·	222·5	287·4	1854·	453·6	1174·
1	2398·	222·8	287·8	1856·	454·2	1176·
2	2401·	223·1	288·2	1859·	454·8	1178·
3	2404·	223·4	288·6	1861·	455·5	1179·
4	2408·	223·7	289·0	1864·	456·1	1181·
5	2411·	224·0	289·4	1866·	456·7	1182·
6	2414·	224·3	289·8	1869·	457·3	1184·
7	2418·	224·6	290·2	1871·	458·0	1186·
8	2421·	224·9	290·6	1874·	458·6	1187·
9	2424·	225·2	290·9	1877·	459·2	1189·
740	2427·	225·5	291·3	1879·	459·8	1190·
1	2431·	225·8	291·7	1882·	460·4	1192·
2	2434·	226·1	292·1	1884·	461·1	1194·
3	2437·	226·5	292·5	1887·	461·7	1195·
4	2441·	226·8	292·9	1889·	462·3	1197·
5	2444·	227·1	293·3	1892·	462·9	1198·
6	2447·	227·4	293·7	1894·	463·5	1200·
7	2450·	227·7	294·1	1897·	464·2	1202·
8	2454·	228·0	294·5	1899·	464·8	1203·
9	2457·	228·3	294·9	1902·	465·4	1205·
750	2460·	228·6	295·3	1905·	466·0	1207·
1	2464·	228·9	295·7	1907·	466·7	1208·
2	2467·	229·2	296·1	1910·	467·3	1210·
3	2470·	229·5	296·5	1912·	467·9	1211·
4	2473·	229·8	296·9	1915·	468·5	1213·
5	2477·	230·1	297·3	1917·	469·1	1215·
6	2480·	230·4	297·6	1920·	469·8	1216·
7	2483·	230·7	298·0	1922·	470·4	1218·
8	2486·	231·0	298·4	1925·	471·0	1219·
9	2490·	231·3	298·8	1927·	471·6	1221·
760	2493·	231·6	299·2	1930·	472·2	1223·
1	2496·	231·9	299·6	1932·	472·9	1224·
2	2500·	232·2	300·0	1935·	473·5	1226·
3	2503·	232·5	300·4	1938·	474·1	1227·
4	2506·	232·9	300·8	1940·	474·7	1229·
5	2509·	233·2	301·2	1943·	475·4	1231·
6	2513·	233·5	301·6	1945·	476·0	1232·
7	2516·	233·8	302·0	1948·	476·6	1234·
8	2519·	234·1	302·4	1950·	477·2	1236·
9	2523·	234·4	302·8	1953·	477·8	1237·
770	2526·	234·7	303·2	1955·	478·5	1239·
1	2529·	235·0	303·6	1958·	479·1	1240·
2	2532·	235·3	303·9	1960·	479·7	1242·
3	2536·	235·6	304·3	1963·	480·3	1244·
4	2539·	235·9	304·7	1965·	480·9	1245·
5	2542·	236·2	305·1	1968·	481·6	1247·

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6	2546·	236·5	305·5	1971·	482·2	1248·
7	2549·	236·8	305·9	1973·	482·8	1250·
8	2552·	237·1	306·3	1976·	483·4	1252·
9	2555·	237·4	306·7	1978·	484·1	1253·
780	2559·	237·7	307·1	1981·	484·7	1255·
1	2562·	238·0	307·5	1983·	485·3	1256·
2	2565·	238·3	307·9	1986·	485·9	1258·
3	2569·	238·6	308·3	1988·	486·6	1260·
4	2572·	239·0	308·7	1991·	487·2	1261·
5	2575·	239·3	309·1	1993·	487·8	1263·
6	2578·	239·6	309·5	1996·	488·4	1264·
7	2582·	239·9	309·8	1998·	489·0	1266·
8	2585·	240·2	310·2	2001·	489·6	1268·
9	2588·	240·5	310·6	2004·	490·3	1269·
790	2591·	240·8	311·0	2006·	490·9	1271·
1	2595·	241·1	311·4	2009·	491·5	1273·
2	2598·	241·4	311·8	2011·	492·1	1274·
3	2601·	241·7	312·2	2014·	492·8	1276·
4	2605·	242·0	312·6	2016·	493·4	1277·
5	2608·	242·3	313·0	2019·	494·0	1279·
6	2611·	242·6	313·4	2021·	494·6	1281·
7	2614·	242·9	313·8	2024·	495·2	1282·
8	2618·	243·2	314·2	2026·	495·9	1284·
9	2621·	243·5	314·6	2029·	496·5	1285·
800	2624·	243·8	315·0	2032·	497·1	1287·
1	2628·	244·1	315·4	2034·	497·7	1289·
2	2631·	244·4	315·8	2037·	498·3	1290·
3	2634·	244·7	316·2	2039·	499·0	1292·
4	2637·	245·0	316·6	2042·	499·6	1293·
5	2641·	245·3	316·9	2044·	500·2	1295·
6	2644·	245·6	317·3	2047·	500·8	1297·
7	2647·	246·0	317·7	2049·	501·4	1298·
8	2651·	246·3	318·1	2052·	502·1	1300·
9	2654·	246·6	318·5	2054·	502·7	1301·
810	2657·	246·9	318·9	2057·	503·3	1303·
1	2660·	247·2	319·3	2059·	503·9	1305·
2	2664·	247·5	319·7	2062·	504·6	1306·
3	2667·	247·8	320·1	2065·	505·2	1308·
4	2670·	248·1	320·5	2067·	505·8	1310·
5	2673·	248·4	320·9	2070·	506·4	1311·
6	2677·	248·7	321·3	2072·	507·0	1313·
7	2680·	249·0	321·7	2075·	507·7	1314·
8	2683·	249·3	322·1	2077·	508·3	1316·
9	2687·	249·6	322·4	2080·	508·9	1318·
820	2690·	249·9	322·8	2082·	509·5	1319·
1	2693·	250·2	323·2	2085·	510·1	1321·
2	2696·	250·5	323·6	2087·	510·8	1322·
3	2700·	250·8	324·0	2090·	511·4	1324·
4	2703·	251·1	324·4	2092·	512·0	1326·
5	2706·	251·4	324·8	2095·	512·6	1327·
6	2710·	251·7	325·2	2098·	513·3	1329·
7	2713·	252·0	325·6	2100·	513·9	1330·
8	2716·	252·4	326·0	2103·	514·5	1332·
9	2719·	252·7	326·4	2105·	515·1	1334·
830	2723·	253·0	326·8	2108·	515·7	1335·
1	2726·	253·3	327·2	2110·	516·4	1337·
2	2729·	253·6	327·6	2113·	517·0	1339·
3	2733·	253·9	328·0	2115·	517·6	1340·
4	2736·	254·2	328·4	2118·	518·2	1342·
5	2739·	254·5	328·8	2120·	518·9	1343·
6	2742·	254·8	329·1	2123·	519·5	1345·
7	2746·	255·1	329·5	2125·	520·1	1347·
8	2749·	255·4	329·9	2128·	520·7	1348·
9	2752·	255·7	330·3	2131·	521·3	1350·
840	2756·	256·0	330·7	2133·	522·0	1351·
1	2759·	256·3	331·1	2136·	522·6	1353·
2	2762·	256·6	331·5	2138·	523·2	1355·
3	2765·	256·9	331·9	2141·	523·8	1356·
4	2769·	257·2	332·3	2143·	524·4	1358·
5	2772·	257·5	332·7	2146·	525·1	1359·
6	2775·	257·8	333·1	2148·	525·7	1361·
7	2778·	258·1	333·5	2151·	526·3	1363·
8	2782·	258·5	333·9	2153·	526·9	1364·
9	2785·	258·8	334·3	2156·	527·5	1366·
850	2788·	259·1	334·7	2159·	528·2	1367·
1	2792·	259·4	335·0	2161·	528·8	1369·
2	2795·	259·7	335·4	2164·	529·4	1371·
3	2798·	260·0	335·8	2166·	530·0	1372·
4	2801·	260·3	336·2	2169·	530·7	1374·
5	2805·	260·6	336·6	2171·	531·3	1376·
6	2808·	260·9	337·0	2174·	531·9	1377·
7	2811·	261·2	337·4	2176·	532·5	1379·
8	2815·	261·5	337·8	2179·	533·1	1380·
9	2818·	261·8	338·2	2181·	533·8	1382·
860	2821·	262·1	338·6	2184·	534·4	1384·
1	2824·	262·4	339·0	2186·	535·0	1385·
2	2828·	262·7	339·4	2189·	535·6	1387·
3	2831·	263·0	339·8	2192·	536·2	1388·
4	2834·	263·3	340·2	2194·	536·9	1390·
5	2838·	263·6	340·6	2197·	537·5	1392·
6	2841·	263·9	341·0	2199·	538·1	1393·
7	2844·	264·2	341·3	2202·	538·7	1395·
8	2847·	264·5	341·7	2204·	539·4	1396·
9	2851·	264·9	342·1	2207·	540·0	1398·
870	2854·	265·2	342·5	2209·	540·6	1400·
1	2857·	265·5	342·9	2212·	541·2	1401·
2	2860·	265·8	343·3	2214·	541·8	1403·
3	2864·	266·1	343·7	2217·	542·5	1404·
4	2867·	266·4	344·1	2219·	543·1	1406·
5	2870·	266·7	344·5	2222·	543·7	1408·
6	2874·	267·0	344·9	2225·	544·3	1409·
7	2877·	267·3	345·3	2227·	545·0	1411·
8	2880·	267·6	345·7	2230·	545·6	1413·
9	2883·	267·9	346·1	2232·	546·2	1414·
880	2887·	268·2	346·5	2235·	546·8	1416·
1	2890·	268·5	346·9	2237·	547·4	1417·
2	2893·	268·8	347·2	2240·	548·1	1419·
3	2897·	269·1	347·6	2242·	548·7	1421·
4	2900·	269·4	348·0	2245·	549·3	1422·
5	2903·	269·7	348·4	2247·	549·9	1424·
6	2906·	270·0	348·8	2250·	550·5	1425·
7	2910·	270·3	349·2	2252·	551·2	1427·

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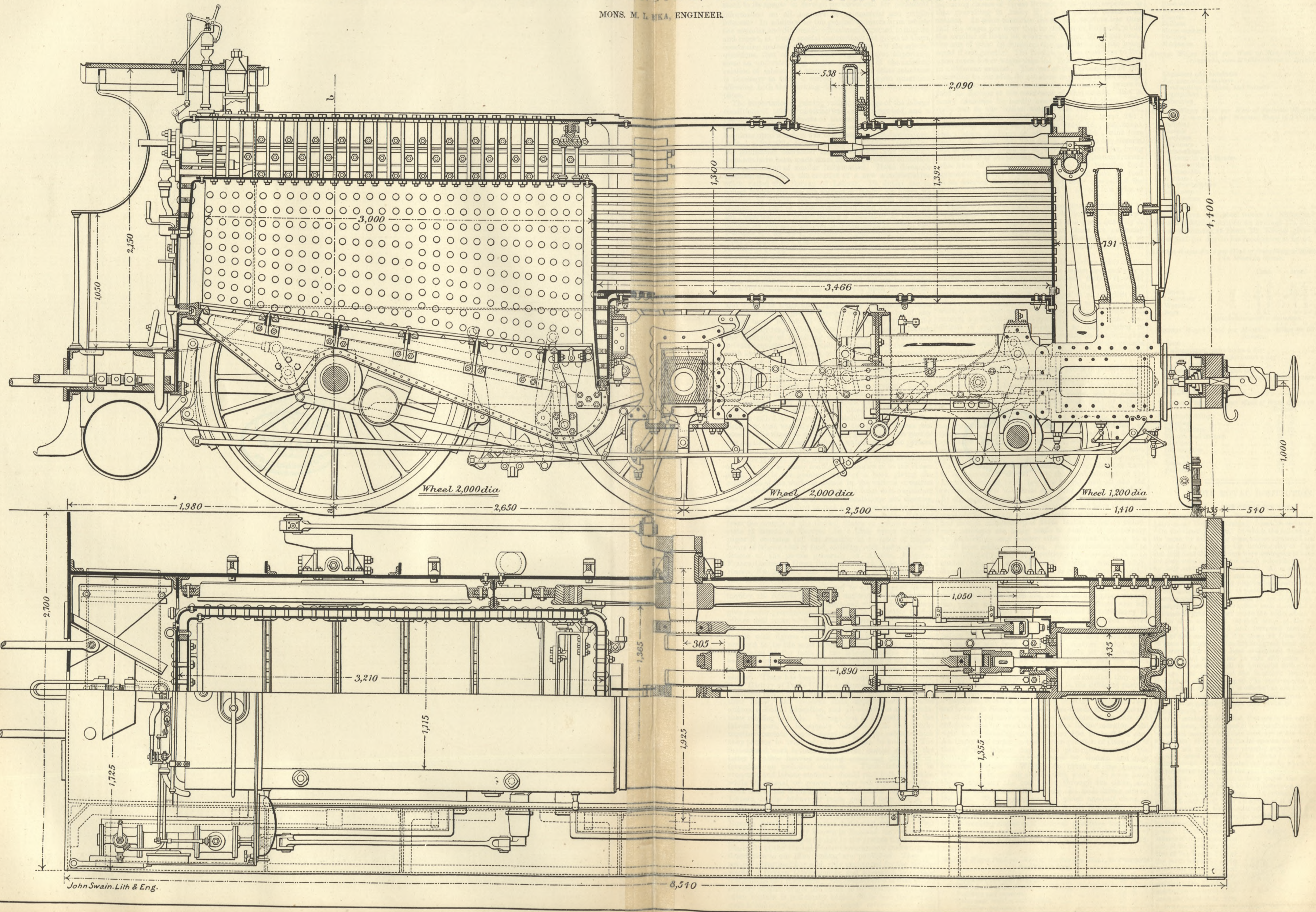
8	2913·	270·6	349·6	2255·	551·8	1429·
9	2916·	271·0	350·0	2258·	552·4	1430·
890	2920·	271·3	350·4	2260·	553·0	1432·
1	2923·	271·6	350·8	2263·	553·7	1433·
2	2926·	271·9	351·2	2265·	554·3	1435·
3	2929·	272·2	351·6	2268·	554·9	1437·
4	2933·	272·5	352·0	2270·	555·5	1438·
5	2936·	272·8	352·4	2273·	556·1	1440·
6	2939·	273·1	352·8	2275·	556·8	1442·
7	2943·	273·4	353·2	2278·	557·4	1443·
8	2946·	273·7	353·6	2280·	558·0	1445·
9	2949·	274·0	354·0	2283·	558·6	1446·
900	2952·	274·3	354·3	2285·	559·2	1448·
1	2956·	274·6	354·7	2288·	559·9	1450·
2	2959·	274·9	355·1	2291·	560·5	1451·
3	2962·	275·2	355·5	2293·	561·1	1453·
4	2965·	275·5	355·9	2296·	561·7	1454·
5	2969·	275·8	356·3	2298·	562·3	1456·
6	2972·	276·1	356·7	2301·	563·0	1458·
7	2975·	276·4	357·1	2303·	563·6	1459·
8	2979·	276·7	357·5	2306·	564·2	1461·
9	2982·	277·0	357·9	2308·	564·8	1462·
910	2985·	277·3	358·3	2311·	565·5	1464·
1	2988·	277·6	358·7	2313·	566·1	1466·
2	2992·	277·9	359·1	2316·	566·7	1467·
3	2995·	278·3	359·5	2319·	567·3	1469·
4	2998·	278·6	359·9	2321·	567·9	1470·
5	3002·	278·9	360·3	2324·	568·6	1472·
6	3005·	279·2	360·6	2326·	569·2	1474·
7	3008·	279·5	361·0	2329·	569·8	1475·
8	3011·	279·8	361·4	2331·	570·4	1477·
9	3015·	280·1	361·8	2334·	571·0	1479·
920	3018·	280·4	362·2	2336·	571·7	1480·
1	3021·	280·7	362·6	2339·	572·3	1482·
2	3025·	281·0	363·0	2341·	572·9	1483·
3	3028·	281·3	363·4	2344·	573·5	1485·
4	3031·	281·6	363·8	2346·	574·1	1487·
5	3034·	281·9	364·2	2349·	574·8	1488·
6	3038·	282·2	364·6	2352·	575·4	1490·
7	3041·	282·5	365·0	2354·	576·0	1491·
8	3044·	282·8	365·4	2357·	576·6	1493·
9	3048·	283·1	365·8	2359·	577·3	1495·
930	3051·	283·4	366·2	2362·	577·9	1496·
1	3054·	283·7	366·5	2364·	578·5	1498·
2	3057·	284·0	366·9	2367·	579·1	1499·
3	3061·	284·4	367·3	2369·	579·7	1501·
4	3064·	284·7	367·7	2372·	580·4	1503·
5	3067·	285·0	368·1	2374·	581·0	1504·
6	3070·	285·3	368·5	2377·	581·6	1506·
7	3074·	285·6	368·9	2379·	582·2	1507·
8	3077·	285·9	369·3	2382·	582·9	1509·
9	3080·	286·2	369·7	2385·	583·5	1511·
940	3084·	286·5	370·1	2387·	584·1	1512·
1	3087·	286·8	370·5	2390·	584·7	1514·
2	3090·	287·1	370·9	2392·	585·3	1516·
3	3093·	287·4	371·3	2395·	586·0	1517·
4	3097·	287·7	371·7	2397·	586·6	1519·
5	3100·	288·0	372·1	2400·	587·2	1520·
6	3103·	288·3	372·5	2402·	587·8	1522·
7	3107·	288·6	372·8	2405·	588·4	1524·
8	3110·	288·9	373·2	2407·	589·1	1525·
9	3113·	289·2	373·6	2410·	589·7	1527·
950	3116·	289·5	374·0	2412·	590·3	1528·
1	3120·	289·8	374·4	2415·	590·9	1530·
2	3123·	290·1	374·8	2418·	591·6	1532·
3	3126·	290·5	375·2	2420·	592·2	1533·
4	3130·	290·8	375·6	2423·	592·8	1535·
5	3133·	291·1	376·0	2425·	593·4	1536·
6	3136·	291·4	376·4	2428·	594·0	1538·
7	3139·	291·7	376·8	2430·	594·7	1540·
8	3143·	292·0	377·2	2433·	595·3	1541·
9	3146·	292·3	377·6	2435·	595·9	1543·
960	3149·	292·6	378·0	2438·	596·5	1544·
1	3153·	292·9	378·4	2440·	597·1	1546·
2	3156·	293·2	378·8	2443·	597·8	1548·
3	3159·	293·5	379·2	2446·	598·4	1549·
4	3162·	293·8	379·6	2448·	599·0	1551·
5	3166·	294·1	379·9	2451·	599·6	1553·
6	3169·	294·4	380·3	2453·	600·3	1554·
7	3172·	294·7	380·7	2456·	600·9	1556·
8	3175·	295·0	381·1	2458·	601·5	1557·
9	3179·	295·3	381·5	2461·	602·1	1559·
970	3182·	295·6	381·9	2463·	602·7	1561·
1	3185·	295·9	382·3	2466·	603·4	1562·
2	3189·	296·2	382·7	2468·	604·0	1564·
3	3192·	296·5	383·1	2471·	604·6	1565·
4	3195·	296·9	383·5	2473·	605·2	1567·
5	3198·	297·2	383·9	2476·	605·8	1569·
6	3202·	297·5	384·3	2479·	606·5	1570·
7	3205·	297·8	384·7	2481·	607·1	1572·
8	3208·	298·1	385·0	2484·	607·7	1573·
9	3212·	298·4	385·4	2486·	608·3	1575·
980	3215·	298·7	385·8	2489·	608·9	1577·
1	3218·	299·0	386·2	2491·	609·6	1578·
2	3221·	299·3	386·6	2494·	610·2	1580·
3	3225·	299·6	387·0	2496·	610·8	1582·
4	3228·	299·9	387·4	2499·	611·4	1583·
5	3231·	300·2	387·8	2501·	612·1	1585·
6	3235·	300·5	388·2	2504·	612·7	1586·
7	3238·	300·8	388·6	2506·	613·3	1588·
8	3241·	301·1	389·0	2509·	613·9	1590·
9	3244·	301·4	389·4	2512·	614·5	1591·
990	3248·	301·7	389·8	2514·	615·2	1593·
1	3251·	302·0	390·2	2517·	615·8	1594·
2	3254·	302·3	390·6	2519·	616·4	1596·
3	3257·	302·6	391·0	2522·	617·0	1598·
4	3261·	303·0	391·4	2524·	617·6	1599·
5	3264·	303·3	391·7	2527·	618·3	1601·
6	3267·	303·6	392·1	2529·	618·9	1602·
7	3271·	303·9	392·5	2532·	619·5	1604·
8	3274·	304·2	392·9	2534·	620·1	1606·
9	3277·	304·5	393·3	2537·	620·8	1607·
1000	3281·	304·8	393·7	2539·	621·4	1609·

[SUPPLEMENT TO THE ENGINEER, FEBRUARY 5, 1886.]

FOUR-COUPLED PASSENGER ENGINE, BELGIAN STATE RAILWAYS.

MONS. M. L. BIKA, ENGINEER.



John Swain. Lith & Eng.