ON A STEAM ROAD ROLLER.

By Mr. W. F. BATHO, of Birmingham, and Mr. T. AVELING, of Rochester.

The idea of employing steam power in place of animal labour for rolling down newly macadamised roads originated with the Chief Engineer to the Calcutta municipality, Mr. W. Clark, whose attention had been drawn to the subject by experiencing the expense and difficulty attending the employment of bullocks for drawing rollers over the Calcutta roads. A Steam Road Roller was consequently designed for him by Mr. Batho, which was sent out to Calcutta, and has done good work there during the last seven years, notwithstanding the defects in details attending a first and experimental design; and this steam roller has long since cleared its first cost by the saving in cost of its work compared with that done by rollers drawn by bullocks.

The principle of the machine is the use of three rollers arranged in a triangle, one roller on each side of the machine at the one end, and the third roller in the centre at the other end; the two side rollers are driven by the engine by means of pitched chains, and the centre roller is mounted in a turntable frame so as to swivel horizontally for the purpose of steering. The third roller is made wide enough to cover the intermediate space between the two side rollers; and the weight of the boiler and engine, which are vertical and placed in the centre of the machine, is distributed over the three rollers. The results of trials carefully made to determine the difference in cost of working with this steam roller as compared with the ordinary plan of rolling by bullocks, for rolling an area of road of 44,631 square yards, gave £146 4*s*. 6*d*. as the cost of steam rolling and £269 5*s*. 9*d*. as the cost with bullocks, being a saving of 46 per cent. in cost with the steam rolling, in addition to the economy arising from the much superior and more durable nature of the work done.

A steam roller on a different principle was subsequently constructed in France, which has now been extensively used for several years in Paris, and has thoroughly proved on a large scale the great practical value and economy of steam rolling in the making and maintenance of roads. This machine, which was described at a former meeting of the Institution (see Proceedings Inst. M. E. 1869 page 101), is carried wholly upon two long rollers, each one extending the full width of the machine, and both driven by the engine; and the steering is effected by sliding the axles at one end so as to throw them out of parallel when traversing curves.

The three-roller principle has been successfully carried out by Messrs. Aveling and Porter, in combination with their steam traction engine, with which the successful experience of many years' working had been previously obtained; and a number of steam road rollers of this make are now in use both in this country and abroad, having been at work from 1 to $2\frac{1}{2}$ years.

This machine is shown in Figs. 1 to 5, Plates 18 to 21. The two side rollers A A are driven by the engine and connected to the same axle B, and the centre roller C is made in two portions, turning separately upon their axle for facility in steering, and carried in a turntable frame D for steering. Each portion of the centre roller is the same width as one of the side rollers, and the centre roller overlaps the side ones to a small extent. The total weight of the machine is distributed equally upon the two axles, so as to equalise the action of the rollers in working.

A single steam cylinder E is employed for driving, as in the traction engines, for the sake of simplicity and economy of construction; and with the use of intermediate gearing reducing the speed considerably, and a flywheel F upon the crank shaft for turning the engine by hand over the dead points when requisite at starting, the single cylinder has been found sufficient both in the road rollers and the traction engines. It is fixed on the front end of the boiler, surrounded by a steam jacket in direct communication with the boiler, as shown in Fig. 5, and having a dome on the top

from which the steam is taken into the cylinder. The use of steam pipes is thus avoided, and priming upon steep gradients is prevented. From the crank shaft the motion is taken by spur gearing to a countershaft G carrying at its end the pitch-chain pinion; the bearings of this shaft are carried in curved slots H, Fig. 2, formed in the supporting brackets, so that the shaft can be raised when required in order to tighten up the slack that usually occurs in a pitch chain after some time of wear. The chain is covered up by a wrought-iron casing, and drives the chain wheel K, which is keyed upon the front axle B of the machine; the two driving rollers A are not keyed upon the axle, but are secured to it by the strong locking bolts I I, Fig. 5.

The turntable D, Figs. 2 and 3, carrying the centre steering roller C, is constructed with only two vertical carrying wheels J J, placed fore and aft, which allow it to swivel vertically to a slight extent, for the purpose of letting the rollers accommodate themselves to the convex surface of the road. The set of horizontal friction wheels L L guide the turntable horizontally in steering; and the machine is steered by a chain passing round the turntable, and worked by worm gearing from a handwheel M in reach of the steersman upon the foot-plate. The machine can be turned round by this means in a distance of little more than its own length; and it can be turned within its own length if required, by disconnecting either of the two driving rollers A A, which is done by withdrawing the locking bolt I that couples the roller A to the driving axle B, as shown in Fig. 5. A friction break, consisting of a wrought-iron strap upon a pulley N on the side of one of the driving rollers, and worked by a worm and screw P from the foot-plate, affords control over the machine, in case any of the gearing should give way. The boiler is horizontal and multitubular, placed longitudinally between the two driving rollers; the coal bunker and water tanks are placed at the sides of the firebox, containing a supply of coal and water sufficing for two hours' work.

The ordinary size of this road roller, such as is shown in the drawings, weighs 15 tons; and the total width over the rollers being 6 feet, this gives a compressing load of $2\frac{1}{2}$ tons per foot width

upon the road: the rollers are all 5 feet diameter, and the load is distributed nearly uniformly over them all. There are thirteen of these 15 ton machines now at work, several being in India and in the United States. Single machines have also been made of 20, 25, and 30 tons weight, which roll widths of 7, 8, and 9 feet respectively: the 25 ton roller has been working two years at Sheffield, and the 30 ton roller two and a half years at Liverpool. This 30 ton roller is $9\frac{1}{2}$ feet total width, giving a compressing load in rolling of 3 tons per foot width; the steering roller is 5 feet diameter and the two driving rollers 7 feet.

The average cost of working the 15 ton rollers, under the ordinary conditions of this country, has been found from a number of different trials to be as follows, taking the actual cost of working, and adding an allowance for wear and tear and interest, but not including general superintendence charges, nor cost of water used. The daily working expenses amount to

	s.	d.	s.	d.
Wages to enginedriver 5s., steersman 3s. . . .	8	0		
Coke, $4\frac{1}{2}$ cwts. at 1s.	4	6		
Oil and cotton waste	2	0		
			14	6
Allowance for wear and tear at 10 per cent., and interest at 5 per cent., on the cost of the roller £550, taking 250 working days in the year			6	7
Total cost per day			21	1

There has not yet been a sufficient length of experience in the working of these steam rollers for determining accurately the cost of wear and tear, but the above estimate is based upon the long experience that has been obtained with the traction engines.

The average work done per day is 2376 square yards rolled complete; and with the above total cost of working, 21s. per day, the work amounts to $9\frac{1}{2}$ square yards rolled for one penny, including wear and tear and interest; or $13\frac{1}{2}$ square yards rolled for one penny, for wages and fuel alone. Taking only 2000 square yards for the day's work, this gives $11\frac{1}{2}$ square yards rolled for one penny of working expenses; or 8 square yards for one penny, allowing for wear and tear and interest. These results are confirmed by those obtained in the working of two of the same rollers in India,

where the cost of working has amounted to 43*s.* per day for each machine in rolling a space of 7040 square yards, which gives $13\frac{1}{2}$ square yards rolled for one penny, the same as in the previous statement.

A further development by Mr. Batho of the three-roller machine is shown in Figs. 6 to 10, Plates 22 to 24; in which the object has been to make the construction more complete and perfect, by adding to the complication and first cost, with the view of obtaining an increased amount of work from the machine. In this machine the two side driving rollers A A are placed upon separate axles B B, Figs. 8 and 10, which, as well as the axle of the centre roller C, are fitted with bearing springs S S, for the purpose of allowing the rollers to adjust themselves more readily to the curved cross section of the road, so as to apply the pressure more evenly throughout, and also for the purpose of easing the shocks produced by the passage of the heavy machine over the rough surface of the road. The adoption of bearing springs enables the machine to travel at a greater speed to and from its place of work, preventing the loss of time that occurs when this speed of travelling is limited to only about three miles an hour, as is usually the case in the absence of bearing springs. With the springs the roller easily travels to and from its work at a rate of four miles an hour. The springs have also an advantage in reducing the risk of crushing drains or breaking water pipes under the road that is being rolled.

A double-cylinder engine E E is employed, in order to give the means of starting in any position, and to afford greater facility for getting over the difficulty of one of the rollers sinking into a hole in the road. Each driving roller A is also provided with a separate driving chain K and a disengaging clutch T, so that either roller can be driven independently of the other, if desired in any emergency. In order to provide the means of tightening up the pitch-chains without interfering with the action of the bearing springs, the driving axles B B are carried in guides by means of radius links R R, Figs. 6 and 8, which have a screw adjustment at the outer end. For the disengaging clutches, Weston's friction clutch was at first

employed, with the view of allowing either of the driving rollers to be partially or wholly disengaged while working, so that in turning sharp curves the inner roller could slip or remain at rest. In consequence however of practical difficulties arising from the heating of the clutch discs by the boiler, an ordinary solid clutch has since been adopted, and this has been found successful. A powerful lever break N is applied to the surface of the centre roller, for controlling the motion downhill when required.

This steam roller has been made of the increased weight of 25 tons, and 9 feet width, giving a compressing load of $2\frac{3}{4}$ tons per foot of width. The increase in total weight is for the purpose of accomplishing the rolling in less time, by a smaller number of courses over each portion of the ground, so as to get the work done more economically as well as quicker, by getting more done for the same cost of wages of the enginedriver and steersman working the machine. No difficulty has been experienced in this machine from the driving rollers slipping, and the adhesion is found sufficient to propel the third roller under ordinary conditions, even up a gradient of 1 in 9; when the road is smooth and wet, sand is required, as in starting a locomotive. The machine, which has been working in different situations during the last two months, rolls an area of 300 square yards of road complete per hour, and the consumption of coal is about 1 cwt. per hour; a supply of coal and water is carried sufficient for half a day's work.

The practice of leaving the metalling of roads to be consolidated only by the traffic passing over them has been so universal in this country, that rolling the roads, whether by horses or by steam power, is still generally looked upon rather as a refinement than as a source of economy in road maintenance. On the Continent however experience has led the French and Germans to consider rolling as the most important improvement ever made in the construction and maintenance of roads. The absence of any centralised authority in the road administration of this country, such as is customary on the Continent, has been unfavourable to the adoption of rolling here.

Road making is also subject to so many varying influences in the nature of the traffic, the locality, the quality of the metalling, the construction of the road, and the method of maintenance, that it is difficult to arrive at the exact amount of the economy resulting from rolling as compared with the absence of rolling; but from an average of extended experience in different countries, the economy attending the practice of rolling, even when horse rollers only are employed, is found to amount to as much as 34 per cent. saving in cost of metalling alone. Rolling prevents the metalling from being crushed piece-meal by the traffic, as is done when it is laid down loose without rolling; and the entire road is rendered better able to resist the injuries caused by moisture soaking in. A saving in labour in the construction or repair of a road is also effected by rolling, as the rolling allows of a greater area of metalling being laid down at a time, and a thicker coating of it when requisite; and instead of the stones being thrown down in small patches wherever defects show themselves in the road surface in course of time, the maintenance of the road can be carried out in a systematic manner. The force of draught required upon freshly laid unrolled metalling is as much as five times the draught for the same load upon a fairly good road surface, as ascertained by old established experiments; and this great difference shows the important saving which the users of a road derive from the adoption of rolling. This increase of draught also involves increased injury to a road from the horses' feet; so that in the ordinary case of rolling down a road by the action of the wheel traffic, this is not done, as commonly supposed, without cost to the maintainers of the road. On a well rolled road however, the wear that takes place is mainly that due to friction, as the vehicles passing over it are not jolted about with a continued series of concussions on the road surface, while the horses have less force of draught to exert, and the metalling is not crushed to pieces.

The drawbacks attending horse-rolling are however very great, especially in the case of a road with heavy traffic. The rolling interferes with the passage of vehicles, on account of the long string of horses required to drag the roller, and the consequent trouble and delay of turning round at the ends of the course; and the horses'

feet disturb the metalling in a way that cannot be corrected by the succeeding passage of the roller. To roll a road completely with such a light weight as only a six-ton or even a ten-ton roller, which is the heaviest possible horse roller, it requires to be gone over a great number of times; and this weight of roller is much below that of the traffic in large towns, when calculated by the same measure of tons weight per foot width of the wagon wheels.

With the steam roller however all these objections are overcome: on account of its greater weight and the greater facility with which it is managed, it consolidates the metalling with much greater rapidity, and can be easily turned round, and worked up steep inclines; and it has been shown by experience in Paris that under proper management it can be worked without passing horses being frightened. As to the relative expense, the same work can be done by a steam roller at less than one half the cost of horse rolling; while in cost of metalling a considerable further saving is effected beyond that realised with horse rollers. In Paris the steam-rolled roads are found to last twice as long as those rolled by horses; and roads which formerly had to be rolled by steam power once every six months, and previously much oftener by horses, have been so much improved by this operation upon the successive layers that they now require rolling only once a year. This result has occurred too under a traffic that is annually increasing; and as the centre of the heaviest traffic in Paris is macadamised, and not paved as in London, the experience there obtained evidently affords a sound basis for comparison with the streets of the large towns in this country. Rolling has proved of great service not only for surface repairs, but also for consolidating the foundations in making new roads; and in Germany the horse roller is very generally used also for setting paving stones, instead of using the hand rammer.

In repairing a road, the expensive and troublesome process of picking up the surface in order to prepare it for the fresh layer of metalling, is effected by the steam roller with great expedition and economy, by simply fixing a number of short steel spikes in the working faces of the two side rollers, as shown dotted in Fig. 6, Plate 22; the rollers are prepared for the purpose by having

countersunk holes cast all round their circumference at about 12 inches pitch, into which the spikes are fixed by nuts screwed on inside, as shown to a larger scale in Fig. 7. The rollers are readily changed from plain to spiked while the machine is out at work, about half an hour being sufficient for the purpose; and the spikes are all removed again in a quarter of an hour, the holes being stopped by wood plugs driven in when in ordinary work. An area of about 700 square yards of road is broken up by the machine per hour.

The usual process of road repairs with the steam roller is, after loosening the surface with the spiked rollers, to have it levelled in the customary way, and a layer of from 2 to 6 inches thickness of metalling laid upon a length of about 35 yards. The roller is passed two or three times over every portion of this length, working its way gradually across from one side of the road to the other, until the flat surfaces of all the stones are brought uppermost. A covering of one inch of sharp clean sand is then spread over the entire surface and well watered from a cart or hose, after which the rolling is continued until the stones are thoroughly bedded, and, as it were, concreted into their places; the surplus sand is then swept off, and the road is left in a finished durable state, the whole operation occupying usually about two hours for each length of 35 yards of road. The proportion of sand and water used varies in different places, different opinions being at present held as to the most desirable proportion for the purpose; but the value of sharp sand in preference to all other kinds of binding material is everywhere recognised, as is also the advantage of laying on no more of this material than suffices to fill up properly the interstices between the stones.

In places of crowded heavy traffic, such as in the streets of London, the evils arising from the constantly defective condition of macadamised roads as ordinarily made, and the frequent stoppages for repairs, have led to the substitution of stone pitching as the less of two evils, notwithstanding the serious objections to its roughness, slipperiness, and noise. But if such a street can be re-made in a single night without any stoppage of the day traffic, and can be started the next morning in a thoroughly finished and consolidated condition, as can readily be done by means of steam rolling, it

becomes an important consideration whether the objections previously experienced with macadamised roads would not be got rid of, however frequently this re-making of the road might be necessary: particularly when the much greater durability of the steam rolled roads is taken into account.

The steam roller described in the paper, with double-cylinder engine and bearing springs, was shown in operation in the neighbourhood, upon a road undergoing repairs.

Mr. BATHO observed that the experience of several years' working of the steam road rollers in different parts of this country had shown beyond all doubt that there was a considerable advantage in the use of the steam roller as compared with rollers drawn by horses. There was some difference of opinion as to the size of the stones that should be used in the metalling, and his own impression was that larger stones would be better with steam rolling than the present size, as he considered the object to be aimed at should be to use a minimum quantity of binding material and a maximum of granite, so as to have the road surface composed of the hardest material possible. The plan too often pursued at present of laying stones down without either binding material or rolling resulted in the crushing of the stones by the traffic, the sharp edges being broken off by the wheels; but by the use of a roller the sharp edges of the stones were preserved, and with the addition of proper binding material they helped to form at once a hard homogeneous road with a smooth and even surface.

Mr. J. BALDWIN believed there was a strong feeling in favour of employing a steam roller for the roads in Birmingham, and he hoped it would not be long before one was in regular use in the town. With the present unrolled roads instances were frequent of injury to horses from passing over newly repaired portions of a

road; and the defective condition of the road surface, even when a horse roller had been used upon it, became apparent after a shower of rain, by the water lying in numerous little pools in the hollows that were left. In the process of rolling, the horses' feet displaced the stones in front of the roller, and the roller was not able afterwards to roll them down again and make the surface really level, but left it in an uneven condition. On this account the steam roller was superior to a horse roller, as the rolling was done without the stones being disturbed at all by horses' feet during the process. An objection made to the steam roller was that its great weight would crush the stones, and they would not wear half so long; but the weight of the machine distributed over the width of the broad rollers was not actually so great per inch of width as the weight upon the wheels of heavily loaded omnibuses or carriers' vans. In Birmingham there was the advantage of being able to obtain in the neighbourhood an abundant supply of the small Lickey gravel, which was better than sand for using as the binding material on a newly macadamised road, and could be procured as cheap as sand for the purpose; and by the use of this material, together with the employment of a steam roller, he was satisfied the roads would become year by year so much improved that a great saving would be effected in the expense of maintaining them. The important advantages of rolling the roads had long been recognised, as he remembered more than sixty years ago that wagons having wheels upwards of 15 inches broad used to be allowed to travel upon the turnpike roads without payment of toll, in consequence of the beneficial effect which they produced upon the road by their broad wheels acting as rollers.

Mr. F. A. PAGET said that, from some extensive statistics which he had collected upon the question of the maintenance and rolling of roads, he had found the saving effected by the use of horse rollers had been ascertained to be from 25 to 66 per cent. in the cost of the materials alone, without reckoning the great saving in labour. These were the results with horse rolling, the experience of which had already extended in some cases over periods of from thirty to forty years; and steam rolling would now double the duration of

the metalling, in comparison with horse rolling, judging from the experience obtained in Paris, where steam rolling had been extensively employed for seven years and was found to be attended with a saving in material of 50 per cent. over horse rolling. By those who had to pay for the maintenance of the roads, the question of saving in cost of material was the one mainly considered; but another important advantage of road rolling was that the force of draught required upon a properly rolled road was only about one third of that upon an unrolled road, while the draught upon the loose metalling of a newly macadamised road which had not been rolled was actually five times as much as on a thoroughly good smooth road. With this combined saving in cost of maintenance and in draught, the system of steam road rolling if generally adopted would have the effect of covering the country with universal cheap tramroads that every one could use, without the necessity for the present expenditure of as much as £10,000 per mile in some instances for the construction of special tramroads. It was in the case of London that the importance of the saving to be effected by steam rolling was most particularly apparent, on account of the magnitude of the sums now spent upon the maintenance of the roads there. Upon the 2000 miles of macadamised and paved roads comprised within the thirty-nine districts into which London was divided, the sum of £300,000 had been expended in the year 1861 for the entire maintenance; and during the subsequent years this amount had continually increased, until in last year it had reached as much as £800,000. This great increase in expense was to be attributed to the increased extent of the paved roads, all the roads within a radius of two miles from St. Paul's being now paved with granite paving at a cost of about 18*s*. per square yard. Both the paving blocks and the macadam employed in London were better and more expensive than those used elsewhere, the metalling of the macadamised roads being composed of Guernsey granite, which cost 16*s*. per cubic yard when broken up into five-ounce pieces ready for laying on the roads. In places of the heaviest traffic the destruction of the macadam was very rapid, and only a small portion of the total expense was for labour; in

Piccadilly the whole annual cost of repairing the macadamised portion kept up by the St. George's vestry was £1384, of which £1359 was the cost of the metalling alone. Taking into account only that the duration of the roads would be doubled, as in Paris, by the use of a steam roller, he had found the result would be a clear saving in London of at least £140,000 per annum in the cost of metalling alone. The improved condition of the roads rolled by steam power would also greatly enhance the value of the vast amount of capital already invested in horses and vehicles; within a radius of $4\frac{1}{2}$ miles from Charing Cross it was estimated there were nearly 72,000 horses and 31,000 vehicles, representing together a capital of probably not less than four millions sterling; and the improvement of the roads and consequent saving both of horses and vehicles were benefits that would be shared alike by all classes of the community.

Mr. E. YATES thought the particulars given in the paper as to the advantages of the steam road roller were thoroughly convincing in respect to the importance of road rolling. In regard to the plan of fixing spikes in the rollers for breaking up the road surface in preparation for a layer of new material, he had observed in one instance that after the passage of the spiked rollers it had been necessary for the men to use their picks all over the surface of the road, in order to bring it into a fit state for receiving the new material; and he enquired whether it was intended for the spikes of the new roller to finish the whole breaking up of the road, so as not to require any work with the picks afterwards. He asked also whether the addition of the bearing springs in the improved roller would be sufficient to prevent the breakage of gas and water pipes by the passage of the heavy machine along the road; the damage being done he supposed by the weight of the machine itself, he did not see how it would be obviated by the addition of the springs, unless at the same time the weight of the roller were reduced.

Mr. J. ROBINSON considered the bearing springs now added to the steam roller were a very great improvement, and would certainly prove of great value in preventing the machine from

breaking gas and water pipes in its passage over the roads. The shocks occasioned by the passage of the heavy roller over inequalities in the road surface would be effectually absorbed by the bearing springs; and though the weight of the machine was not diminished, it was prevented by the springs from coming down with a violent blow upon the surface of the road in passing over uneven places. On this account a roller which might be so heavy as to break the gas and water pipes, when not mounted on springs, would by the intervention of the springs be enabled to travel over them without doing them any damage. Only recently he had noticed a lorry loaded with pigs of cast iron driven along a paved street with such remarkably little noise that his attention had been attracted to the unusual quietness of its motion, and he found the reason to be that it was mounted on springs, which absorbed the shocks arising from the jolting of so heavy a load over the rough street. Besides preventing damage to pipes laid below the road surface, the bearing springs added upon the steam roller would also be beneficial to the machine itself, causing a saving in wear and tear by mitigating the injurious effects of constant jolting.

Mr. BATHO said his object in adopting the bearing springs for the steam roller had been that just explained, namely to obviate the danger of the heavy machine breaking the pipes laid in the road; and for the same reason he had also considered it preferable to place each roller upon a separate axle with separate bearing springs, so that the two driving rollers should be able to adapt themselves independently to the transverse curvature or unevenness of the road surface, whereby the strains upon the machine and the shocks upon the ground in passing over inequalities would be less than if the two rollers were both fixed upon one axle. There was also less probability of the rollers skidding, when each was on a separate axle and driven independently. Another advantage was that the adoption of separate axles for the driving rollers allowed of a considerably wider machine being used, causing a saving in wages, because the same man could drive the wider machine as readily as the narrower one. The greater rate at which the machine fitted with bearing springs could travel to its work was also an

advantage of much importance, and the increased width enabled the rolling to be done quickly during the night in streets where there was great traffic in the daytime; and the quicker the rolling could be finished, the better was it both for the machine itself and for the road too.

The spikes fixed round the circumference of the rollers for breaking up the road surface previous to metalling were not intended to do away with the ordinary process of picking the surface up by picks, but only to make a number of holes into which the picks could afterwards be inserted for loosening the intermediate surface; and so greatly did the passage of the spiked roller facilitate the work of breaking the surface up, that it was found the amount of labour was reduced to only about one twentieth of that ordinarily required in picking up a road surface for metalling. In a street in Birmingham an area of 1200 square yards had in this way been broken up in half an hour; and the efficiency of the roller for this purpose was almost more apparent than even its advantages in rolling a newly macadamised road.

Mr. J. SADLER would have been glad to have the results given of the experiments that had been made in Birmingham with steam road rollers, as to the economy realised by their work, instead of the results in other towns only being referred to.

Mr. T. WALKER thought there could not be any doubt as to the advantage of using a steam roller; for wherever there was heavy work to be done and steam could be made to do it, the work was better done by steam power than by any other means. Three steam rollers had now been tried in Birmingham, and he thought some one of these ought now to be adopted and employed permanently in the town, as it was known that each of them would do the work in a substantial and lasting manner. He had seen the steam roller in operation in Liverpool and elsewhere, and was desirous to see it used also in Birmingham, being satisfied that any steam roller, even though not the best that could be obtained, was vastly superior to the horse rollers at present employed.

The PRESIDENT said he had that day seen in operation the steam roller described in the paper, with double-cylinder engine and

bearing springs, and he did not think there could be any question as to the great advantages attending the application of steam power to the rolling of roads. The same principle might also he thought be extended with advantage to the lighter rollers used for agricultural purposes, enabling farming operations to be performed more rapidly and efficiently; and he did not see why steam power should not be used for many purposes where horses were now employed.

He moved that the discussion should be adjourned to the next meeting; and proposed a vote of thanks to Mr. Batho and Mr. Aveling for the paper, which was passed.

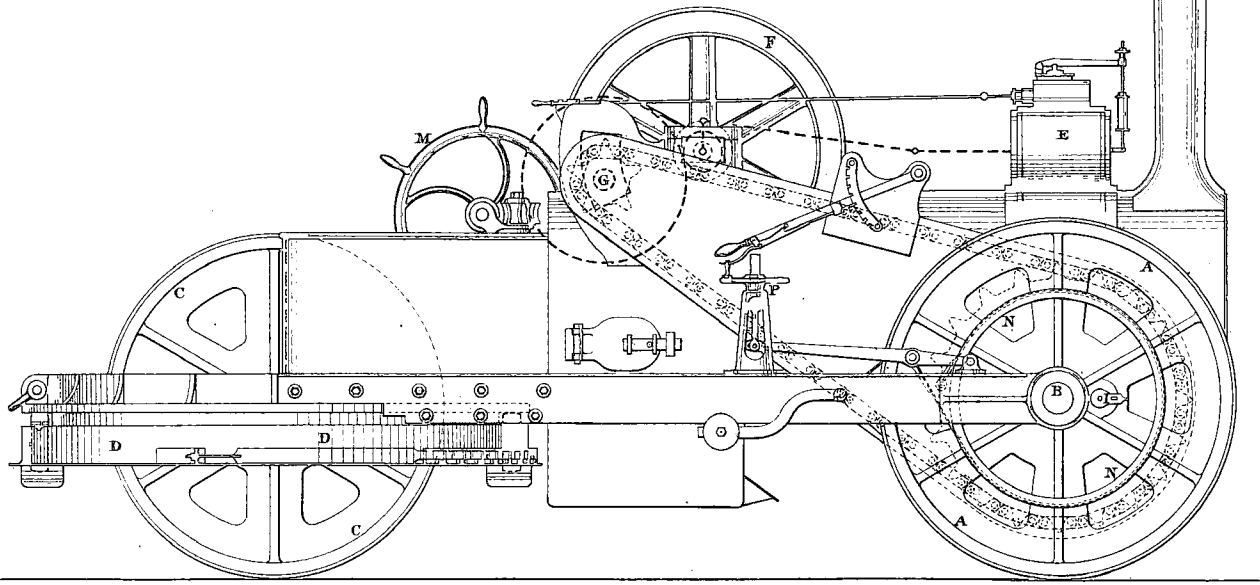
The Meeting then terminated.

STEAM ROAD ROLLER.

Plate 18.

Three-Roller Machine with Single-cylinder Engine.

Fig. 1. *Side Elevation.*



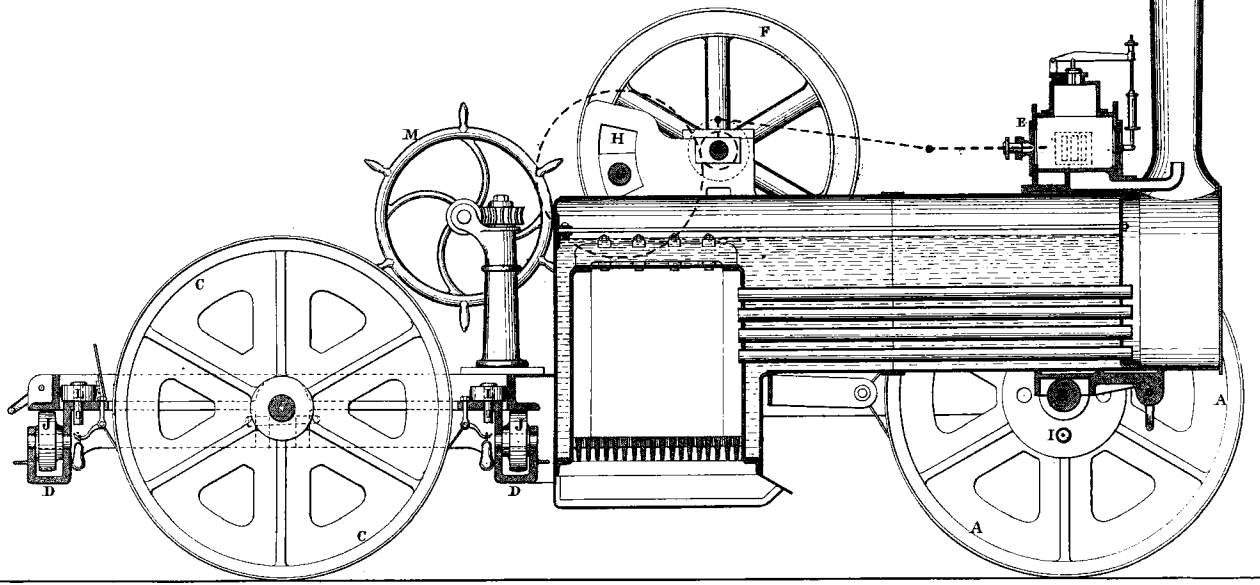
(Proceedings Inst. M.E. 1870.) Scale 1/30th Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet

STEAM· ROAD ROLLER.

Plate 19.

Three – Roller Machine with Single – cylinder Engine.

Fig. 2. *Longitudinal Section.*



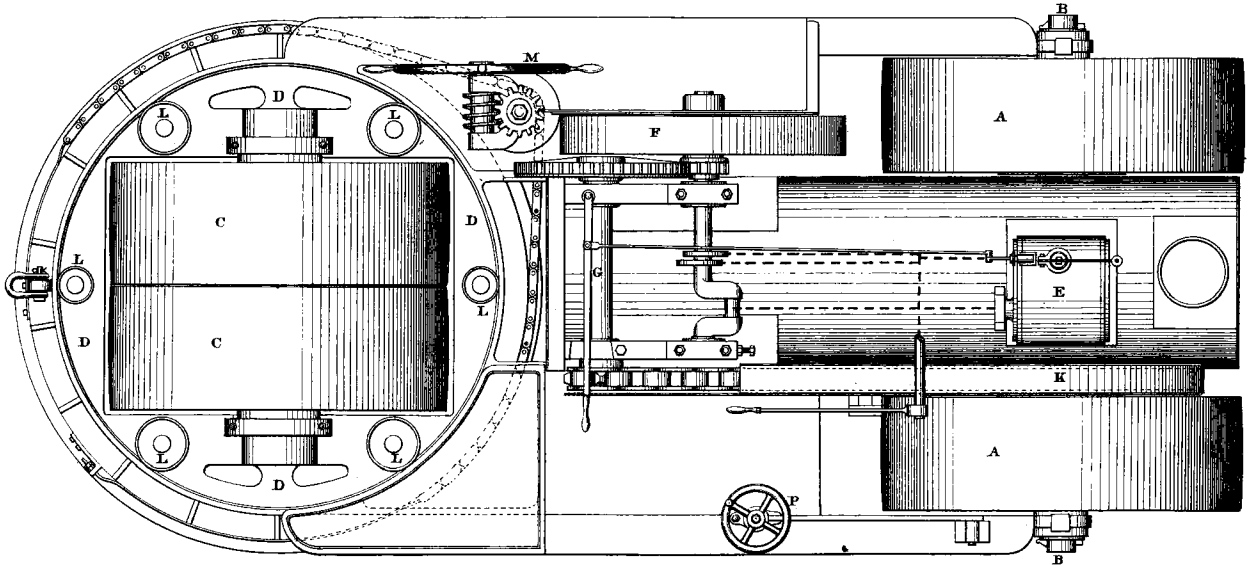
(*Proceedings Inst. M. E. 1870.*) *Scale* 1/30th. Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet.

STEAM ROAD ROLLER.

Plate 20.

Three-Roller Machine with Single-cylinder Engine.

Fig. 3. *Plan.*



(Proceedings Inst. M. E. 1870.) *Scale 1/30th* Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet.

STEAM ROAD ROLLER.

Three-Roller Machine with Single-cylinder Engine.

Plate 21.

Fig. 4. *Back Elevation.*

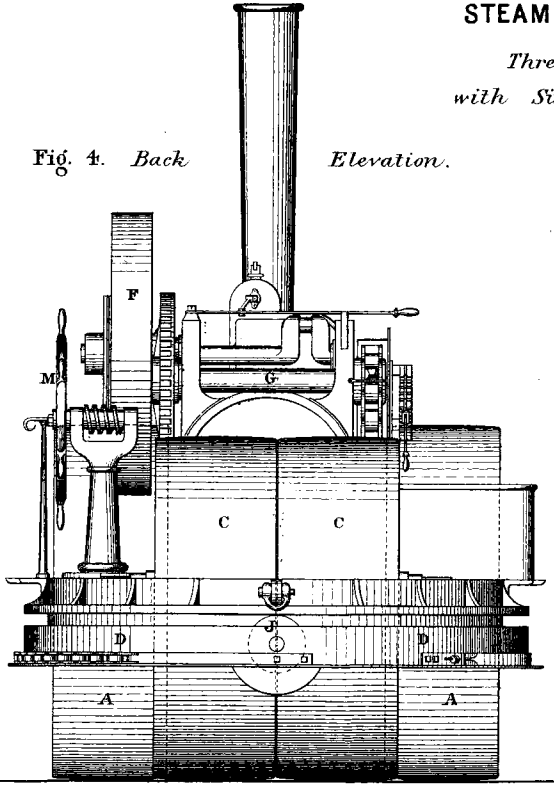
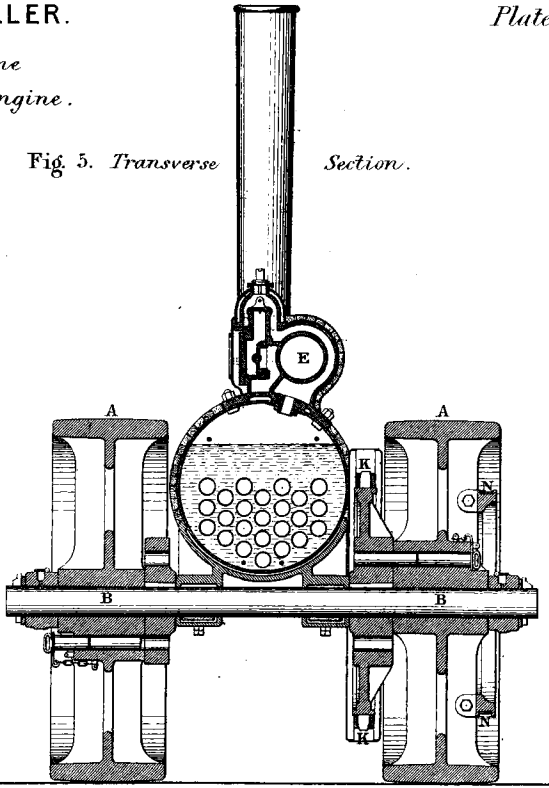


Fig. 5. *Transverse Section.*



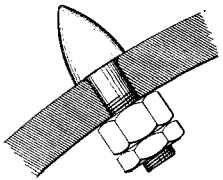
(*Proceedings Inst. M.E. 1870.*) *Scale* 1/30th

Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet.

STEAM ROAD ROLLER.

Plate 22.

Fig. 7. *Spikes for breaking up road surface.*



Scale 1/8 th.

Three – Roller Machine

with Double – cylinder Engine and Bearing Springs.

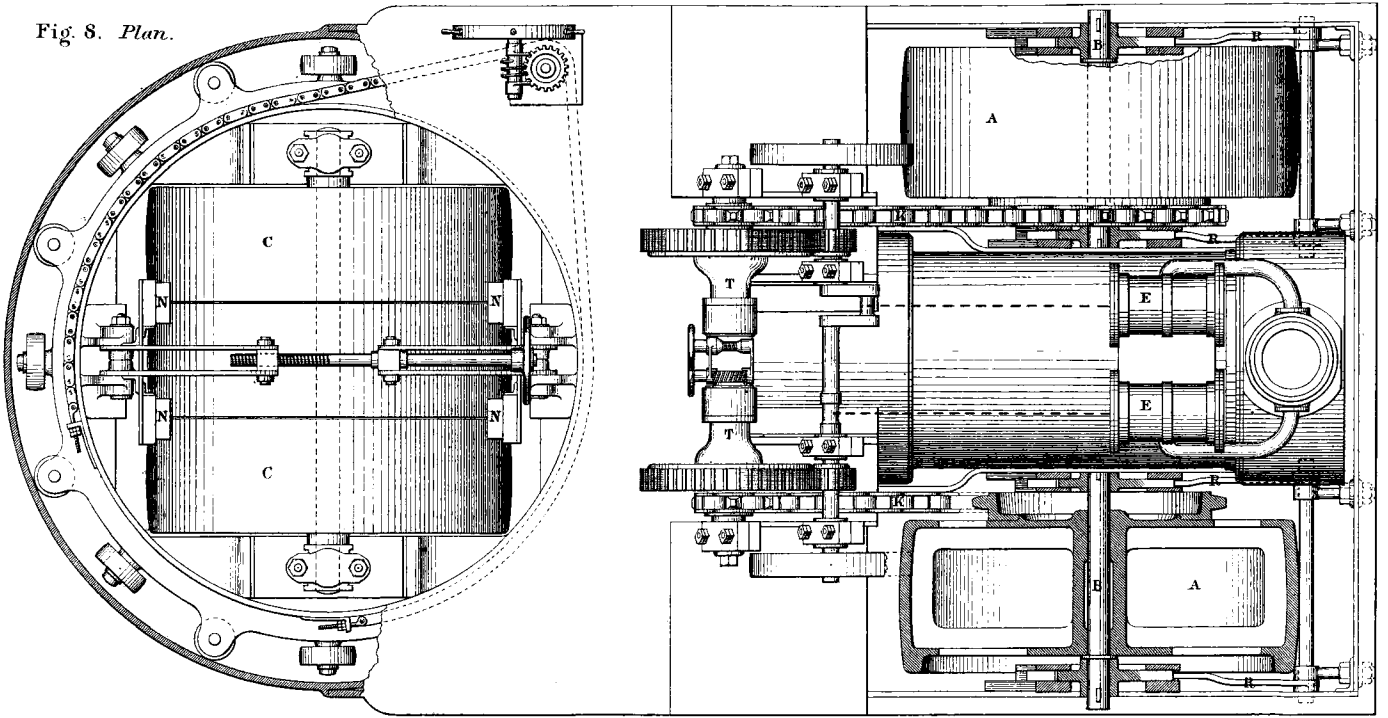
Fig. 6. *Side Elevation.*

STEAM ROAD ROLLER.

Plate 23.

Three-Roller Machine with Double-cylinder Engine and Bearing Springs.

Fig. 8. *Plan.*



(*Proceedings Inst. M.E. 1870.*) *Scale 1/30th*

Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet.

STEAM ROAD ROLLER.

Three - Roller Machine

with Double - cylinder Engine and Bearing Springs.

Plate 24.

Fig. 9.

Back Elevation.

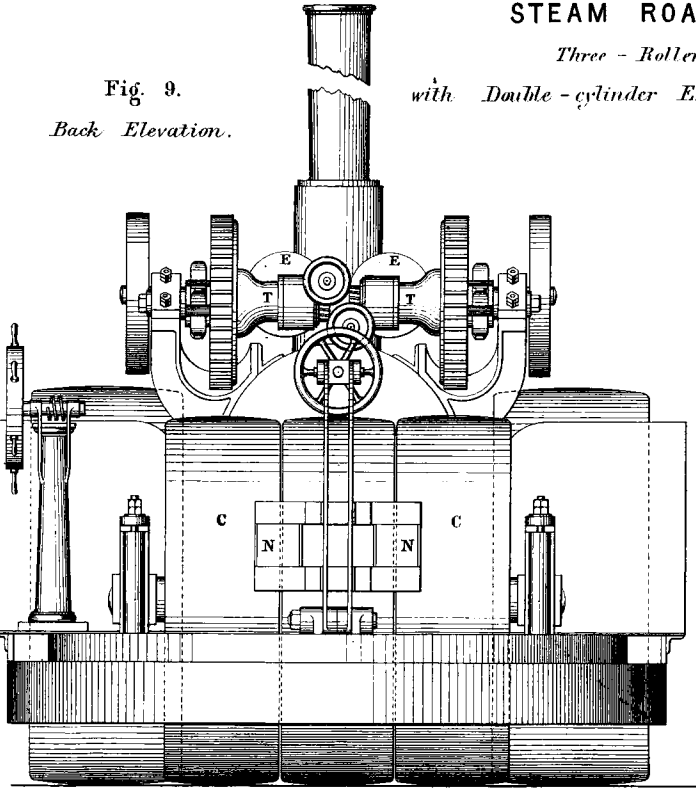
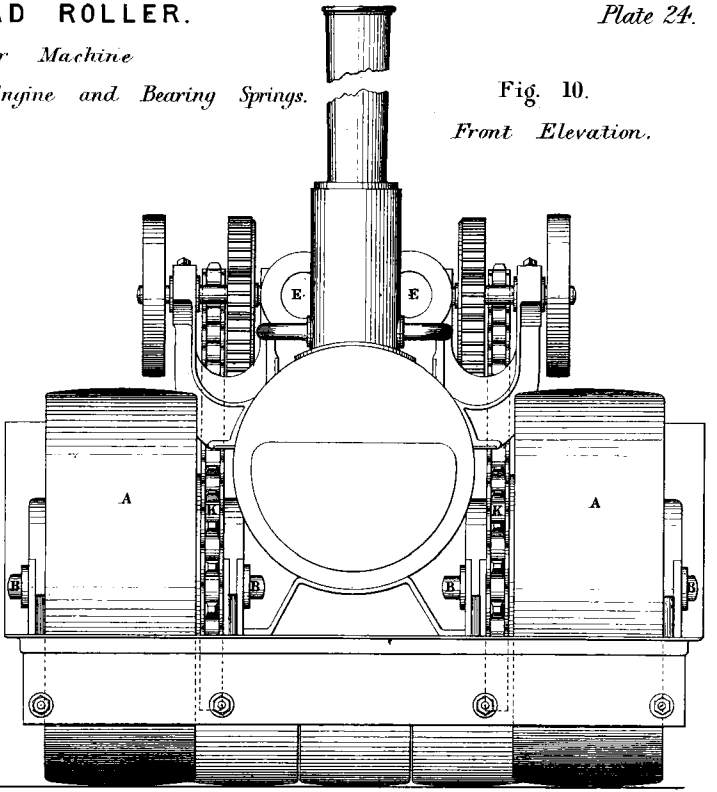


Fig. 10.

Front Elevation.



(Proceedings Inst. M.E. 1870.)

Scale 1/30 th.

Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 *Feet.*