The Engineering Times.

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The Attempted "Boycott" of the Paris Exhibition.

We are gratified to find that our opinion on this subject, which we gave expression to in no uncertain terms in our last issue, is entirely in accord with that held by the majority of the British Exhibitors, and certainly by nearly the whole of the engineering section. Our plain speaking has evidently not been relished by the "boycott" press, judging from the way in which our remarks have been criticised. And, after all, there is *some* excuse for their disturbed feelings since the attempt was such an utter failure.

The *Review of Reviews* has a few words to say on this matter in its last issue, which are very much to the point:—

"The newspapers were filled with suggestions of varying degrees of *idiotcy* as to the duty of the outside nations to punish France for the verdict of the court-martial on Dreyfus. Paris is to hold a great Exhibition next year, the chief attraction of which will be the presence of exhibitors from all lands. Some *featherhead* seems to have imagined that it would tend to improve matters if the outside public were to boycott the French Exhibition by way of indicating its dissent from the verdict of the court-martial, etc." "Over-emphasized?" not in the least.

A strange fact is that the sensational "boycott" journals are continually crying out about foreign competition and blaming the British trader and engineer for their alleged "lack of enterprise," and here the same journals advocate the closing of one of our important markets!—in other words handing over our French export business to our competitors!

We do not intend to discuss the subject further in these columns. The less now said about it the better for British trade. But we cannot refrain from giving an extract from a leader in *Feilden's Magazine*:—"We have noticed with some amusement the claims made by rival members of the daily press to the very *dubious* honour of evolving the 'boycott' of the Paris Exhibition; especially considering the fact that the movement really had its *origin in the offices of this journal*." Dubious? We should say so. But what a confession!

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The Education and Training of an Engineer.

Professor Lineham's article in our last issue bearing the above title has attracted a great deal of attention, and a large amount of correspondence has reached us on the subject. Our correspondents are not wholly in agreement with Professor Lineham's ideal course of education and training as there laid down, and as some of these correspondents hold very high positions in the engineering world, our readers will, doubtless, be interested to learn their views. The general line of opposition argument taken is, that a youth cannot be expected to do hard manual work all day, and then in the evening be fresh and able to master the theory of engineering. It is argued that time spent in a works from say 8.30 to 5 is not conducive to study from 7 to 10 in the evening. As to whether this is so or not we would rather offer no opinion. The subject is peculiarly one for the consideration of Professor Lineham and others who have charge of the training of the engineering youth, and are in a position to judge of his capacity.

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Brake Power of Mechanical Tramcars.

The most important part of a mechanically-operated tramcar—considered from the point of view of public safety—is, of course, the braking facilities. This importance, says *The Practical Engineer*, is rendered even greater at the present moment on account of the growing feeling in favour of higher speeds. It has long been claimed for electric cars that they may be pulled up immediately at any time within their own length. Some mishaps which have been recorded in this country have not served to strengthen the belief of the public in this direction; but whether the various braking arrangements are to blame, or the man who ought to operate them, is not always clear. We are inclined to think that it is more often the man who is at fault than the equipment; and the electrical tramcar with the most up-to-date brakes is equal to any ordinary track, although the descent of steep gradients may call for something additional, as at Bradford, Halifax, and Sheffield. Of course, everything must be done to have the human element efficient and reliable; but it may be possible to devote too much attention there, at the risk of not improving the mechanical or electrical equipment. Too much cannot be done in perfecting such apparatus; and when it is known which systems of braking are really the most reliable, the facts cannot be too widely circulated among tramway engineers. Therefore we attach something more than the usual importance to the tests which are now being made on certain tram lines in New York of power brakes. It is stated that about fifty devices, including air, electrical, and mechanical brakes, are being tried; and when the investigation has been completed, and the results issued by the New York Board of Railroad Commissioners are known, they will be of considerable value to electric and other mechanical tramway men on this side of the Atlantic, as well as in the States.

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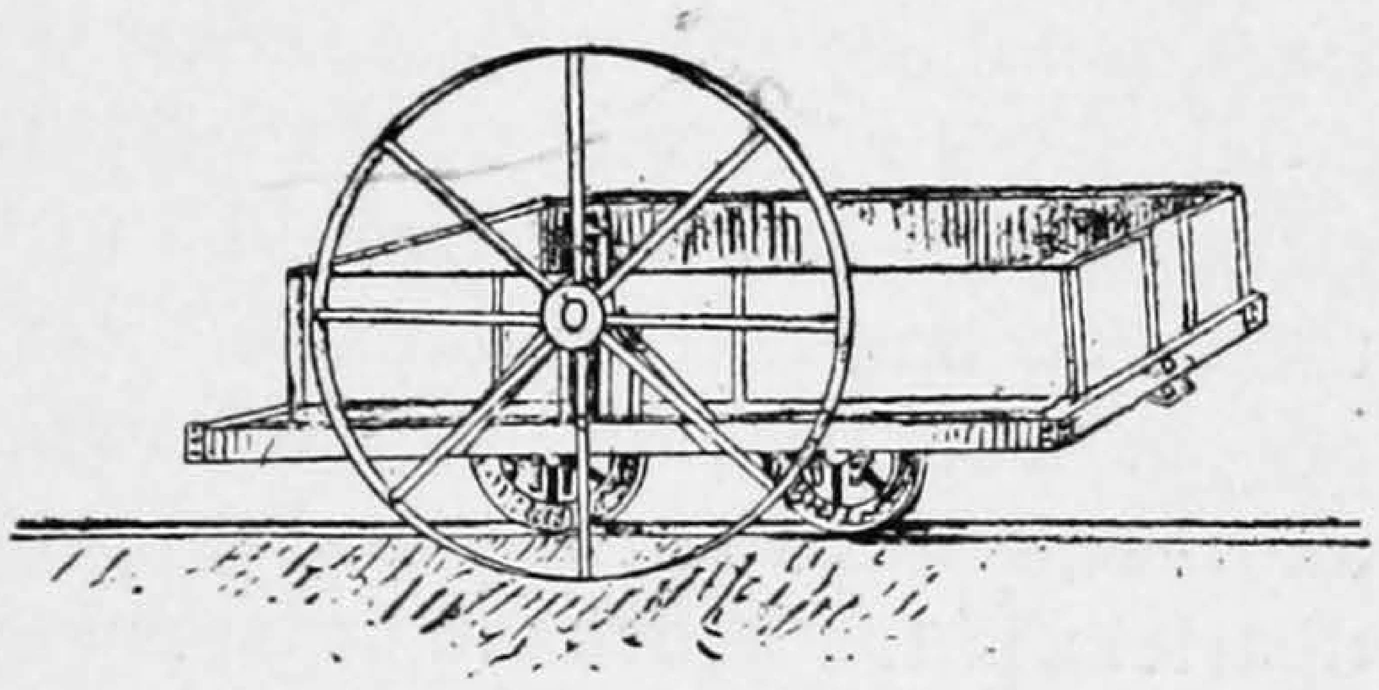
Ewing's Single-Rail Tramways.

Some interesting particulars of a single-rail tramway are given in a recent issue of *Transport*. This tramway is the invention of Mr. Charles Ewing, and is being successfully used in India. It somewhat resembles Caillet's Monorail, an account of which will be found in our issue of March last.

In this system "the trucks are carried on two (or sometimes three) double-flanged wheels, which are placed centrally under them and run on the rail. They are fitted also with a wide-tyred side or balance wheel of large diameter, which keeps them in an upright position. This side wheel runs on the roadway, while the double-flanged wheels, being placed



OPEN PLATFORM TRUCK WITH REMOVABLE BOX-SIDES.

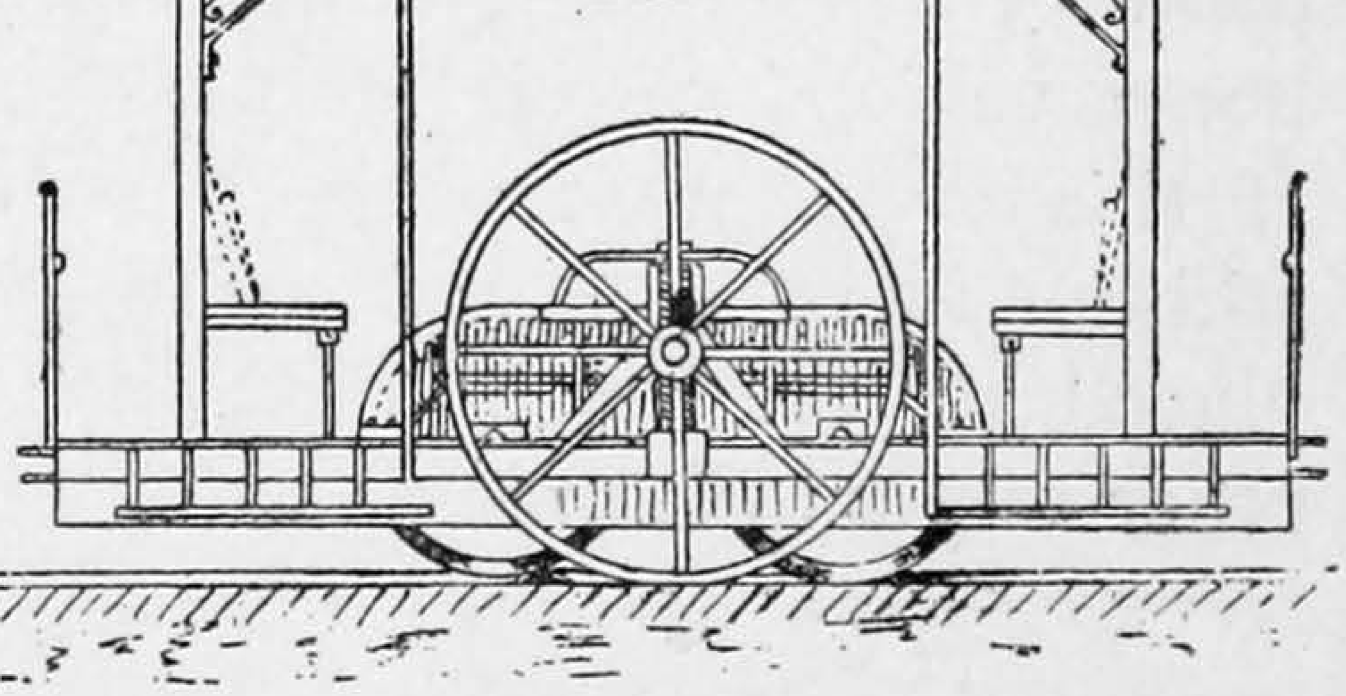
centrally under the platform of the car, bear the whole weight of the car and its load. The side wheel has, according to the pattern of the truck, either a straight or cranked axle, which is pivoted at the centre of the truck, and this axle is provided with double helical springs which take up any jolting caused by inequalities in the road surface in the path of the side wheel.

"The side wheel is comparatively light, but being placed at some distance, usually 5ft., from the centre of the truck, it exerts a leverage greatly in excess of its weight, and this allows of the truck being considerably overloaded on the far side without any risk of its upsetting. The wheel weighs generally 165 lb., which allows for an excess weight of $2\frac{1}{2}$ cwt. being placed on the far side of the light 1-ton truck without any danger of its overbalancing. In the larger trucks an excess of 5 or 6 cwt. may be so carried.

"The great advantage of the system is that the line takes up very little space; it can be laid along the edge of a road, leaving the whole of it free for ordinary traffic, and as the rail projects only about one inch above the road surface it does not form a serious obstacle to vehicular traffic, even if left unguarded by guard rails at crossings. The line can also be laid on any fairly level ground fit for ordinary bullock carts, and it is very suitable for use in the hills also.

"The rolling stock can be made of many patterns for goods or passenger traffic. For ordinary purposes the open platform truck, in which the side wheel axle is cranked to go underneath the platform, leaving the full width of the latter entirely clear, is probably the best, but in certain cases where it is of advantage to have the centre of gravity as low as possible, it may be better to have trucks, the platforms of which are only 8in. above ground level; it makes an upset impossible—a matter of importance in a steep hill line.

"The open platform trucks can be very easily loaded when tipped. For this purpose the side wheel is raised off the ground, which can easily be done by one man. For loading timber, barrels, and other heavy things, this is a great advantage. Logs of timber, dismounted guns,



etc., can easily be loaded by parbuckling. The facility with which trucks can be tipped does away with the necessity for loading and unloading platforms—a great advantage.

"The trucks can be drawn singly or in a train—steam, electricity, or other power, can be applied for draught purposes, but for ordinary use animal power, which is so cheap in this country, would be the most suitable. One pair of bullocks, or one buffalo, can with ease draw a train of six light trucks, each loaded with one ton, or of two $3\frac{1}{2}$ ton trucks—compare this with what a pair of bullocks can draw in a country cart! Taking 15 miles a day as a fair day's work for a pair of bullocks, the keep of which, with their driver's pay, say averages 12 annas a day, it means that 6 to 7 tons can be carried in this country 15 miles for 12 annas, or one shilling, or from 90 to 100 tons a mile at the same cost. The economy of animal draught on this line is evident."

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Motor Omnibuses in London.

Half-a-dozen omnibuses have started running in London between Kennington Park and Victoria Station. They are driven by light oil engines, and resemble the usual 'bus with a stairway behind and garden seats on top, but with the addition of an extension in front for the motor and driver, which are placed over the front axle. The 'bus complete weighs about 3 tons and, like the ordinary horse vehicle, carries 26 passengers. If this experiment prove a success, additional vehicles will at once be placed on the before-mentioned and other routes in London.

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An International Tramways Exhibition in London.

We learn that an International Tramways and Light Railways Exhibition will be opened in the Agricultural Hall, Islington, London, on the 30th of June, 1900. The fact that such a scheme is even proposed shows the enormous strides which have been made in this country during the last three or four years in the direction of improving the means of local communication. Not merely are local authorities and tramway companies fully alive to the necessity of providing better methods of traction for street cars, but the general public are beginning to see that the most effective means of providing for the quick and convenient transport of people from one part of a town to another, or between city and suburban districts, is the provision of tramways, and plenty of them, with swiftly-running cars propelled by electricity, or in some other way by mechanical power. The fact that there are 16,000 miles of electric tramways and light railways in the United States and Canada, shows how large the development is there, and the continent of Europe is also being rapidly supplied with electric lines for local purposes. For several years there has been an exhibition of tramway apparatus and appliances at the annual meetings of the American Street Railway Association, but the forthcoming show at the Agricultural Hall is the first of the kind ever held in this country, or indeed in Europe. It is promoted by the proprietors of the *Tramway and Railway World*, and an excellent list of patrons has been secured. They include the Lord Mayors of Liverpool, Manchester, Leeds, Sheffield, Belfast, Dublin, and York; the Lord Provost of Glasgow; the Mayors of Sunderland, Croydon, Birkenhead, Derby, Halifax, Bradford, and other towns; the Chairmen of the Tramway Committees of the Corporations of Aberdeen, Blackburn, Blackpool, Bolton, Dundee, Huddersfield, Newcastle, etc.; and the chairmen of the leading tramway companies in the country, such as the North Metropolitan, British Electric Traction, Bristol, Dublin, Edinburgh and District, and London United. The recently formed Tramways and Light Railways Association are also patrons, and there is a strong advisory committee, consisting of the principal general managers of tramways in the country. The Agricultural Hall, where the Military Tournaments and exhibitions requiring large space are held, has been selected as the most central position, and it will be extremely convenient for the purpose, as it has doorways sufficiently large to admit fully-equipped tramway cars —a most important consideration—and floor space sufficient to allow of as many as ten different lines of tramway track. The exhibits will comprise all sorts of electric systems, cable systems, compressed air, gas and steam systems, permanent way construction, tunnel construction for underground lines, power station equipment (including boilers, engines, dynamos, and all sorts of auxiliaries), cable driving machinery, rolling stock, electric car equipments, trucks, power brakes, etc. Support is already assured, not only from manufacturers and dealers in this country, but from very many abroad, and in particular from the United States, which may be looked upon as the great home of the electric traction industry. Corporations and companies in the United Kingdom are now so actively engaged in electrically equipping their existing lines and in building new tramways that they will all be deeply interested in the exhibition. Many of them have already arranged to send representatives, where every opportunity will be afforded them of closely examining and obtaining information regarding all that is newest and best in connection with tramways and light railways. The general public also who attend the show will get many new ideas, and will no doubt depart determined to urge their local authorities or tramway companies to give greater and greater facilities for rapid, cheap, and pleasant local communication. We wish the undertaking every success.

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Bryan Donkin, M. Inst. C. E., M. I. Mech. E.

It is probable that the present decade has produced more notable engineers, civil, mechanical and electrical, than any previous one, and it is to these, doubtless, in the larger degree, that the world owes its rapid improvement, progress, advancement. In the front rank of these stands the subject of our frontispiece, and a few particulars of his career will not fail to interest our readers.

Mr. Bryan Donkin is the son of the late Mr. John Donkin, and grandson of the late Mr. Bryan Donkin, F.R.S., who, it will be remembered, made, about 1806, the first practical paper machine for making paper in a continuous web, and who was the original founder of the present firm.

Born in London in 1835, and after having been educated at various schools, Mr. Bryan Donkin was sent to the University College, London; and later on to the Ecole Centrale, Paris, where he passed in French his examination for Technical Education.

At the age of 22 he entered his father's engineering works, which employed some 200 hands, and went through the various workshops.

The years from 1859-62 he spent at St. Petersburg as resident engineer to a large paper mill employing between two and three thousand hands, which his firm erected to the order of the Russian Government for making all Bank Note and State papers.

Five years later he became a partner in the firm, and is now Chairman and Managing Director.

He has made and published numerous Experiments on Steam Engines and Boilers, as well as various experimental Research works on "Condensation in Steam Engine Cylinders and Temperature Cylinder Walls" — "The Value of Steam Jackets"—"Transmission of Heat"—"Centritrifugal Fans"—etc., etc.

Mr. Bryan Donkin is a member of the Institution of Civil Engineers; of the Institution of Mechanical Engineers American Society of Mechanical Engineers; of the Verein Deutsche Engenteure (Germany): of the Royal Institution; and also of the British Association.

For the first-named institution, he has within the last 15 years contributed many papers. He was also elected a member of the late Committee on the Efficiency of the Steam Engine, and is now a member of the Committee for Reporting on Standard Forms for Tabulating Steam Engines and Boilers. From this institution he received the Watt Gold Medal; Telford Premium and also the Manby Premium.

To the Institution of Mechanical Engineers he has contributed several papers, notably that on Steam Engines and Steam Jackets. He was elected a member of the Council about seven years ago. Amongst the many committees upon which he has served, may be mentioned "Marine Research," and he is now serving upon the "Steam Jacket," "Gas Engines and Steam Engines" Committees.

To the American Society of Mechanical Engineers, he has read several papers, and also was a member of the Committee for Standardising Boiler and Steam Engine Experiments.

He is the designer of an instrument called by Hirn "The Revealer," which illustrates the effect of condensation in steam engine cylinders.

He has written several technical and scientific articles for both English and French papers, and is the author of the following books: "Gas, Oil, and Air Engines" (soon to be in its third edition), "Heat Efficiency of the Steam Boilers," and joint author with Dr. Kennedy of "Experiments on Steam Boilers."

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The British Association Meeting at Dover.

Some unusually interesting papers have been read this year before the British Association at Dover, one by Sir William H. White, Director of Naval Construction (whose portrait we gave in a recent issue), on Steam Navigation at High Speeds, was especially important. After tracing briefly the principal steps in the increase of speed of mercantile and naval steamships during the present reign, Sir William indicated the constantly growing difficulties in the way of the still further increase of speed, and showed how past experience is against inventors' theories of sixty miles an hour. We will not attempt a summary of this paper here, as it is our intention to reproduce it *in extenso* in an early issue.

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Dover Harbour Works.

The paper by Messrs. W. Matthews and J. C. Coode on the Dover Harbour Works, was opportune. It opened with a sketch of the efforts that have been made to improve the navigation facilities of the port of

Dover, some records of which extend back to more than four hundred years. After various commissions and inquiries, the contract for the first portion of the Admiralty Pier was let in October, 1847, and the pier was completed, excepting a small addition to the seaward end in 1871. It gave fairly good accommodation for landing and embarking passengers, but during exceptional gales there was some difficulty and even risk. To improve the then existing conditions, the Dover Harbour Board consulted Sir John Coode with a view to the construction of a deep-water harbour, and the work was sanctioned by Parliament in 1891. This scheme was what is generally known as the "commercial harbour," and consisted of an eastern pier and an extension of the Admiralty pier. The sheltered area would have been 56 acres, and about five acres would have been reclaimed. The only part of this scheme commenced up to the present time is the east pier, the contract for the construction of which has been let to Sir John Jackson. Towards the end of 1895 the Admiralty instructed the authors to prepare a design for an enclosed harbour suitable for the accommodation of Her Majesty's Navy. The works recommended consist of (*a*) an extension of the Admiralty pier east south-east for 2,000ft.; (*b*) an arm commencing against the chalk cliffs a few hundred feet from the east boundary wall, its direction being approximately south by west, and its length, 3,200ft.; (*c*) an isolated breakwater, 4,200ft. long, forming the southern protecting arm; and (*d*) the reclamation of 21 acres of the foreshore. There are to be two entrances, one 600ft. and the other 800ft. wide, with a depth of seven fathoms. The length of sheltering works is to be 9,520ft., and the area enclosed, exclusive of the commercial harbour, 610 acres at low water. The contract for the Admiralty harbour was let in 1897 to Messrs. S. Pearson and Sons, London.

Mr. E. Marshall Fox read a paper on "Non-Inflammable Wood for Warships." Another paper was given by the Hon. Chas. Parsons, which consisted mainly of suggestions for increasing the speed of cross-Channel steamers by the adoption of the steam turbine bearing the author's name. Mr. Mark Robinson, of Rugby, discussed the Niclausse boiler, and Mr. A. Siemens "Electrical Machinery on Board Ship."

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"The Centenary of the Electric Current."

The above is the title of a lecture delivered by Professor J. A. Flemming, in the course of which the author said that the investigations of Alessandro Volta, born in Como in 1745, opened a new chapter in the history of electrical discovery by giving to the world the voltaic pile. To regard the modern uses of the electric current thus given to us by Volta was to realise the astounding results which a century had brought about. Some idea of these results might be found in the fact that in the year 1898 very little less than £85,000,000 was invested in Great Britain alone in electrical enterprise.

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"Recent Experiences with Steam on Common Roads."

A paper worthy of particular notice also was one by Mr. J. I. Thornycroft, F.R.S., on the above subject. The author, after referring to the work of early inventors in this field, went on to refer to the restrictions still put upon self-propelled vehicles by the law. The Locomotive on Highways Act, 1896, though removing some obstacles, was still an imperfect measure. The clause pressing most hardly was that restricting the weight of the vehicle unladen to less than 3 tons. Merchants and manufacturers insisted on loads of from 5 to 10 tons being dealt with, but it was commercially impossible to build a durable vehicle within the limits of the tare, although one might be constructed that would perform the service on trial runs.

Other very interesting papers were read, which we hope to be able to refer to in early issues.

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"England's only hope."

A most interesting and instructive serial article on "American Competition," by Mr. W. Kent, the Associate editor of the *Engineering News* of New York, has been running through the columns of recent issues of *Engineering*. We do not agree with some of the arguments put forward, but, as an American view of the question, it is well worth perusal. The author concludes as follows :—"England's trouble with American competition to-day is not due to any fault of geographical location nor to any failure of natural resources. It seems rather to be due to the natural peculiarities, or to the prejudices, of her people. Forty years ago the English workshops were the best in the world, her workmen were the best and so were her products. Every Englishman knew this, as did the rest of the world, and every Englishman was brought up to believe not only that everything English was the best, but that it would always continue to be, and that no improvement was necessary. Meantime, the rest of the world has been advancing, while Englishmen have been content to have things remain as they were. The English owner of workshops has now had his eyes opened, and his mental peculiarity—call it conservatism, or as some do, pigheadedness—will disappear, and he will do his part to retain his fair share of the world's markets ; although he must be content to share some of them with America, Germany, Belgium, and, perhaps, some day, say twenty years hence, with Russia. But what of the English workman? He has a fundamental fallacy implanted in his brain to the effect that the total amount of work to be done is a limited quantity, and if he does too much in a day, or obtains the help of a machine to do more than he has done, there will be less work for him to do to-morrow, or else he will be reducing the amount to be done by his fellow-workman, and "taking the bread out of his mouth." Will he ever get this fallacy dislodged from his brain, and learn that whenever he gets a machine to help him double his day's work, he thereby increases the world's wealth, and makes it possible for him to get a larger share in the division?

The labour question, it seems, therefore, is the greatest factor in the great problem of England's meeting American competition. It cannot be solved by reducing the daily wage of labour. It must be solved by the owner providing the machinery, and by the workman using that machinery to produce double the work that he has done heretofore. This plan affords the only hope of the workman's having his daily wages increased as they should be, and of England's holding the place her geographical position and natural resources entitle her to in the world's markets."

THE HISTORY AND DEVELOPMENT OF MOTOR CARS.

By W. FLETCHER, M. Inst. Mech. E.

Author of "Steam on Common Roads," &c.

IV.—SOME RECENT TYPES.

THE "Serpollet" motor cars of French construction claim some notice at our hands. It is quite true that a couple of years ago these carriages figured frequently in the technical papers; of late we have not heard much concerning them, b.t as a variety of carriages have been built, and have answered admirably in practice, these articles would not be complete were they to be omitted. Fig 20 shows the Serpollet boiler and engine as used on the motor cars which gave excellent results. The boiler is the chief feature of interest and it is clearly seen in the illustration. It is a capillary water-tube boiler, the tubes of which were, as first made, closed up by flattening, so that there was scarcely any passage for water. The tubes were subsequently made of the crescent form as shown by Fig. 21, and were encased in cast iron, the tubes being put in the mould and cast iron run round them. It is an instantaneous generation boiler, into which the feed water is formed into steam as required. The boiler has been used for many purposes, including steam tricycles, and numerous motor cars by M. Serpollet and others. The working pressure is 300 lb. per sq. inch or more, while the test pressure has been from 15 to 20 times as great as the highest used in actual practice; the boiler is very satisfactory as to economy. The engine employed is of the horizontal type having two cylinders bolted to the frame of the vehicle. On the crankshaft there are two pinions of different diameters, for gearing into two spur wheels on the countershaft, by means of these wheels two speeds

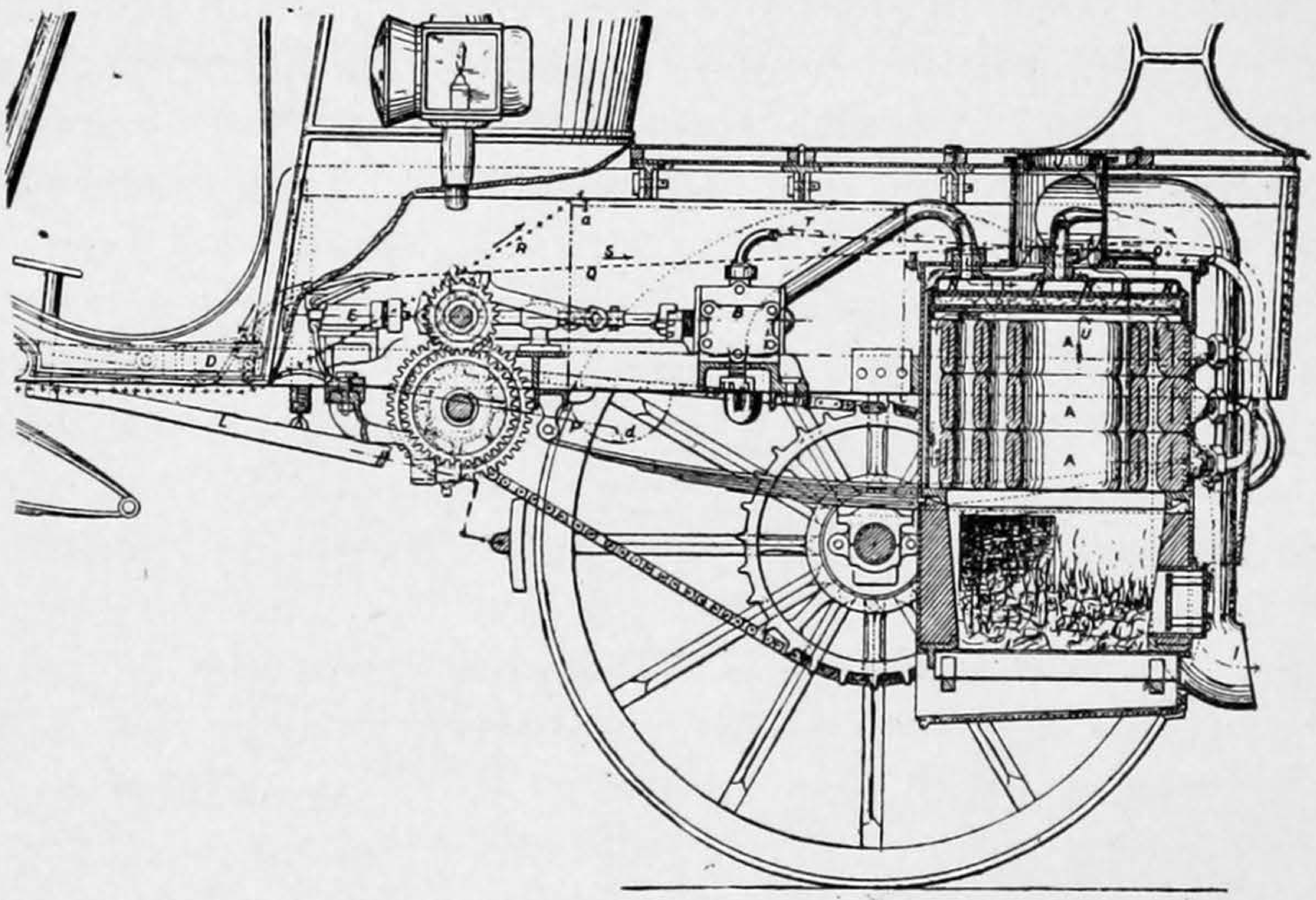


FIG. 20.—THE "SERPOLLET" BOILER AND STEAM PHAETON ENGINE.

are secured. On each end of the countershaft a chain pinion is fixed, which communicates motion to the driving axle, as shown. The feed pump is driven from the crankshaft. When the driver desires to

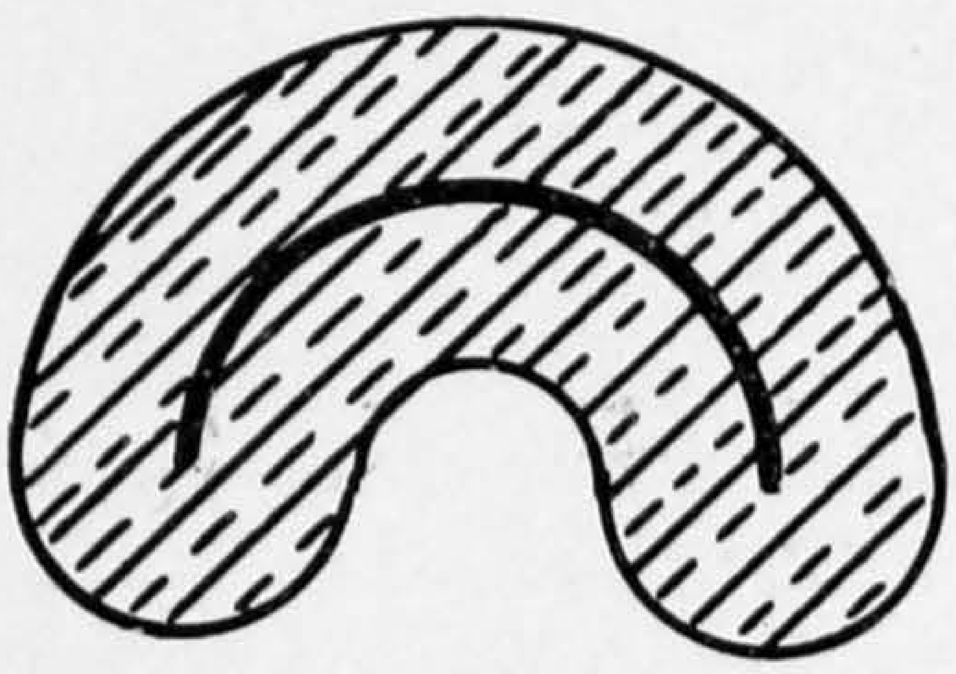


Fig. 21.

start the carriage he moves a lever, which causes water to be pumped into the boiler. After the engine is once started the pump feeds the boiler continuously and automatically. The exhaust steam is conveyed to the top of the boiler, and is there super-heated in a silencer, and leaves the motor car in an invisible form. In order to prevent the escape of smoke, which, of course, would be an annoyance on a public road, the fuel employed is coke. The stoking is to a considerable extent automatic, the arrangement being such that the coke is caused to fall on the fire grate by the motion of the vehicle as it progresses.

A more recent type of Serpollet vehicle is shown by Figs. 22 and 23. The engine consists of a pair of horizontal cylinders, $2\frac{1}{2}$in. diameter and $2\frac{1}{4}$in. stroke, the crankshaft being connected to the driving wheels by means of pitch chains. The coke storage is sufficient for a journey, under good conditions, of 40 miles, but the water tank has to be refilled several times in that distance. The pump used for supplying the boiler is of about 1in. in diameter and of $\frac{3}{4}$in. stroke. In the earlier motor vehicles Serpollet employed one steering wheel, which was not altogether satisfactory. In the later machines he has adopted a new method of steering, devised by Mr. Jeantaud. In this arrangement the forward axle is not movable, but is fixed parallel to the rear axle, as is shown in Figs. 24 and 25. From these figures it will be seen that the fixed axle terminates in a fork at each end, in which is placed the tee piece made with bearings, and extended to carry

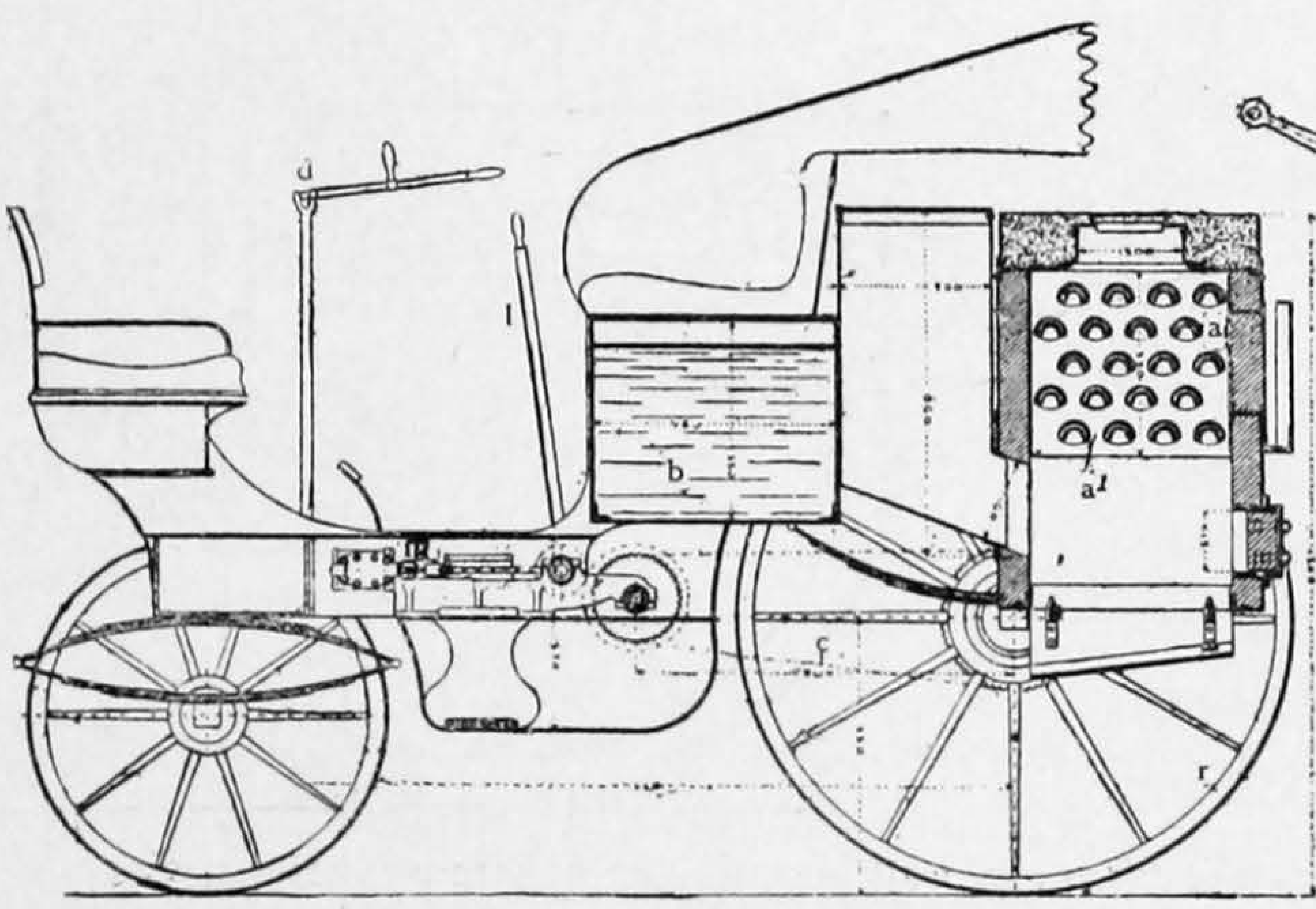
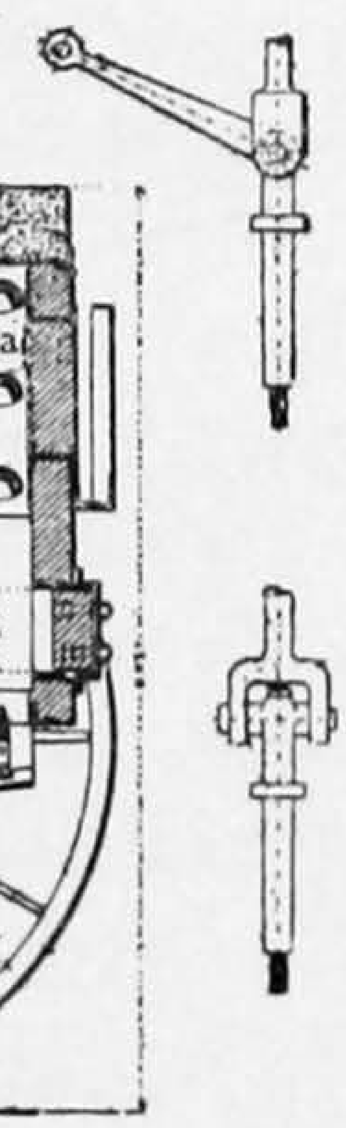


Fig. 22. The Serpollet Steam Carriage.



Figs. 24 & 25.

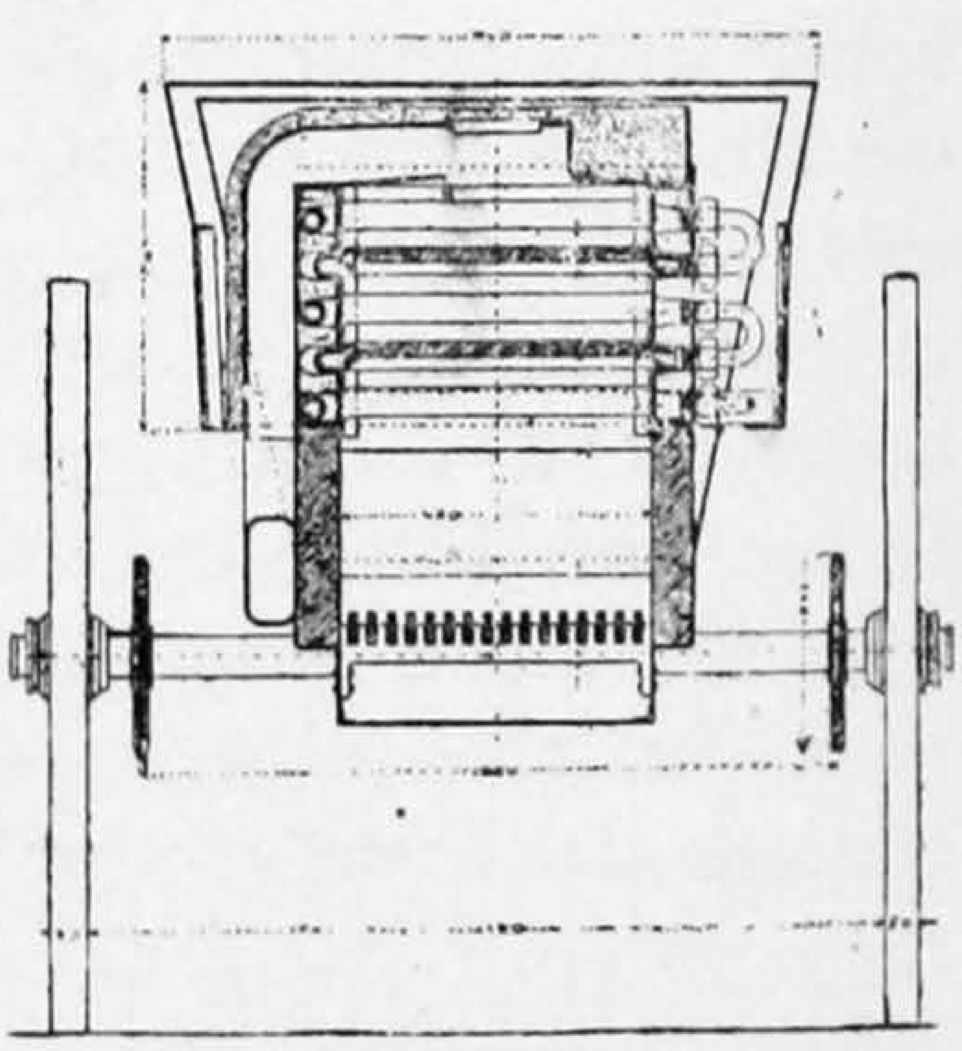


Fig 23

the wheel. By this arrangement a free movement is allowed to the wheels in a horizontal plane, around the bearings of the crosshead. The manner of working the system will be understood by reference to the diagram Fig. 26, where it will be seen that the ends of the levers M,M, are kept at a fixed distance apart by means of a connecting rod, and any movement transmitted to this rod is transferred to the wheels through the levers which, however, passed through different angles when shifted as indicated by the dotted lines in Fig. 26. By this system the motor car can be turned very easily and with quite a short radius. For the present, at all events, this system of steering gear has been definitely adopted by M. Serpollet.* From the illustrations Figs. 22 and 23, it will be seen that the motor of this vehicle is placed beneath the floor. The engines are shown by Figs. 27 and 28, the two cylinders are placed side by side, the connecting rods are coupled to the crankshaft in the usual manner, a spur pinion on the crankshaft drives a wheel on the countershaft. A neatly devised set of compensating gear is placed on the countershaft, by means of which the chain wheels on each end of the shaft act as drivers whether the motor car is travelling in a straight line or turning a corner. From Fig. 22 it will be seen that the chain wheels on the countershaft drive the axle by two pitch chains, and two chain wheels keyed to the driving axle. The feed pump is driven by an eccentric on the crankshaft ; the motor and other wearing parts are lubricated by an automatic arrangement, so as to save the conductor as much trouble as possible.

Messrs. Serpollet have recently introduced a newly-constructed motor car of a smaller and lighter type than those already described. It is intended for two passengers. The motor is a new idea, a half-sectional elevation of it is shown by Fig. 29. It consists of four open-ended cylinders placed horizontally in opposite pairs ; the cylinders are connected to a crank chamber, as shown. The four piston rods are coupled to a two-throw crank, having the crank pins disposed 90 deg. apart ; each crank pin is connected to a pair of opposite piston rods. Slide valves are discarded, the steam distribution is effected by cams on a second shaft, driven by equal-sized pinions from the crankshaft. The four cams

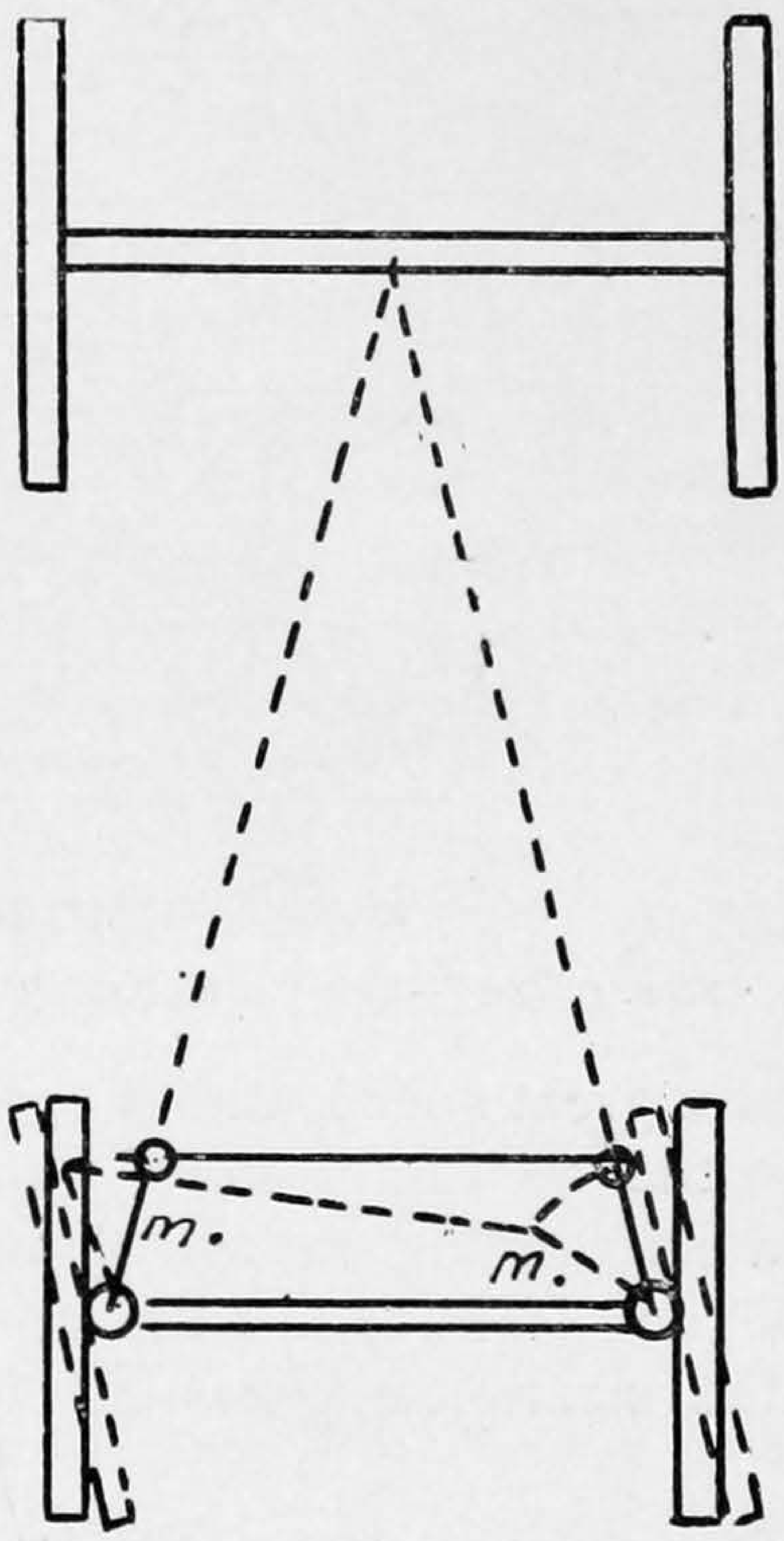
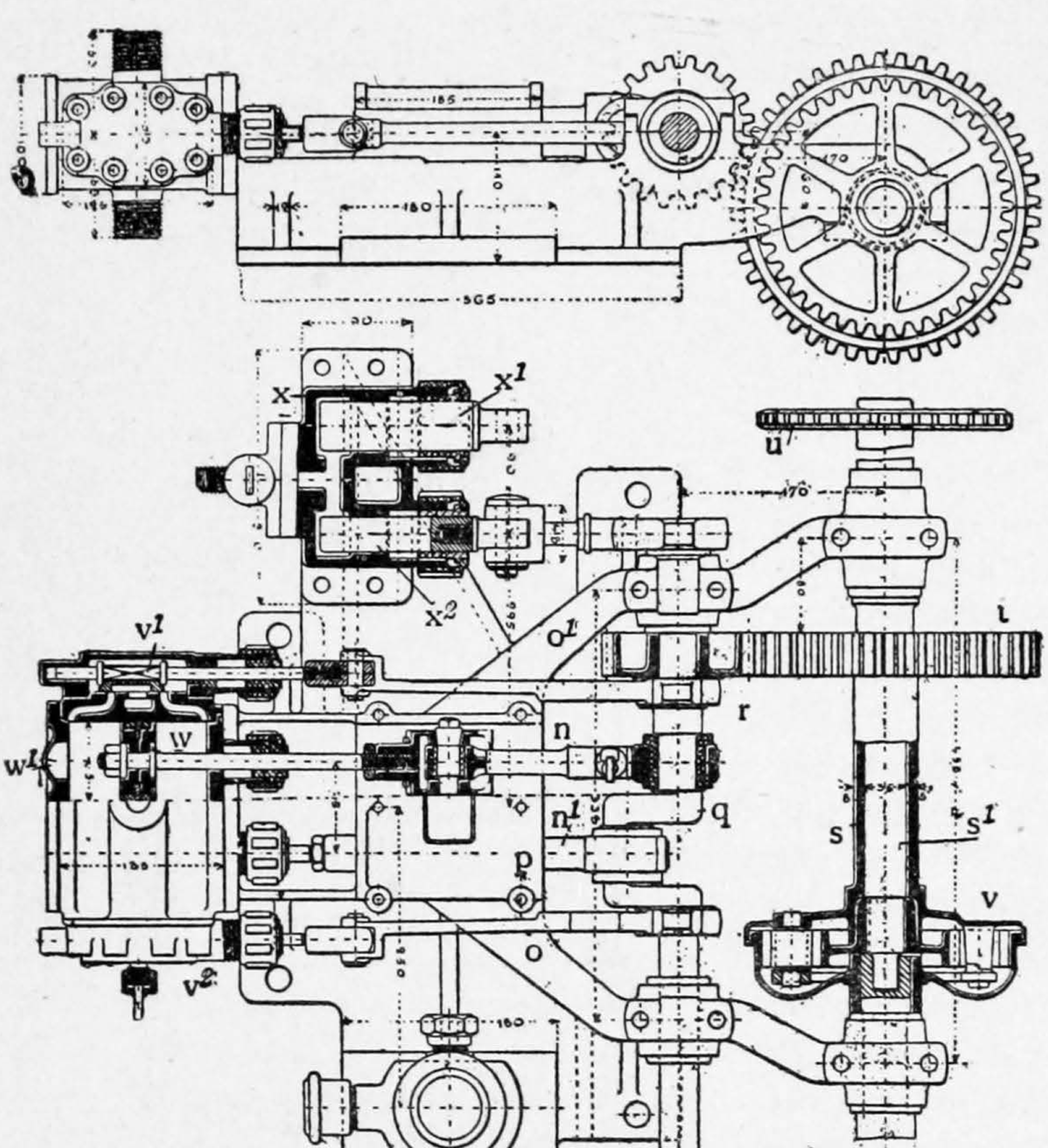


Fig. 26

which operate the sliding stems are shown ; the sliding stems have rollers which are kept in contact with the cams by springs, which are secured to crossheads on the valve stems. The cams are made to slide longitudinally upon the second motion shaft ; by altering the position of the cams, the period of admission can be regulated from nothing to as much as 80 per cent. of the stroke. The motor can

* *Engineering*, October 25th, 1895.



FIGS. 27 & 28.—THE "SERPOLLET" STEAM CARRIAGE.

secure economical results. Fig 30 shows a half-elevation of the boiler, which is arranged for burning petroleum instead of coke, as before. The boiler consists of three parts, a coil of piping in the lower part of the casing, which acts as a preliminary heater; a system of four rows of twisted tubes arranged in series, which acts as a vapouriser, and a super-heating coil placed in the upper part of the boiler. The joints of the tubes are protected from the heat of the furnace by means of baffle plates.

be run at a great speed, and is economical in the consumption of steam. The cranks running in an air-tight box is a good feature, and the reduction of the clearance spaces helps to

The principles aimed at in designing this boiler were:—to regulate the supply of petroleum in accordance with that necessary for the complete vaporisation of all the water in the

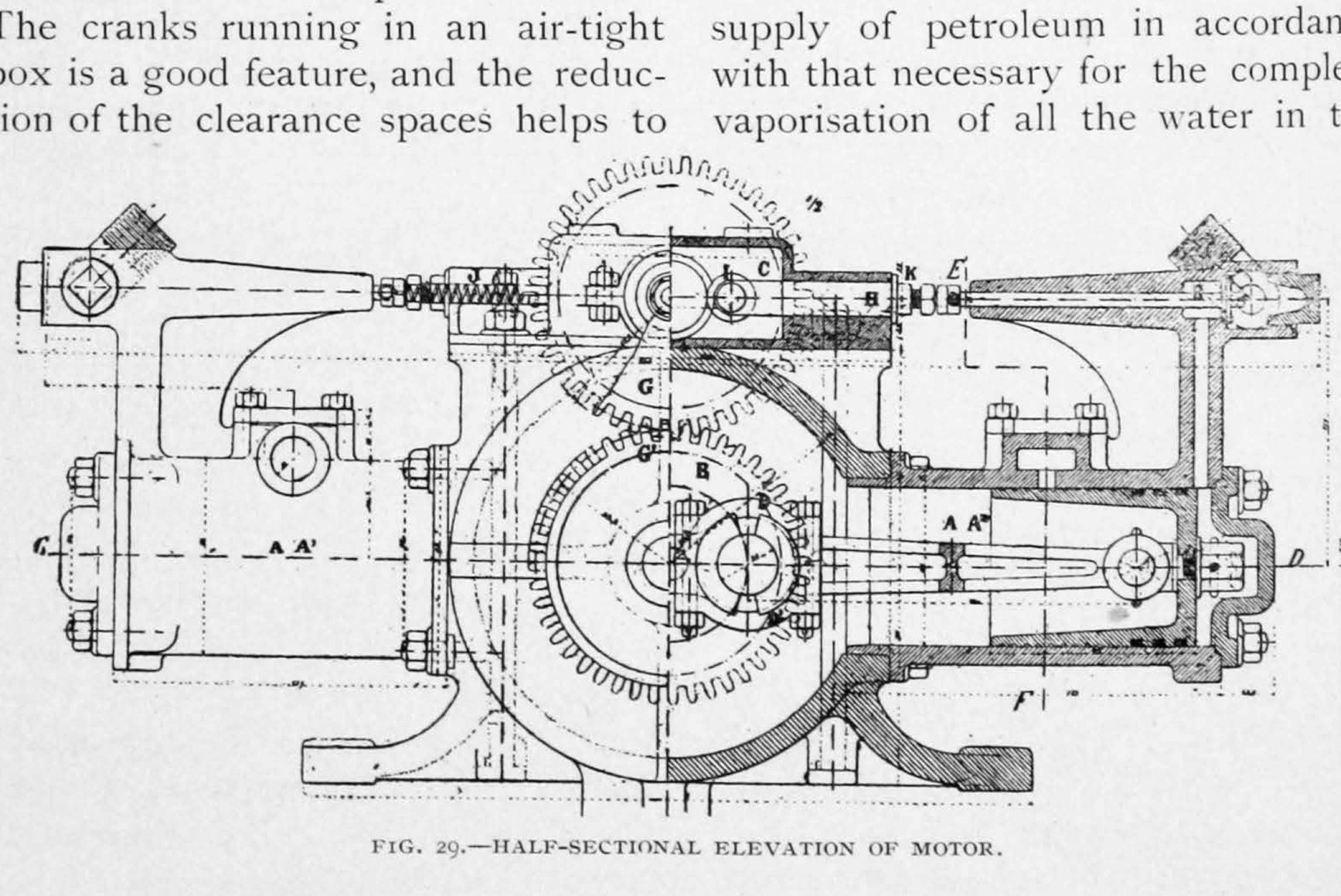


FIG. 29.—HALF-SECTIONAL ELEVATION OF MOTOR.

boiler; to make the consumption of oil and water vary with the energy developed by the motor, and to make the production of energy a matter of automatic regulation. These objects are effected by means of two plunger pumps of unequal diameter and variable stroke, the one supplying oil and the other feeding the boiler with water; these pumps are worked by a lever and an eccentric, and the strokes and displacements are so arranged that the ratio between the quantity of petroleum and the quantity of water pumped can either be a fixed one or varied at will.*

Messrs. Atkinson and Philipson, of Newcastle, have recently introduced a motor carriage, which is illustrated by Fig. 31. Mr. John Philipson, like many other engineers, believes that the application of steam to light motor cars has not received the attention which it deserves. Mr. Philipson has, therefore, been working in conjunction with Messrs. Toward, a Newcastle firm of engineers, and the outcome is a vehicle which has attracted much attention in the North of England, where it has been put to some very exacting tests. The carriage is absolutely free from noise and vibration when travelling, and it climbs very easily hills with a gradient of one in nine. The carriage is of the wagonette type, carrying two persons on the box and four behind seated *vis-à-vis.* The body is supported on elliptical springs of great elasticity, attached to a double of original design on which are mounted the engine and boiler. The latter consists of a number of stout spiral steel tubes situated in a circular steel casing, one of them acting as a feed heater and the others as generators and superheaters. Petroleum or coke can be used for firing; in the latter case the fuel is fed in from the top of the boiler. The working pressure is 175lb. per sq. inch. The motor consists of a pair of horizontal reversing engines, capable of propelling the motor car fully loaded at a speed of ten to twelve miles an hour. Power is transmitted from the engine shaft to the hind carriage wheels by pitched chain and sprocket wheels; a compact differential gear is fitted to the driving axle. The

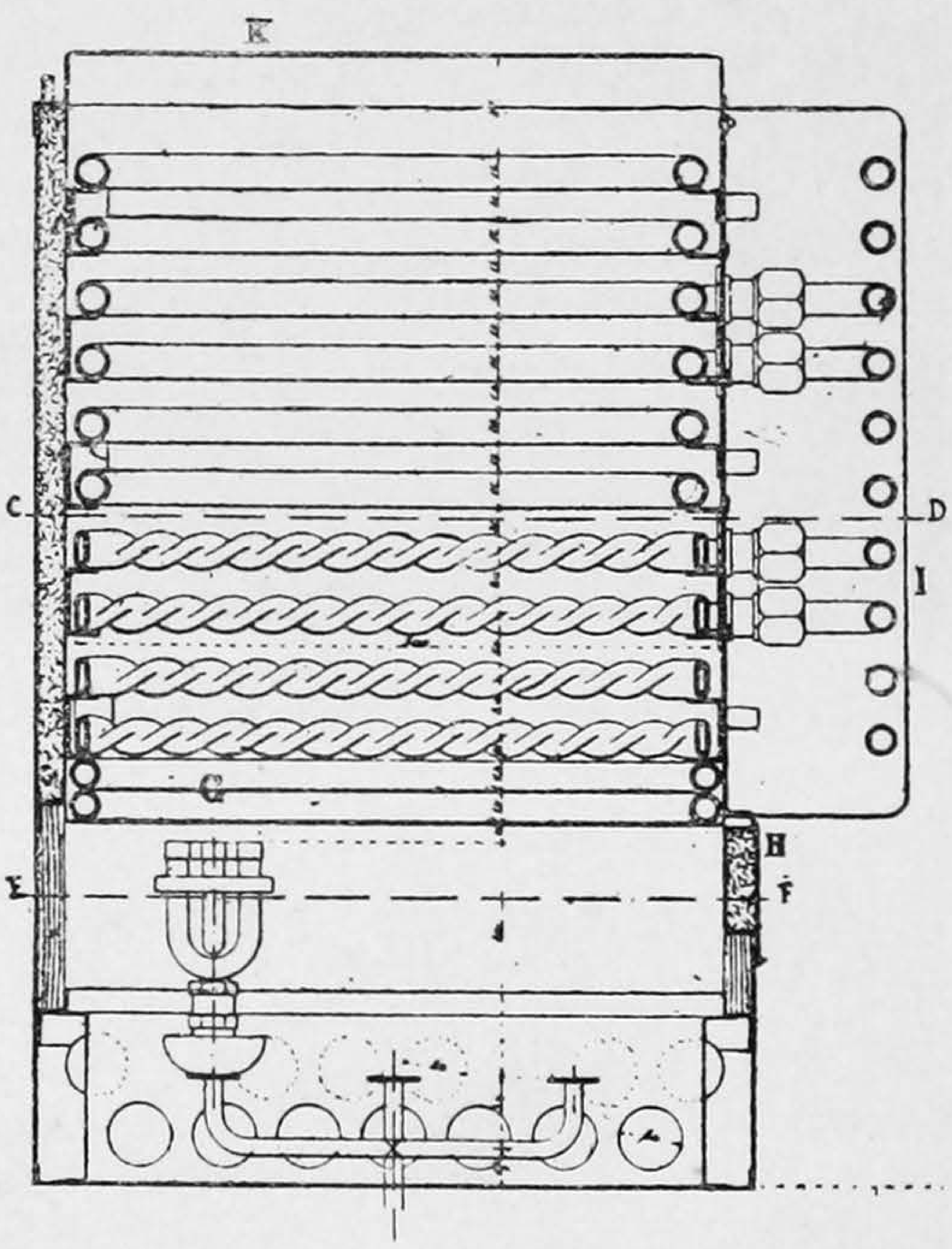


FIG. 30.—HALF-ELEVATION OF BOILER USED IN "SERPOLLET" CAR.

steerage is effected by a lever on a vertical spindle and chains; the wheels are of the "Sarven" type and have solid rubber tyres. Two powerful brakes are provided. The point for congratulation respecting the construction of this vehicle, is the fact that two old-established firms of coach builders and engineers have worked together in harmony with most satisfactory results. We may say that the

* *La Revue Technique.*

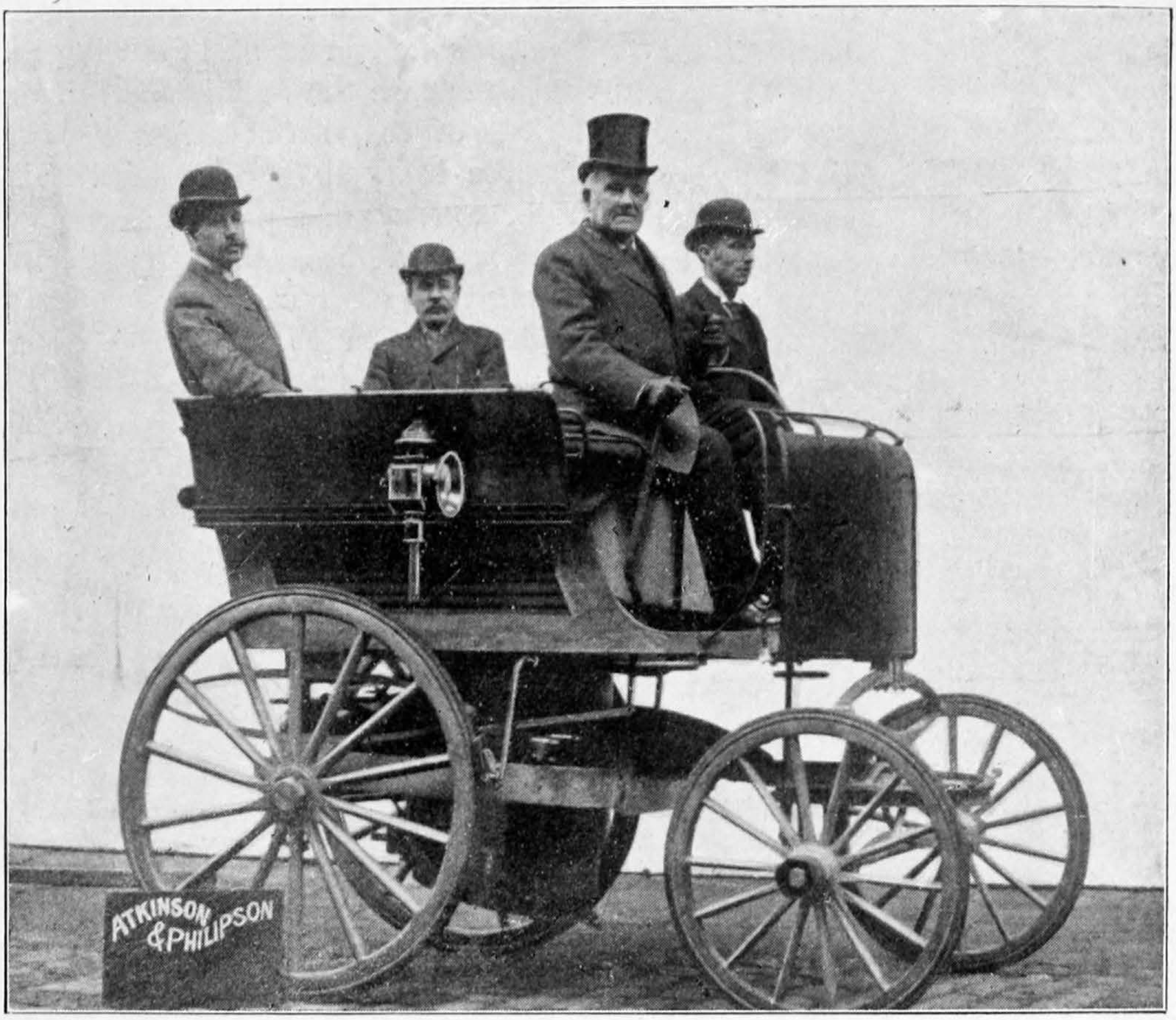


FIG. 31.—MESSRS ATKINSON AND PHILIPSON—STEAM MOTOR CAR.

No. 1 motor car was so efficient, that several others have been made on the same lines.

(To be continuea.)

W. Fletcher.

MODERN LOCOMOTIVE PRACTICE OF THE WORLD.

By HERBERT PARKER and JAS. HORSFALL.

I.—Introductory.

WE are often asked, "Why are there so many different kinds of locomotives? Why not make them all the same, like so many Waltham watches? They all have one duty to perform—to pull trains, just as watches record the flight of time."

All very true, and if this could be brought about a great deal of time and trouble would be saved.

But all iron horses do not require to travel at the same speed, as all watches do or ought to do. Nor do they all need to develop the same power.

A goods engine having cylinders 17½in. diameter by 26in. stroke, and wheels 5ft. 2½in. diameter will develop a tractive force of 127·4lb. for each pound of effective pressure per square inch in the cylinders. Thus:—

$$\frac{17.5 \times 17.5 \times 26}{62.5} = 127.4$$

A passenger engine with 7ft. driving wheels and cylinders of 18in. diameter by 26in. stroke will exert only 100·3lb. of tractive force, although its cylinders are larger, the difference being due, of course, to the different sizes of the driving wheels. Thus:—

$$\frac{18 \times 18 \times 26}{84} = 100.3$$

But the latter engine would travel comfortably at 60 miles per hour, while the goods engine would only be expected to reach about half this speed.

Suppose we made them all goods engines, with eight small wheels coupled. Now, suppose you wanted to get from Manchester to Liverpool in the shortest possible time.

Under the present arrangements you take a seat in the train at the Central Station then:—R-r-r-r-r-Warrington, the only stopping place. You have negotiated the sixteen miles in eighteen minutes. Then:—R-r-r-r-r-Central Liverpool. You have done the whole thirty-four miles under three-fourths of an hour—which is not so very bad. Perhaps you have accomplished this feat frequently, and being quite accustomed to it, take it as a matter of course. So, should you wish to know what it would be like supposing there were nothing to fall back upon but our eight-wheel goods engine, then just attempt to repeat the experiment some fine Sunday.

Soon after starting you come to a full stop. What! Warrington already? "Can such things be—or is visions around?" By no manner of means, neither Warrington nor visions are around. No, this is simply the first station, and therefore the first stopping place on the way. The second station will be the second halting place. The third will be the next, and so on apparently for ever.

A change comes o'er one's spirits, and the impression prevails that every railway station in Great Britain and Ireland is crowded into the space between Manchester and Liverpool. You had no idea there were so many in the whole world. All this is bad, but worse remains in front. For when you reach a certain spot in the far interior all the passengers will have to turn out and go into encampment: and the train will crawl away empty. Now you will have a glorious opportunity to cool down and wait until another train can be picked up somewhere to carry you a little further.

Very little of this experience would suffice to make you completely tired of the slow progress made, even supposing the engine to have done its best in the way of speed. Probably before you reached the half-way encampment, you would be praying for an engine that could get over the ground a little quicker—in a word, for a passenger engine. You will have learned by now that at least two different types of engines are desirable. And, if you look further into the subject, will see that far more than two are needed, and will perceive that use has not spoiled, nor custom staled, their infinite variety.

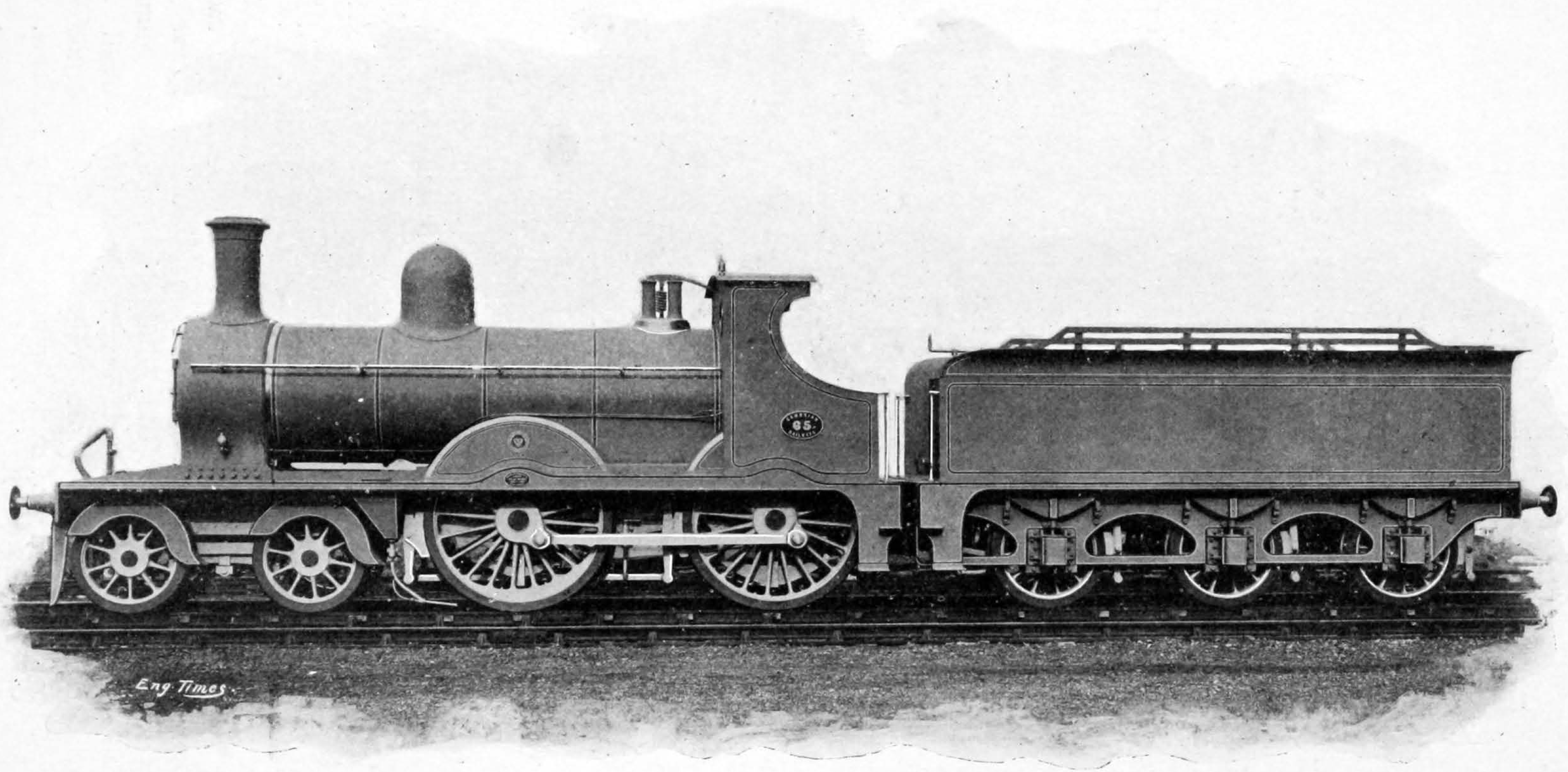
We must remember that railways are not built to suit engines; but engines must be built to suit railways, and must be competent to handle their traffic. Very probably your new engine will need to be considerably more powerful than any other on the railway for which it is intended.

When designing a locomotive, one of the very first questions to be asked is:—What gauge has it to suit? Like the Great Eastern steamship the seven feet gauge is now happily extinct. But it has left quite a little family behind it, ranging from 5ft. 6in. down to nothing. For have we not the single line railway? And we may call this the duck egg gauge. symbol=O.

You will find that the extreme dimensions allowable are somewhat strictly defined. You want to design an engine of a certain power, and which is not to exceed a certain space of the dimensions. For instance, take the 4ft. $8\frac{1}{2}$in. gauge. If the 7ft. was too big the 4ft. $8\frac{1}{2}$in. is too little, for this figure at once settles the distance between the tyres as 4ft. $5\frac{1}{2}$in., and you will have to crush a lot of work into this space.

By the altitude of bridges and tunnels the height of the chimney is confined within certain limits; if these limits are exceeded then the chimney will be knocked off, as actually happened on the Seacomb and Hoylake Railway. On the other hand the parts must not be placed too close together or they will be inconvenient to get at. The width across the platform must not go beyond a certain figure.

Even the length of the engine is limited by the sharpest curve on the railway. Suppose you have an engine of 8ft. fixed wheel base, with a bogie 6ft. $1\frac{1}{2}$in. in front of the leading wheel. With this engine standing on a curve of 150ft. radius, the bogie centre will be 4·11in. to one side. The fixed wheel base will give you a versed sine of ·65in.; this will have to be deducted and will leave $4{\cdot}11 - {\cdot}65 = 3{\cdot}46$. Say $3\frac{1}{2}$in. of side movement, or a total to right and left of 7in. This amount of side play will have to be allowed for, or the engine will leave the metals. And this is not an imaginary case, but is taken from actual practice.



CAMBRIAN RAILWAY EXPRESS LOCOMOTIVE.

The rails are only calculated to carry a certain load, and this weight must be distributed over a certain number of axles. Then, again, there are such points as, whether the engine has to run over a level road, or to face long and steep inclines, what load to drag; to climb the side of a hill, or worry up the *inside* of a mountain *à la* Mount Pilatus Railway on the shores of Lake Lucerne—when a rack engine will be wanted; if many stoppages have to be made; the distance between water and fuel stations; to run through a carefully enclosed country like England, where every inch of its path will be carefully watched and guarded, or traverse the open prairie lands such as we meet with in the United States, or in South America; its path lighted up at night by its own powerful head lamp, and carrying a steam jet to frighten off the cattle—for here there is not a particle of fencing to keep them off the track.

The answers to these questions, and many others, considerably affect the design, and may alter the appearance of a locomotive to a surprising extent. Look, for instance, at the startling difference between English and American locomotives. The character of the fuel used is not without its effect. For an English fire grate would be quite useless in America. In many respects the Americans have the advantage of us in not being so "cabined, cribbed, confined." They can make their boilers as high and as large as they like.

The bar frame is like the fly in amber; nobody in this country seems to care very much about the fly, the only question seems to be how it managed to get there. It has "got there," and seems inclined to stop. This style of frame was originally made before the advent of rolling mills. We always had smiths who could be depended on to forge a 3in. bar. But to have a lot of 3in. bars welded together and then hammered down into a 1in. plate was expecting too much. But, even now, some people prefer to use bar frames. No doubt they find some satisfaction in doing so. It is a case of survival—like the splint bones in a horse's leg.

We well remember some French engines in which, if a piece of iron 3in. thick were wanted, it was obtained by riveting together six plates of ½in. iron, thus making it appear that there were no smiths in all Gaul.

The same railway had some **W** irons to which our special attention was called, on account of the excellence of their workmanship. As the (English) smith said, in bending a flat bar edgeways, there is always a bad edge and a good edge. After a brief examination, we comforted him by the assurance that they had been punched from a solid plate! There can be no doubt that such was actually the case.

American engineers think that bar frames suit their country best. We *know* that slab frames suit ours; and if slab frames will do for us, they ought to be good enough for everybody else. But everybody else will not have them. *Hinc illæ lacrimæ.*

In addition to all this different superintendents hold different opinions, well founded, doubtless, each upon his own experience. Each is perfectly sure about the colour of *his* side of the shield. No two of them will be found to agree about the dimensions and arrangement of that most important detail, the boiler. What suits one would be utterly condemned by another. The only point in which they all agree is that they shall all differ.

No, we may as well accept it as a fact *ab initio*, that a great variety of locomotives will be called for, and, being called for, will have to be supplied; if they are to be supplied by us, then we must "act accordin'."

It would almost appear that all locomotive works must be situated somewhere in the kingdom of Reconciled Impossibilities. Our much enduring camel must be strong enough and big enough to do its work, but it *must* be small enough to pass through the eye of yonder tunnel.

We shall find ample room for ingenuity and judgment in fulfilling all these seemingly contradictory conditions, the locomotive being the only type of engine to which many of them apply. We feel inclined to invent a proverb that fills the bill, and say—"He who often attempts the extremely difficult, will sometimes achieve the utterly impossible," or, to quote the words of a well-known locomotive chief, "Thus you see that by means of a little scheming we overcome obstacles which at first sight presented every appearance of being utterly insurmountable."

Every river endeavours to straighten out its bed; in doing so, it meets with obstructions it cannot overcome, and is bound to go round. We do not mean to say that every river will eventually become a perfectly straight line from source to sea; but the fact remains that every river in the world is ceaselessly trying night and day to shorten its route as much as it possibly can.

A similar process is going on in the locomotive world, and in these articles—dealing first with passenger, then with goods engines, afterwards with special locomotives, *et hoc genus omne*, we shall finally discuss some of the leading details of construction—we shall endeavour to trace the origin and reason for the 1,001 different styles we see, to define the various obstructions met with, to discover if a straight course will ever be practicable, and if not, why not.

Should time permit, we shall have a few words to say upon a subject which must interest everybody, viz., railway accidents. Once on a time a certain old lady was asked if she would like to be in a railway accident, or would prefer to be blown up on a steamer. She chose the latter, saying:—"Suppose you are in a railway train, and there is a collision, why, where are you? On the other hand, if you are on a steamer and the boiler goes up, why, there you are!"

Tastes differ. Personally, we prefer a railway accident. For one thing, there is not the additional risk of being drowned. However, as a friend of ours once observed, "We must shut our eyes to the cries of the dead," and shall have to confine our attention strictly to the engineering aspect of each case.

Rude people sometimes say: "Put a beggar on horseback and he will drive to the devil."

Gentle reader, after a year or two of humdrum office work did you ever find yourself on the footplate of a swell express passenger engine? If so—being human—perhaps the arch enemy of mankind would not appear just then quite so black as he is generally painted. And you might possibly feel tempted to pay his sable majesty a flying visit, or, at any rate, might feel disposed to look with toleration upon miserable sinners who did.

On a certain railway leading to Santiago, the Capital of Chile, there is a certain half-way house or station called Llaillai, where everybody stops for refreshments. Having been told that in Spanish, every word is pronounced as it is spelled, you are naturally staggered to hear that this name is pronounced Yar-YAR!

At any rate, we have often heard of Santiago, and we have a faint recollection of a great cathedral there having been entirely destroyed by fire. We are very anxious to see this famous and beautiful city, and we are still twenty or thirty miles on the wrong side of Llaillai. For a wonder, in Chile the ground is fairly level, the line approximately straight. Suppose we open her out a "leetle." Not too much open out, but just enough; say, for instance, for about all she is worth. About enough, as it were, to get a move on the train.

Of course, in England it would never do to go beyond regulation speed, for is it not written, "Thou shalt not make up for time lost"? But you have been long enough in this country to know that there is nothing which the Chilinos enjoy so much as a joke. They are always bubbling over with high-class humour. Then why rob them, why deprive them of a little harmless enjoyment? Well, well, what must be, must. So "pull the plug out and let her go."

The engine gives a wild snort, round fly the driving wheels, the spokes and balance weights disappear. The coupling rod becomes a cloud. For a moment she pauses, a little sand is sprinkled on the rails, and then majestically moves the motion work. The couplings tighten, she feels her feet, she grips the rails. She is off!

Before one length of the train has been traversed, the speed is quite respectable.

Soon hedges and trees fly at us like projectiles, they rush upon us, fly past and disappear. The engine dances merrily up and down, and sways from side to side. An exhilarating lunge to starboard, an invigorating plunge to port. We take hold of something to avoid being thrown off. A continuous wall of telegraph poles arises. The engine begins to smell of oil, she becomes electric. A little bird strikes the engine, and falls dead upon the platform. The furnace roars, fragments of coronel coal, highly bituminous and inflammable, dart wildly up and down the fire-box like comets, long tails of fire behind them.

Where is the devil now? If he be in *there*, then heaven help him who cannot help himself. If any cows come in the way *now*, how very awkward it will be for the cows. Oxygen, hydrogen, nitrogen, H_2O, CO_2, SO_2, S and C, and all kinds of chemicals rush roaring from the funnel, forming a beautiful curve in the air, not of necessity quite parabolic, but raising an odour just diabolic.

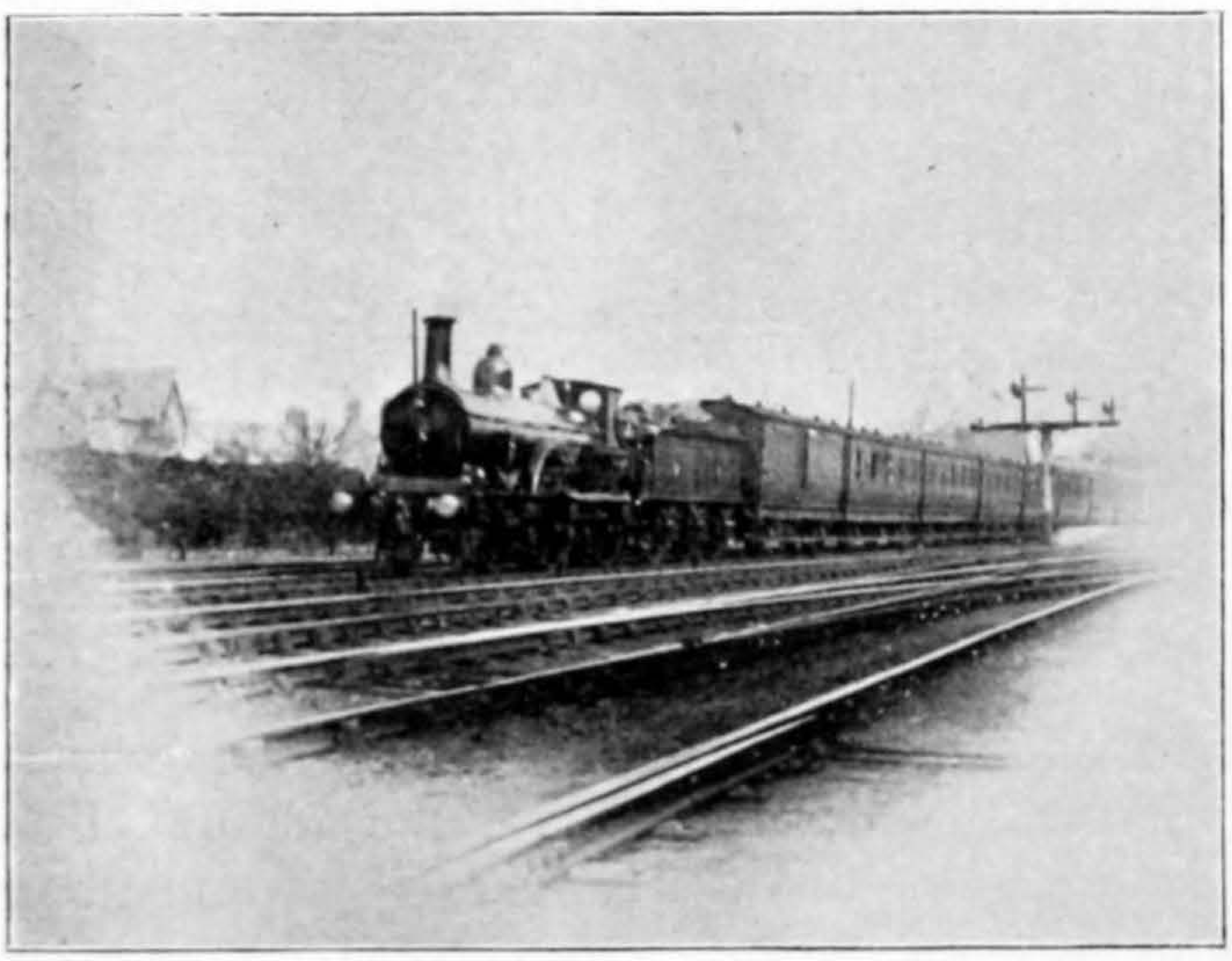
For once we will ride the whirlwind and direct the storm. We catch a glimpse of Lucifer, we stare him in the face. But soon he is far behind, oiling his wings in the vain hope of catching us. Objects leap out of the horizon, grow rapidly in size, and cannonade us right and left. Long streaks of brilliant colour appear and disappear, the flowers are in full bloom. Houses, gates, and various contraptions we have not time to name, bombard us, they fling themselves madly upon us, yet never strike us. A cloud of dust enshrouds the train, and all is as it should be. For once we taste the full poetry of motion.

But such happiness may not endure for ever. Gradually the speed slackens, objects begin to assume their usual sober aspect, houses try hard to look as if they had never stirred a foot in their lives. And then we drop anchor at Llaillai a few seconds before the appointed time. But what matter? Such things will sometimes happen even on the best-managed railway, and for once we can flatter ourselves that we have travelled.

Here, how quiet it seems! We become conscious that a musical accompaniment of noise has attended our wild career. A sort of hammer-and-anvil chorus. Here, in the silence of the tomb, we first begin to notice this. We address each other with quite unnecessary violence. But this soon wears off, and then everybody adjourns to the refreshment-room. Coffee never tasted better, cigars never before exhaled so delicious an aroma.

But we cannot expect to please everybody, and one old gentleman was plaintively enquiring what "devil" had driven the train for the last twenty minutes. And such is gratitude.

(To be continued.)



THE THEORY AND CONSTRUCTION OF BALL BEARINGS.

By W. H. HALE.

(Reproduced from "The Scientific American.")

Up to the date of the advent of the modern bicycle, ball bearings had no practical application. They were scientific toys, mechanical curiosities, of admitted excellence, truly, but far too complicated and delicate for ordinary use. But when man became his own horse, the first task for his ingenuity was the devising of means for lightening his labour, and the ball bearing proved to be foremost among such means.

But the bicycle manufacturer, instead of starting with the theory and principles of ball bearings, and designing a ball bearing perfectly adapted to the bicycle, took the appliance as he found it, and placed it on his bicycle, only making such changes as were absolutely necessary to make it conform to its new conditions. At the present day, twenty years and more after the advent of ball bearings into every-day mechanics, there are to be found many of the troubles and much of the construction of the earlier types.

In the opinion of the writer the most vital parts of a bicycle are its bearings. These should be constructed to run with the least possible friction under service conditions for the longest possible time with the least possible care. These may seem to be unattainable conditions, and it is granted that they are, but their approximation should be the aim of every builder of "high-grade" bicycles. The present universal test of the running qualities of a bicycle ball bearing is to raise the wheel from the floor and spin it, noting the lapse of time till it comes to rest. This is no test of the bearing under service conditions. Many makes of bicycles might be cited whose wheels spin beautifully without a load, but which weary the rider most unaccountably when ridden upon.

We have seen that the superiority of ball bearings lies in the fact that

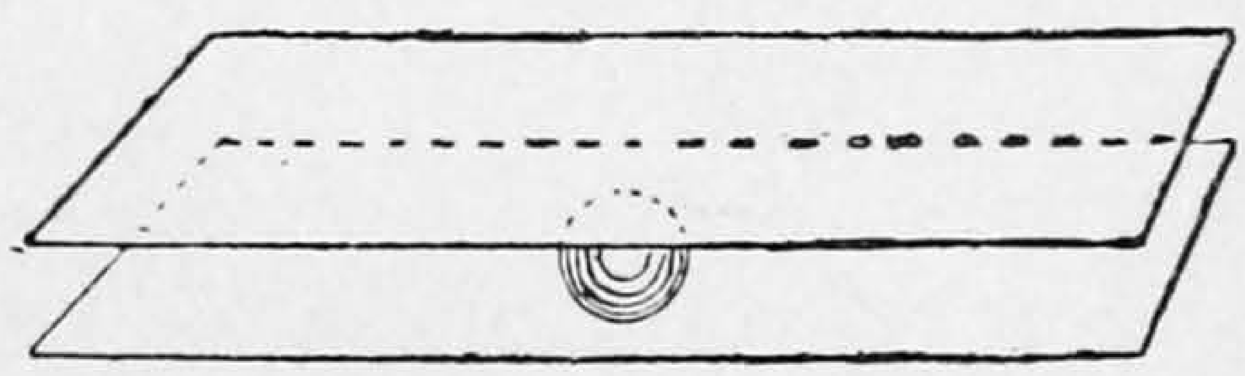


FIG. I.

rolling friction is less than sliding. Further study of the subject will disclose the additional facts that—like wheels—balls must be proportional to the loads they carry and the surfaces on which they travel ; and it is these two conditions, which have been overlooked or ignored, that require solution if the ball bearing is ever to come into general use. That bicycle builders do not understand the principles of ball bearings is proved by the fact that a careful observation of any considerable number of bicycle ball bearings will show there is no uniformity in either the shape or the size of the ball cups, the size or number of the balls, or the shape or angle of the cones; and as these bearings are intended to accomplish identical results, there must be either extreme elasticity in the science of ball bearing construction, or else the majority of these bearings are incorrectly designed.

To properly get at the principles of ball bearings, it is necessary to go back first to the well-known advantage of sliding friction. If a man desires to move a box along a floor, he pushes it. A certain amount of force is required to do it. If he can slide it only by great effort, he places a roller under it, when he moves it

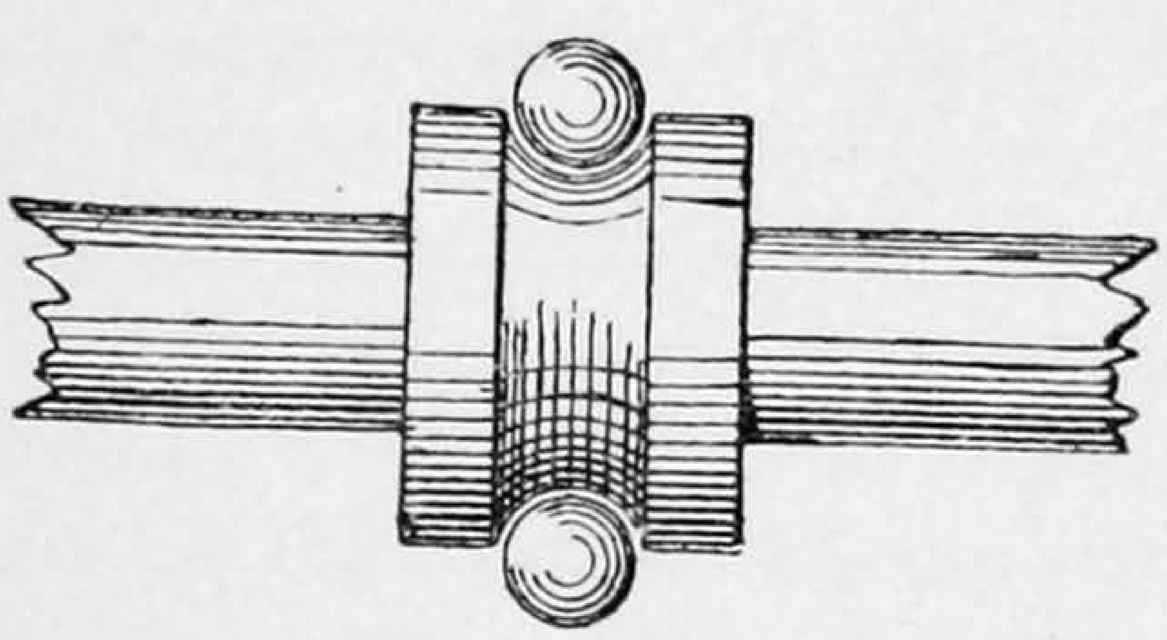


FIG. 2.

with ease. This demonstrates the superiority of rolling over sliding bearings. If, now, he places another roller in contact with the first, he will find that the box will move easier than when slid, but not so easily as when on one roller only, and this increase of friction is due to rubbing or sliding of the two rollers on one another; and so on. Balls can, of course, be substituted for rollers, and the result of the experiments will be the same; you will have eliminated the sliding friction between the box and the floor, but you will have added the sliding friction between the contact points of the rollers or balls.

The simplest form of ball bearing, therefore, is one ball rolling between two plane surfaces (see Fig. 1). Such a bearing is practically frictionless, but it is impracticable in applied mechanics. Two or more balls must be employed, and they must be restricted in their path of travel. These necessities introduce two elements of friction, and it is the purpose of this paper to show how this friction may be controlled and reduced.

It will not be necessary to demonstrate that ball bearings are unsuited to plane surface motion, either continuous or reciprocal, and that they find their proper place as bearings for journals, particularly those running at high speeds. As it is necessary to retain the balls in a definite and distinct path of travel, they cannot be made to run between an inner cylinder and an outer cylindrical tube. In such a bearing they would not remain in their proper places. Some means of confinement is therefore requisite. This should take such a form as to interfere as little as possible with the free rotation of the balls, and is one of our most important lines of investigation. The first method used to accomplish this confinement was to cut a curved channel in the shaft itself, within which the balls rotated (Fig. 2). Then as means of adjustment for wear were found necessary, the outer track of the balls was also made a channel, but divided in the centre, directly in the path of the balls, and the two halves made to advance toward or retreat from one another by means of screw threads cut upon them. Bearings of this character are still in use, although originally designed more than twenty years ago, and this survival is not due to remarkable excellence of design, but to the conservatism of the users. This form of bearing has not only the friction of the balls against each other, but also that of the balls against the sides of the channels.

The first departure from this method consisted in making the

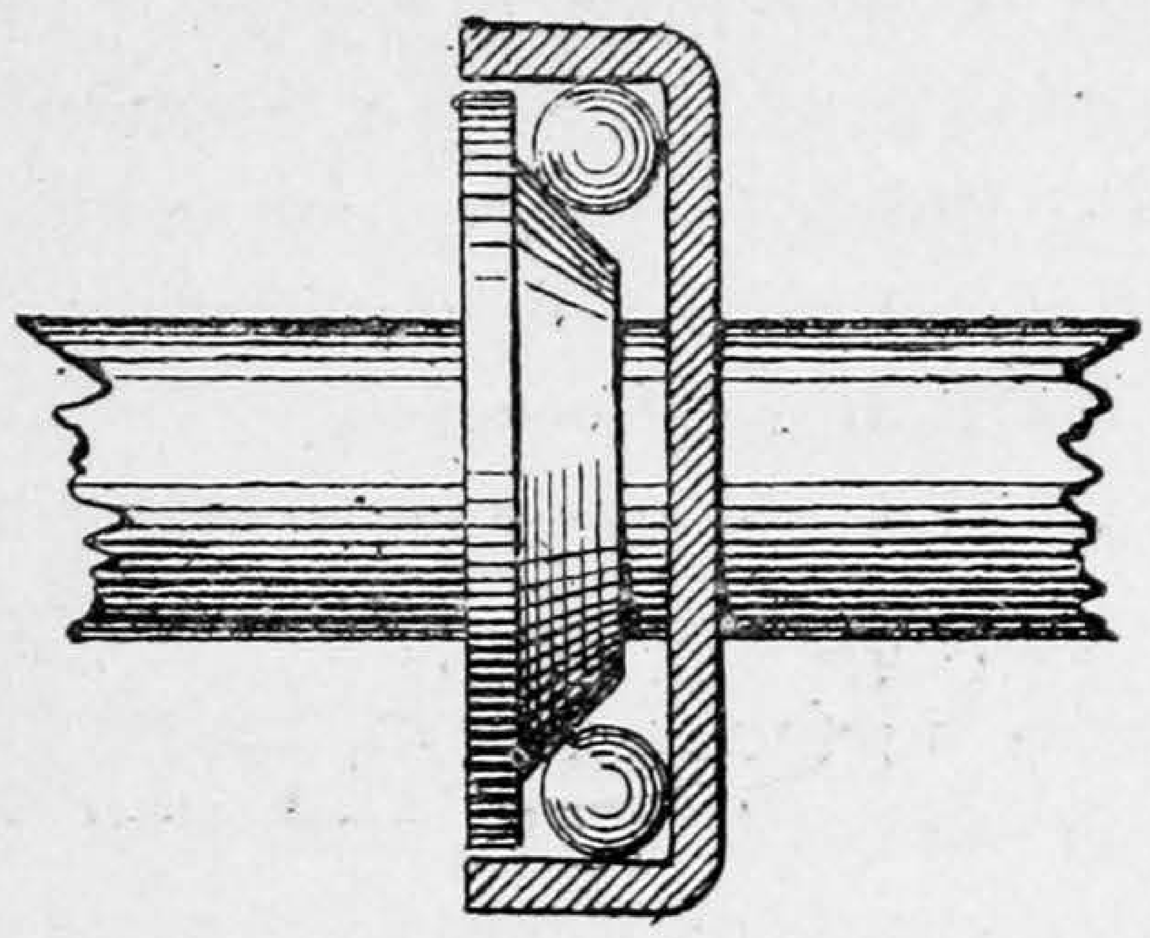


FIG. 3.

channels V instead of U-shaped, in order to make the path of the balls a line instead of a curved surface. To some extent this was an improvement, but it introduced a twisting friction between the balls and their tracks, and increased rubbing between the balls themselves, owing to their not rolling on the ends of their vertical diameters. Some of this style of bearings are still in use.

When the present type of bicycle came into existence it became possible to discard the single form of ball bearings and to construct a double one, and it is this type which is now universally used, and which invites our attention in this discussion. Typically these are all alike. They consist of a circular ball cup, with a flat back, forming two points of contact for each ball. These cups are placed at opposite ends of the shaft, with their backs toward each other, while outside of them, and encircling the shaft, are two hollow truncated cones bearing against the balls, their smaller diameters being in contact with or underneath the balls themselves. Some forms of ball bearings reverse this, placing the cone inside and the ball cups outside, but the type remains the same. This is practically the ball bearing as we know it to-day.

In this form of bearing the balls revolve on three different diameters, varying according to the positions of the three points of contact. They cannot, therefore, obtain perfect rotation in any one plane, and must have some sliding friction at all points as well as the friction upon each other. The bearing surface of the shaft can be neither a cylinder nor a disc, for these would be unadjustable; it must, therefore, be a cone. In the construction of these cones all sorts of arbitrary angles are being used, each maker evidently having one of his own, which he believes to be—or, at least, claims to be—the only correct one. The most common angle is 45 deg., although there are many bicycle builders who could not tell you the angle of the cones they use, and who would not think the matter of any consequence if they could.

The correct angle of a cone should be such as to allow the greatest

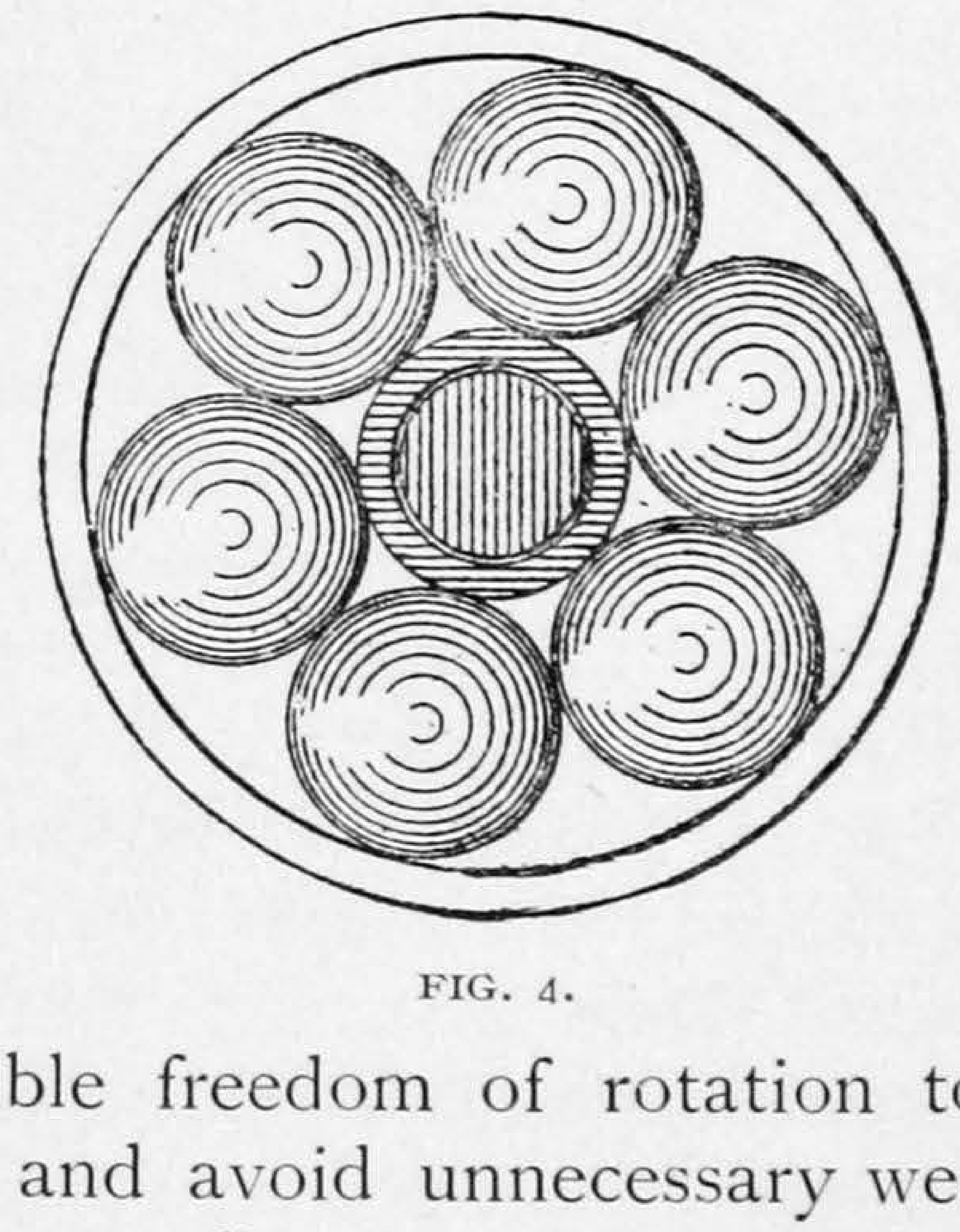


FIG. 4.

possible freedom of rotation to the ball, and avoid unnecessary wedging and crowding. That of 45 deg. (Fig. 3), is clearly wrong, for it presents the three most widely separated paths of rotation possible, and, therefore, causes the greatest amount of twist. What is the best angle, then, and how shall we find it? It is evident that it must be less than 45 deg., for even that angle exerts too great a pressure against the back of the ball cup.

If we take a sectional sketch of a ball cup (Fig. 5), containing balls, and draw two lines through the contact points of ball and case of two opposite balls, we shall find those lines to intersect in the centre of the shaft at a distance back of the centre of the balls equal to one-half the diameter of the ball case. If from this point lines be drawn touching the inner surfaces of these opposite balls, a cone is formed whose apex is the centre of the prolongation of the axis of rotation of the balls, and whose surface is such as to continuously maintain the balls in this rotation. In addition, this cone is governed and determined by the number and size of the balls in the case, size and configuration of the case itself, and the path of the balls.

Another detail that has received far less attention than it deserves is the size and number of the balls used. Quarter-inch was the original bicycle size, but a few years ago it was found that larger sizes were better. They did not break nor split so readily, did not roughen up, they did not jamb, and they did not wear the cones and cups so rapidly. The $\frac{5}{16}$in. was better than the $\frac{1}{4}$in., and the $\frac{3}{8}$in. better than the $\frac{5}{16}$in. These were facts easily proved by demonstration, and the bicycle builder accepted them as such and took advantage of them. He did not seek the cause for the improvement, nor did he try to ascertain how far the improvement would continue.

It remains, then, for the theorist, the experimenter, to take up this good enough improvement and learn the cause of its superiority, as well as to reason out the possibility of continued improvements up to the logical or practical limit. The question is: If the larger ball makes the better bearing, why does it do so, and how long will increase in size continue the improvement?

With a given ball cup and a given size of shaft the largest balls that can be put into the case will have a diameter equal to one-half the difference between the diameters of the shaft and ball cup, but this size of ball

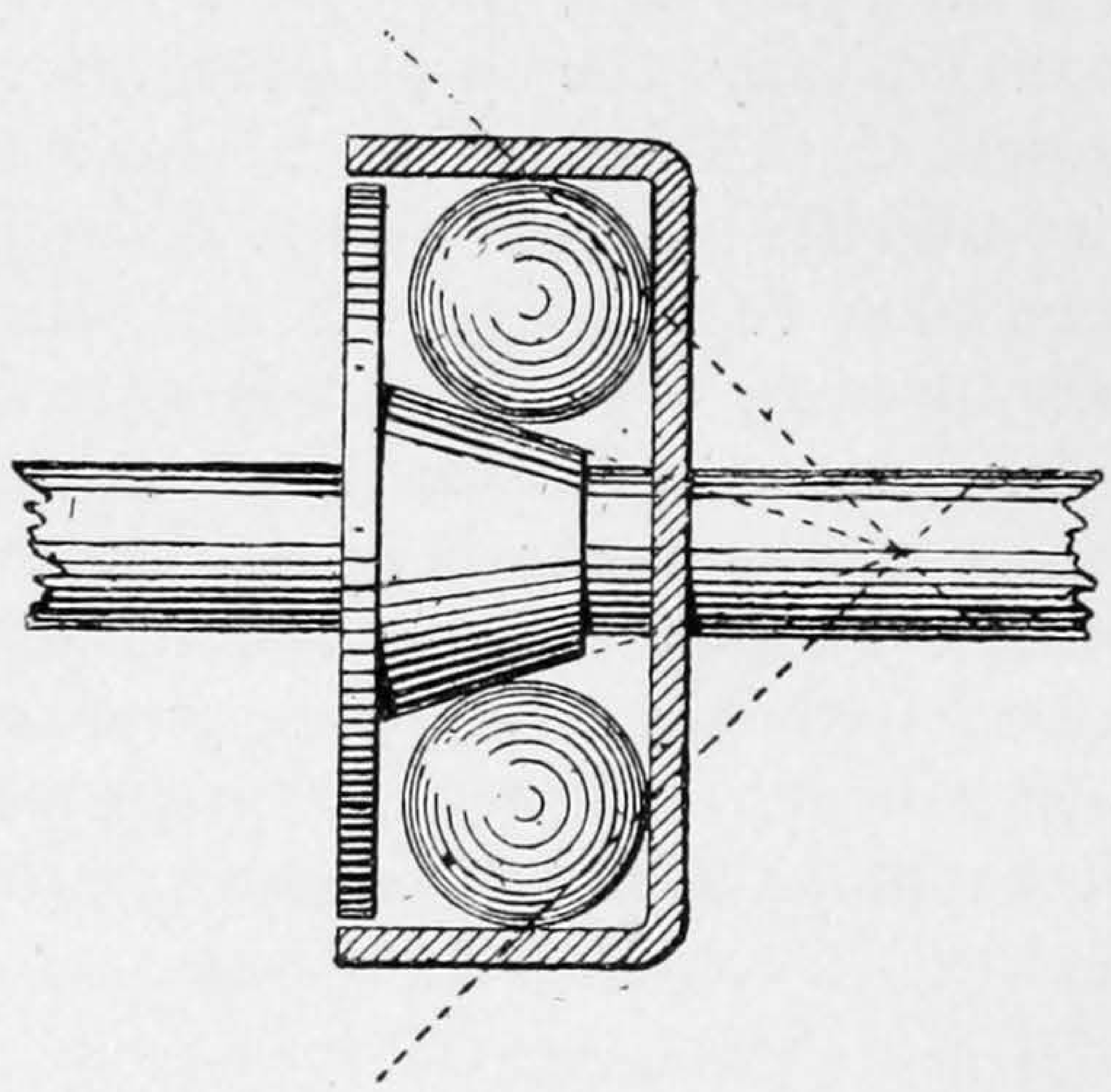


Fig. 5.

could not be used, since there would be no room for the bearing cone, and hence no chance for adjustment. Six is the best, and presents the well-known symmetrical appearance of a circumscribed hexagon, as shown in Fig. 4, and the cone becomes of usable size. Here, too, we note a marked peculiarity; the balls and their bearing cone are approximately the same size.

Experience has shown that too small balls break up in service, and larger balls have been employed until, at the present day, from seven to ten are the numbers generally selected. Decrease in number and increase in size has invariably resulted in improved bearings, but as before stated there has been little or no serious attempt made to ascertain the limit. With every increase in size of ball there is a decrease in the size of the cone until, with six balls, as we have seen, the bearing diameter of the cone and the diameter of the balls are practically the same. This suggests as the logical limit of improvement the point where the wearing diameter of the cone equals the diameter of the balls used.

In designing a ball bearing for general purposes, therefore, which shall embody the principles above presented, the first thing to do is to ascertain the maximum load. This will determine the size of the axle that may be used. As upon this axle is to be placed the hardened cone which serves as the inner bearing for the balls, the thickness of such a cone must be added to the diameter of the axle in order to determine the proper size for the balls, and the diameter of the cone at this bearing point, plus twice the diameter of one of the balls used, will be the inner diameter of the required ball cup.

If the six ball bearings be adopted, and supposing that we have found a $\frac{3}{4}$in. axle to be sufficient, the allowance of $\frac{1}{8}$in. on each side for the bearing cone will be ample, when it is evident that we shall need six 1in. balls for the bearing, and that the outer ball cup will have an inside diameter of 3in. It may be argued that this will make a clumsy bearing, that smaller balls will make a smaller cup and give a neater effect. To this it may be answered that clumsiness is merely the point of view. The present pneumatic tyre was clumsy when it first appeared ; now the absence of it would be clumsy. Ball bearings, to be generally successful, must be practical, and to be practical all sentimental regard for appearances must be cast to the winds, and such a bearing devised as will best fulfil all the demands that may be placed upon it.

THE PROSPECTS OF SHIPBUILDING IN FRANCE.

By EDWARD CONNER.

WHY do Japan, Norway, and other rising nations give preference to England and Germany, rather than to France, when requiring ships? Simply because French dockyards work too slowly, while the prices demanded by French firms are too exorbitant. Another cause of the stagnant state of shipbuilding in France is to be found in the fact that a "stock" of ships is wanting; ships are only built "to order," strictly speaking; hence, no ready-made vessels are to be found when wanted. This defective system of building ships "only to order" engenders considerable delay, in addition to seriously upsetting the plans of ship-brokers. In any case, French dockyards, it must be said, are not equipped, as a general rule, for turning out any special class of ships; this explains why merchant vessels so frequently suffer in this respect. Though dockyards in France can be utilised by subventioned companies, they are next to inaccessible to other trading ships. Not the less, bounties enter largely in the construction of French ships, as will be seen by the following instance. Thus, the bounty for the hull is 65 francs the measured ton, while the bounty on machinery is 15 francs the double hundredweight. Why, then, it is often asked in the interest of French industry, is it not possible, considering such liberal grants, to turn out cheaper ships, and so relieve commercial depression? As far as French shipowners are concerned, they are quite willing to rely on national industry; yet they admit, notwithstanding this, that they are positively discouraged, like M. Bordes, and further maintain that the prices demanded, as well as the bounties accorded, do not suffice to make both ends meet. Actually, they are more than twice the estimates asked in Great Britain. Again, another drawback towards the advance of the French shipbuilding trade is, that *thirty* months are exacted before delivery—hence, why builders in France, much to their regret, are unable to produce cheaper or quicker work. Not only does France occupy the fourth rank among the mercantile navies of the world, but her output of carrying trade is accepted as being one hundred per cent inferior, as compared with that of Germany, or 3,000 times below the standard of British results. No one questions the fact that Great Britain possesses numerous other advantages, that of being able to construct a greater number of steam vessels than France, for instance. It is estimated that England has nearly ninety-four steam vessels to place against the fifty per cent. sailing ships which France builds. Further, labour has so progressed throughout Great Britain lately that from 1889 to 1894, England was able to reduce the number of her hands by a one-sixth, without affecting her operations, this is to be attributed to perfection in plant and machinery ; nor was there the same amount of work done in actual shipping in France at the close of 1896, for example, there were at that epoch 711,562 tons in hand in England as compared with only 35,000 *tonneaux* in France—a wide margin.

As regards a remedy, alas, but few, if any, hopes exist ; at least as long as the Government continues so attached to its economic policy. For instance, among some of the principal obstacles in the way to be removed are to be cited, the taxation of all raw materials necessary for the construction of ships, until this impost is done away with, cheaper production is purely a matter of impossibility. Now in England as well as in Germany, no such tax exists, hence, their commanding advantage over France. If the according of bounties to French shipbuilders has not been beneficial, that to navigation has equally been attended with no happy results.

The aspect of the shipbuilding industry in France is indeed very distressing, and nowhere is this more visible than by casting a rapid glance at the commercial side of the question ; the serious decline of the French mercantile navy is solely to be attributed to the gloomy prospects of shipbuilding proper. In fact, few people in France, if any, believed that their merchant navy was so lamentably defective, until their countryman, M. Roux spoke out, and threw full light upon the many dangers that threaten the commerce of France. M. Charles Roux, who is an authority upon maritime and commercial questions is to be warmly congratulated for so ably representing facts, as they actually exist, and avoiding any further attempt at illusion. In his important report upon the decline of his country's sea-trade, he attributed the cause of the growing evil to a multitude of officious and official wrongs, all of which handicap its progress, and paralyse its efforts to advance. He firmly believes that the Government was aware of the exact condition of affairs, but felt too nervous to disclose facts ; however, since M. Roux undertook to reveal all, the people have lost no time in urging the Legislature to exercise all due dexterity and so check the mischief, which as everyone is prepared to admit increases in gravity every year, and that in spite of State bounties. For instance, eleven millions of francs are annually voted by the Chamber of Deputies for the relief of the French mercantile marine. Apart from these eleven millions of francs, additional financial assistance is also accorded to the few Companies of Navigation that convey the mails as well as goods. This subsidy of eleven millions of francs is divided into two parts ; first, premiums to builders of ships, which amount to three millions of francs, and secondly, eight millions of francs which are duly distributed with the object of supporting and encouraging fluvial and coasting trades. Yet, all this financial assistance proves insufficient to arrest the decline of the merchant navy of France. Well may French taxpayers ask what then becomes of their hard-earned money in presence of such unsatisfactory returns like the few following cases.

In 1887 England had steam-trading

vessels of 100 tons and above, representing a total of 6,592,496 tons; France, 722,252; Germany, 628,296; and Norway, 150,689. Even though France was distantly second to England, the tonnage of her merchant service was next to insignificant when compared with the latter. In 1895, two years after the law was passed according bounties to merchant ships, France occupied but the third place, England, 9,984,280; Germany, 1,306,771; France, 864,598; and Norway, 455,317 tons. Thus, while France gained only 142,346 tons, England's total augmented by 3,391,784; Germany by 678,475; and Norway by 304,628 tons. No wonder, then, that in presence of the relative falling-off on the part of France and of the alarming progress achieved by Great Britain, Germany as well as Norway, M. Roux does not hesitate to prophesy that within the next eight years, unless some radical change takes place, France will occupy but the fourth place as a shipping nation. Nor is M. Roux at all hopeful of seeing his country getting on. Competition, for instance, is much too fierce between countries nowadays to give France a chance of coming again to the front. Of course, France can never compete with, nor does she even entertain such a possibility, at least, with Great Britain, which will ever remain the first of maritime powers, as well as head the list in shipbuilding; but the idea of Germany—that marches with gigantic steps—Norway, Italy, and Spain, surpassing her, is indeed terrible for Frenchmen to contemplate. As regards Germany, it must be added that had she not sold many of her vessels to Japan, the increase in her own commercial fleet would be greater still. In any case, the best proof that Germany is determined before very long to become a serious shipbuilding rival, and that she is bent upon occupying France's former position—that of being second to England—is to be found in the fact that, while in 1896 France had but *two* ships in course of construction, Germany was busily engaged in building no fewer than *thirty-three.*

It is no secret that more than three-fourths of the export trade of France is carried on by foreign bottoms; this state of things bids fair to continue, as there is no remedy likely to be applied. The only possible amelioration, as suggested by M. Roux in his significant report is, to have recourse to an olden-time system or practice, that of according half a bounty to ships built in foreign countries, and to be placed on the French registers. In his opinion, this is the sole means of enabling the French merchant navy to compete with other nations. If this be not done—and soon—subventioned mail boats will remain the only mode of transport available for France, in the East especially, since her mercantile marine is so terribly handicapped that it is doomed to "sink" ultimately out of existence. It would be erroneous to conclude that the actual granting of a half premium as stated would alone suffice to ensure satisfaction; no such thing; on the contrary, too many more impediments still remain to be cleared away. It is at this particular point, that the initiative spirit of French ship-owners, and of Companies of Navigation will find an occasion for displaying their ideas and projects. France, though terribly handicapped in the movements of reform, should endeavour, as she has done lately, to take peaceful possession of important commercial situations, and to establish free ports, as other countries do. By so acting she will do much to strengthen her weak maritime transactions. Free commercial ports are indeed the greatest of blessings to the traders of to-day. What can be better than to possess free accessible places, where goods can be introduced in bond, manipulated and transformed without being taxed, provided they be re-shipped? Every nation is at last beginning to understand more and more the invaluable importance of free ports. Japan has in this respect accomplished wonders, since her recent war with China; she has opened naval schools, for the complete theoretical and technical instruction of her sailors, the better to be in touch with Great Britain. France, indeed, might do worse than study the naval reforms of "pushing" Japan; alas, the former can only admire the progress of other nations, as the want of funds prevents France from adopting any of their admirable ways and means. Aye, more, nor is it too much to add, that France has no facilities for competing with her rivals; "none whatsoever," observes M. Roux. To make matters worse, the temporary admission of merchandise, as well as the laws and regulations of the French warehouse system are opposed to any change taking place in the manipulating of goods; there is even talk of suppressing this semi-toleration; it will be thus easily seen that red-tapeism is also to be dreaded in France.

The absurd law of January 30th, 1872, which has proved so detrimental to the French commercial shipping world in general, though since slightly modified, continues to exercise a ruinous effect upon trade. That law also levies a special quay tax, a "mooring impost," as it were, on all ships, whether French or foreign, that trade with France, and consequently have to make a stay, however short or long, at a port. The tax in question is based on the tonnage of the vessel. Thus an impost of half a franc per ton is levied on ships whose consignment is strictly European, including a few Mediterranean towns—Morocco and Mogador to wit; and one franc per same quantity upon all goods coming from Eastern countries. The unfairness of the said law is, that the amount of merchandise landed counts for nothing; if only part or the whole of the goods be disembarked at any French port the same tax is levied, and has to be paid as a matter of course. Here, again, France is at a disadvantage as compared with other nations, whereas foreign ships can retaliate by refusing to accept goods for France under such conditions, and unless the freight of the merchandise is sufficient to defray cost of the quay dues. French shipowners are unable to maintain such an independent attitude, consequently they are once more victimized. By way of conclusion, M. Roux condemns—and rightly so—the general economical system of his country; and until this phase of the French Legislature be seriously reformed, France must continue to remain impassive while her trade is dwindling, to say nothing of her commercial navy, which has to be propped up by large sums from the pockets of ratepayers, who reap no benefit in exchange for their patriotic liberality. Such is the actual state of the French shipping question, which is engaging so much attention just now throughout the whole country. The enigma still awaits a solution — which seems never coming.

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