The Engineering Times.

VOL. II. JULY, 1899. NO. I.

Pity the Poor Exhibitor!

"Are exhibitions profitable to exhibitors?" is a question which the exhibitors at the Article Club Exhibition must have asked themselves repeatedly during the past few weeks. Some days ago we paid a visit of inspection to the Crystal Palace, and were astonished to find the exhibition almost deserted! and not only by the public but by the majority of the stand-holders! The exhibits were there but, in numerous instances, left in charge—of themselves. The dearth of visitors by no means surprises us, for in not one industry is the exhibition representative or sufficiently attractive to inspire a special visit on its own account. We do not suggest that there is anything deficient in the exhibits, exhibitors, or the arrangement of the exhibits, but the place for such an exhibition is badly chosen. How many people will pay a special visit to the Crystal Palace to see one stoker, one brand of aperient water, or champagne, one make of cycles or machine tools?

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Don't Waste Your Money.

Some good advice comes to hand from our Vice-Consul at Taranto. He says:—"I am perfectly certain that out of the hundreds of catalogues and price lists which are yearly sent to tradesmen here, not 5 per cent. are of any use, simply because they are written in English, which is but little understood, and British weights and measures are used, which are incomprehensible to all but a very few."

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Where to get your Catalogues Translated.

He adds the following suggestion:—"The surest way would seem to be the establishment in London of a central agency, which would make it their business to prepare catalogues for the foreign markets by translating them into the language of the country for which they were required, and by transposing the prices, weights and measures into those used abroad. In all probability it would be found that four languages, viz., French, German, Spanish and Italian would be sufficient for all general purposes. Could such an agency be once established, firms desirous of advertising their goods abroad would merely have to send in their catalogues, with a note as to what language was required; the trouble would be taken off their hands, the expense would be small compared to the advantages which might be gained by wider circulation, and consuls abroad would at least have the satisfaction of seeing home manufactures competing on more equal terms with those of other nations." In connection with this suggestion, we take the opportunity of mentioning that we are in a position to undertake translations of catalogues into the four languages named, and if firms will submit their matter, a price will be quoted in each case in advance. Our translators are engineers, and, therefore, fully acquainted with the workshop and technical terms in each language.

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The Russian Calendar to be Changed.

It is officially stated that the Russian Government have decided to abandon the Julian calendar and adopt the Gregorian, now in use all over the world except in Russia and Greece. A commission of 16 members, including nine astronomers, has been appointed to arrange the details of the change, and it is the intention to have the new calendar go into operation in the year 1901. As readers will understand, the Russian calendar is now 12 days behind that in universal use. A potent cause for the change is stated to be the confusion of dates in correspondence and business transactions between Russians and citizens of foreign countries.

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A Large Engine Shaft.

A steel shaft for an engine of 4,000 h.-p. has just been completed in the United States for the Boston Elevated Railway, to be used in the company's central power station. The shaft is 28ft. in length, 38in. in diameter, at the centre, and weighs 37½ tons.

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How to Become a Locomotive Engineer.

A little book* lies before us which every youthful aspirant to a locomotive superintendentship should peruse. Its title is not one which inspires confidence, for it is too often the case that writers of popular handbooks with a "How to Become" title are most impracticable men. Such cannot, however, be said of the author of this book, Mr. Randal McDonnell, for having had a workshop experience himself, he can appreciate the feelings and failings of the apprentice.

Here is a slice from its opening chapter :—

"There is one very sad delusion which many fond parents seem to labour under when they conclude that a keen interest in the steam engine in their children's earlier years, a propensity for examining the interior of toys to find out how they work, coupled with unusual powers of destruction, are among the first sure signs of a future Stephenson or an Isambard Brunel. Thus it is we so often hear the expressions, 'Jack is a born engineer,' or 'Harry has a great mechanical career before him,' applied to boys who turn out afterwards to be the most indifferent mechanics, or even clumsy men. Let me, therefore, warn the ardent youth who desires to follow in the footsteps of the world's great engineers, to be quite sure that he has the *real taste* for the profession, without which success will be altogether impossible. 'I often observe,' writes James Nasmyth, in his delightful autobiography, 'in shop windows, every detail of model ships and model steam-engines, supplied ready made for those who are "said to be" of an ingenious and mechanical turn. Thus the vital uses of resourcefulness are done away with, and a sham exhibition of mechanical genius is paraded before you by the young impostors—the result, for the most part, of too free a supply of pocket-money. I have known too many instances of parents led by such false evidence of constructive skill, apprenticing their sons to some engineering firm ; and, after paying

* "How to Become a Locomotive Engineer." Whittaker and Co., Paternoster Square, E.C.

vast sums, finding out that the pretender comes out of the engineering shop with no other practical accomplishment than that of cigar-smoking!'"

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The Battle of the Boilers.

Based on the results obtained in the *Powerful* and *Terrible*, our Government pronounced the water-tube boiler for marine purposes to be a complete success. Mr. William Allan and his numerous supporters and the majority of the "special correspondents," with the manœuvring fleets, and public opinion, basing their judgment on the results obtained in the *Powerful* and *Terrible* and other vessels, have pronounced it to be an utter failure. The situation must, therefore, be still regarded as unsatisfactory. In support of the former party, Sir John Durston, engineer-in-chief, has informed us through the medium of a contemporary that he has "carefully studied the subject in all its bearings in France." This may be interesting, but of itself it is not conclusive. Other disciples affirm that France must be followed in this connection. This latter argument is, indeed, considered to be very convincing by the Government. Then there is the "overwhelming" point in favour of water-tubes, steam can be raised quicker, "and more of it," with consequent higher speed. This point is agreed upon by both parties.

JOHN M. HENDERSON, JUNR.,
AUTHOR OF "THE DEVELOPMENT OF CABLEWAYS IN GREAT BRITAIN."

The arguments against are almost too numerous to recite. The water tube boiler is charged with burning more coal; killing and maiming more men; requiring more skilled attendance; discovering the vessel's position to an enemy by means of a cloud of smoke by day and a pillar of fire by night, "observable forty miles distant"; smoke-drying the ship and officer's linen; greater initial cost——

We can offer no opinion on the subject, but we would suggest that the Government appoint a commission of experts to deliberate on the matter. It would allay public anxiety, and relieve the Government of considerable responsibility in the matter, without interfering with their present policy. For, after all, commissions do not act hurriedly, and are altogether harmless.

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Wire Rope Preservation.

A pamphlet is being issued by the Hartlepool Ropery Company on their wire rope preserving compound named Glissautoline. This composition is claimed not only as a preservative but as a lubricant, and an experiment by Mr. Biggart is quoted which showed that while an unlubricated rope stood 16,000 bendings before fracture commenced, a rope constructed on the lubrication principle stood 38,000 bends over the same pulley. In making this wire rope the cores and the wires are thoroughly coated with the compound. A sample immersed 12 weeks in a solution of brine—one salt to three of water—was unaffected. Other samples were all unaffected after immersion of 10 weeks in exhaust steam; 10 weeks in water at 140 deg.; 22 days in strong solution of sulphuric acid; the same period in the solution at 280 deg. F.; 12 weeks in sea water; 17 weeks in the open air; and 12 weeks just buried in earth and exposed to moisture from a hot water overflow at 140 deg. Two weeks in strong ammonia solution also left no effects. It is also claimed that a rope can be recoated should the material in time be worn off or absorbed by dust. The *Street Railway Journal*, in a recent article on this subject, described a form of wire rope filler for filling the interstitial spaces of ropes. In a stranded rope of six strands with a central core there is a good deal of space for the filling, which it is claimed will exude and prevent injury from acids or water. Commenting on this subject, the *Electrical Review* asks:—How long such a filling will retain preservative virtues, and if it is suitable for ropes of small size, such as span wires? There are thousands of miles of small span wire exposed to every vicissitude of climate and smoke, and the efficacy of galvanising is more or less doubtful. Zinc does not give an adherent flexible coating on a wire of iron or steel, and we know of nothing that does. A durable preservative is wanted which will not demand constant attention.

THE EVOLUTION OF THE UNDERTYPE ENGINE.

By JOHN RICHARDSON, M. Inst. C.E., M.I. Mech. E.

THERE are probably few types of engines which have more decidedly won their way to almost universal adoption than that known as the "Undertype Engine." By this is meant a steam engine erected upon a baseplate, which baseplate is so constructed as to form at one end the ash pit of a locomotive boiler, the smoke box end of which boiler rests upon a crutch-shaped casting placed over the cylinder of the engine.

Like many others of our most useful engineering productions, the undertype engine was evolved rather than invented.

The portable engine, from which the undertype naturally springs, was first designed merely for driving light agricultural machinery, and was made originally in one or two sizes only of

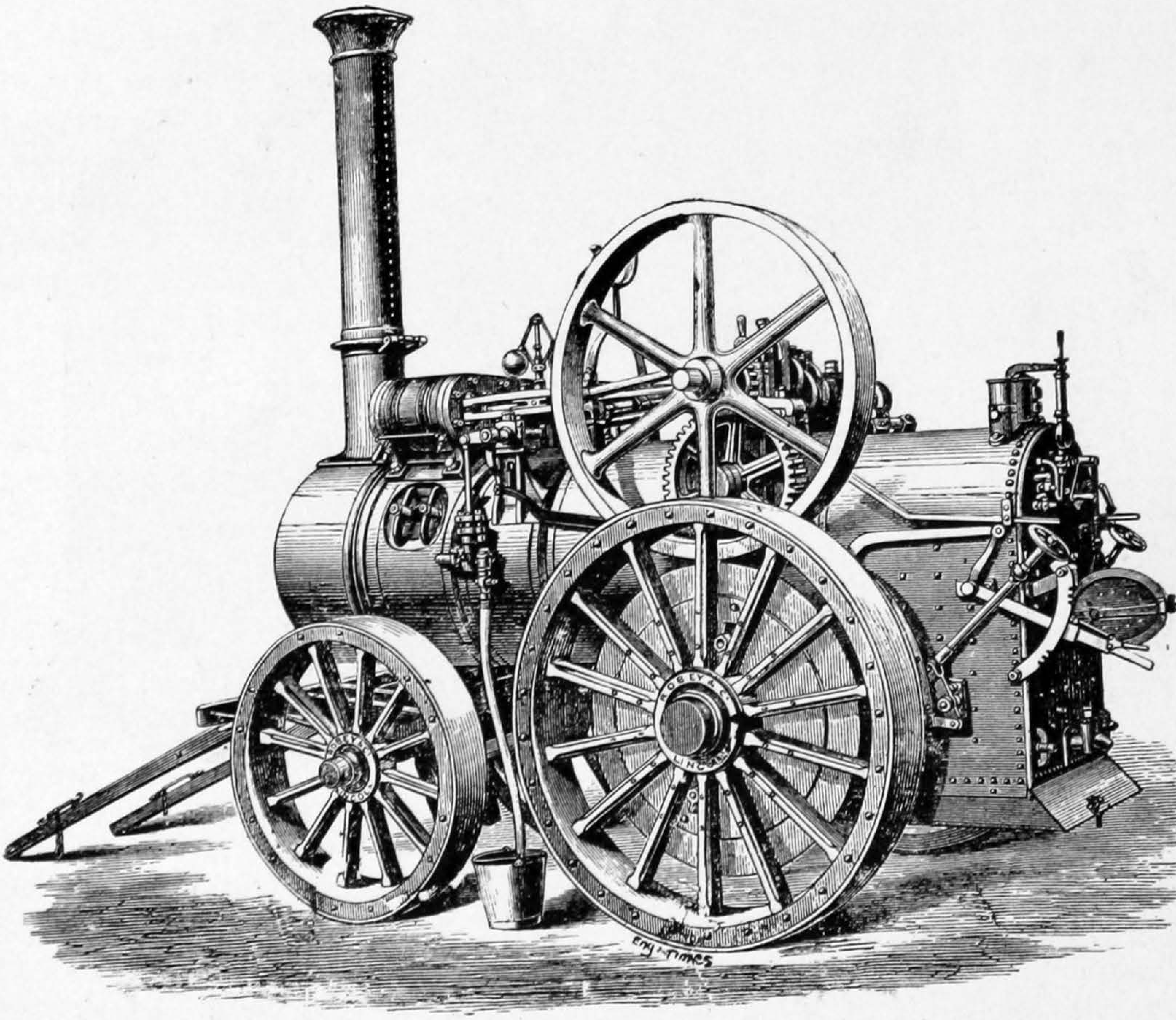


FIG. 1.—SELF-PROPELLED PORTABLE ENGINE WITH A PAIR OF WINDING DRUMS, EXHIBITED AT ROYAL SHOW IN 1860.

from 10 to 14 actual horse-power. The exceeding handiness and usefulness of such a motor, however, soon brought it into extensive use among builders and contractors, and the power rapidly grew until an engine developing 50 to 100 h.-p. was no uncommon sight upon a set of travelling wheels.

In the year 1860, Messrs. Robey and Co., of Lincoln, at the Royal Agricultural Show, held at Canterbury, exhibited a self - propelled portable engine with a pair of winding drums mounted on the main axle, one at each side of the boiler, as shown in the illustration, Fig. 1.

Spite of the prize which was awarded by the Society, the engine was only a qualified success as a ploughing engine, but the firm was quick to see that it made a very convenient and powerful winding engine for sinking pits and working inclines.

It will be observed from the illustration that the size of the winding drums was necessarily limited to a diameter much less than that of the travelling wheels, the next step in the evolution, therefore, was to dispense with the travelling wheels, and place a much larger drum at the side of the engine (see Fig. 2). The inner end of the drum shaft was carried on a bracket bolted to the side of the boiler, the outer end being carried by a trussed wood frame.

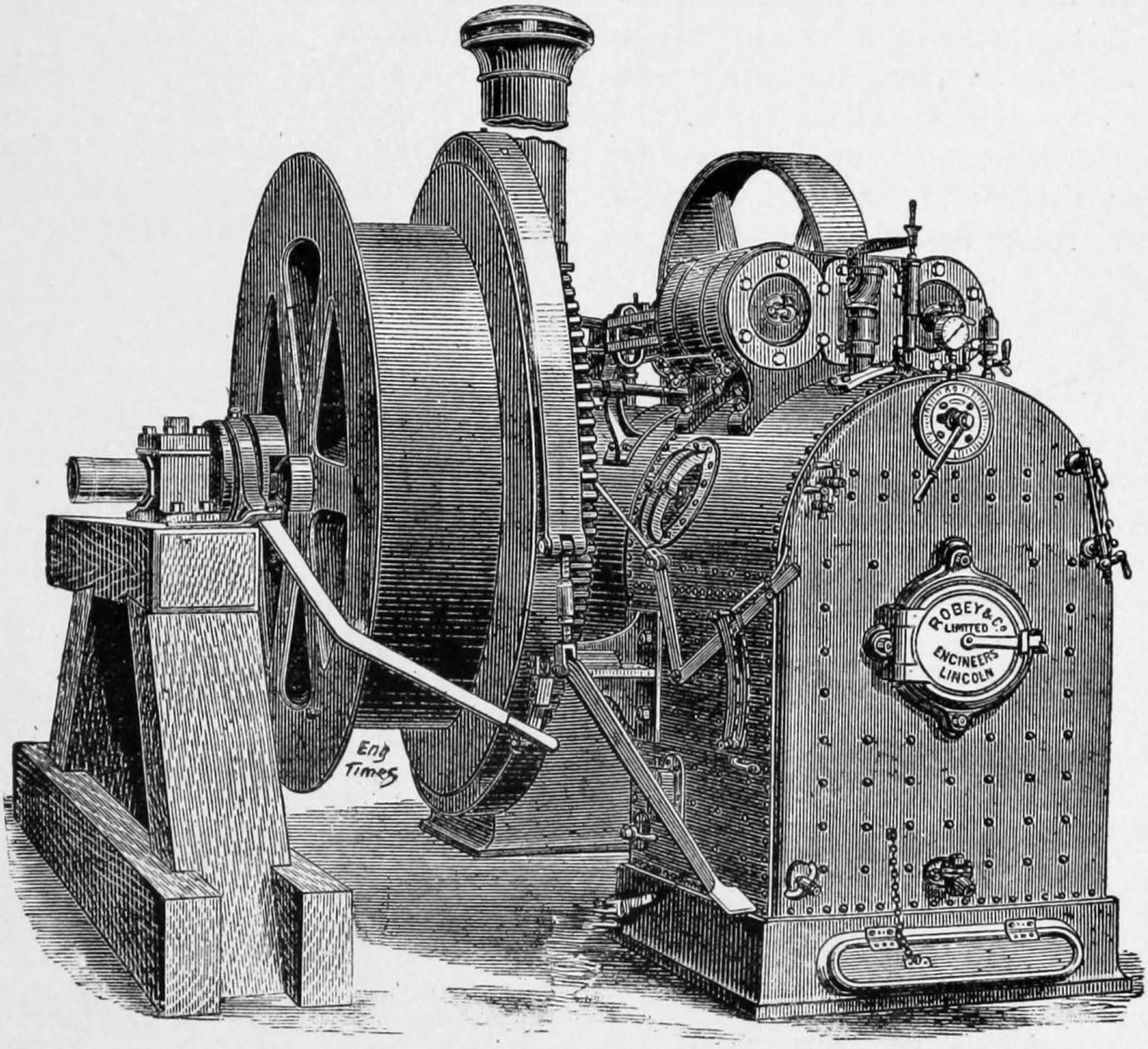


FIG. 2.—WINGING ENGINE BUILT BY MESSRS. ROBEY & CO. IN 1872.

Probably the most conservative part

of the United Kingdom, so far as machinery is concerned, is Cornwall; nevertheless, one of these engines of about 50 h.-p. actual, was put down at the Boscastle Mines in 1872, and attracted much attention.

The engine was purchased by the London Board of Directors, and when the Cornish men saw it they had nothing but contempt for the "toy," as they called it, and freely predicted that the first load it attempted to draw would result in its winding itself down the pit. When, however, it was set to work, and they saw the ease and speed with which it drew its load, and the simplicity of its handling, their contempt changed to enthusiasm, and but few either old or new shafts were opened up during the next few years without the aid of "a little Robey," as they christened it.

The year following the introduction of the "Robey Engine" into Cornwall the summer meeting of the Institute of Mechanical Engineers was held at Penzance, and, in view of the great attention which the winding engine had received, the author of this notice was requested by the council of the Society to read a paper on the subject of "Portable and Semi-Portable Winding Engines," the discussion following being extremely interesting and animated. From this time, not only in Cornwall, but in Wales and the North of England, such engines were soon in regular use.

The coal districts demanded much more powerful engines, and within a short time they were being made up to 200 h.-p., the illustration Fig. 3 showing the largest of this type.

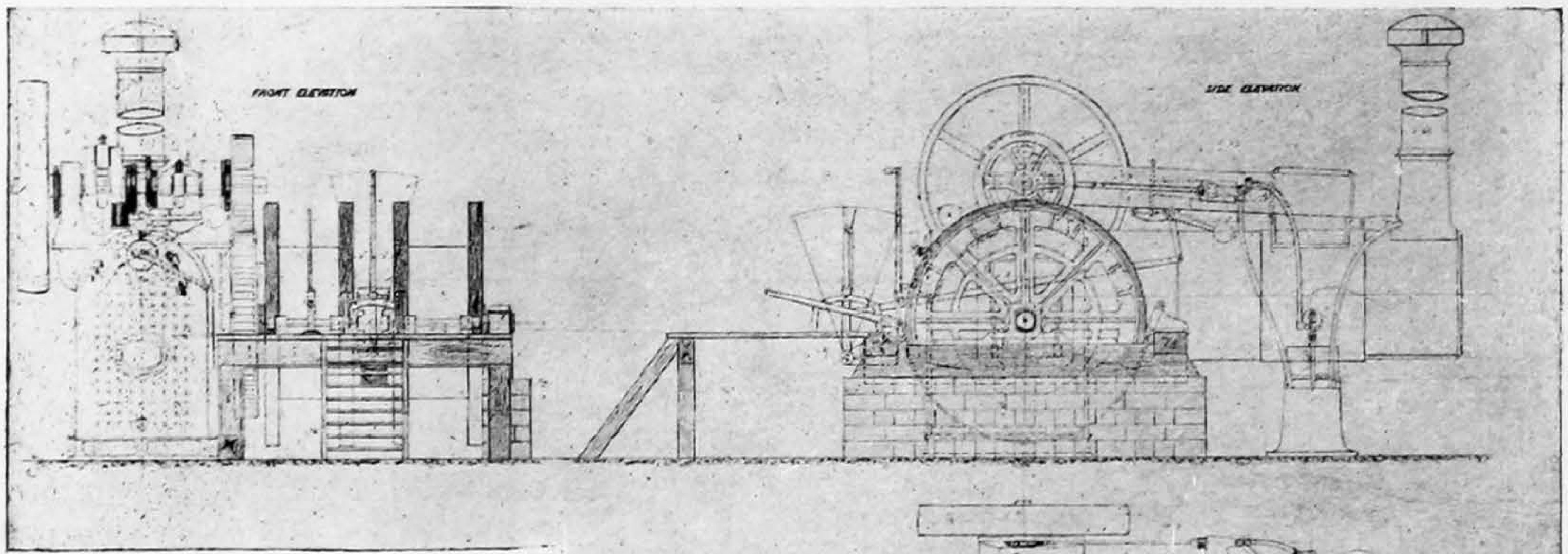
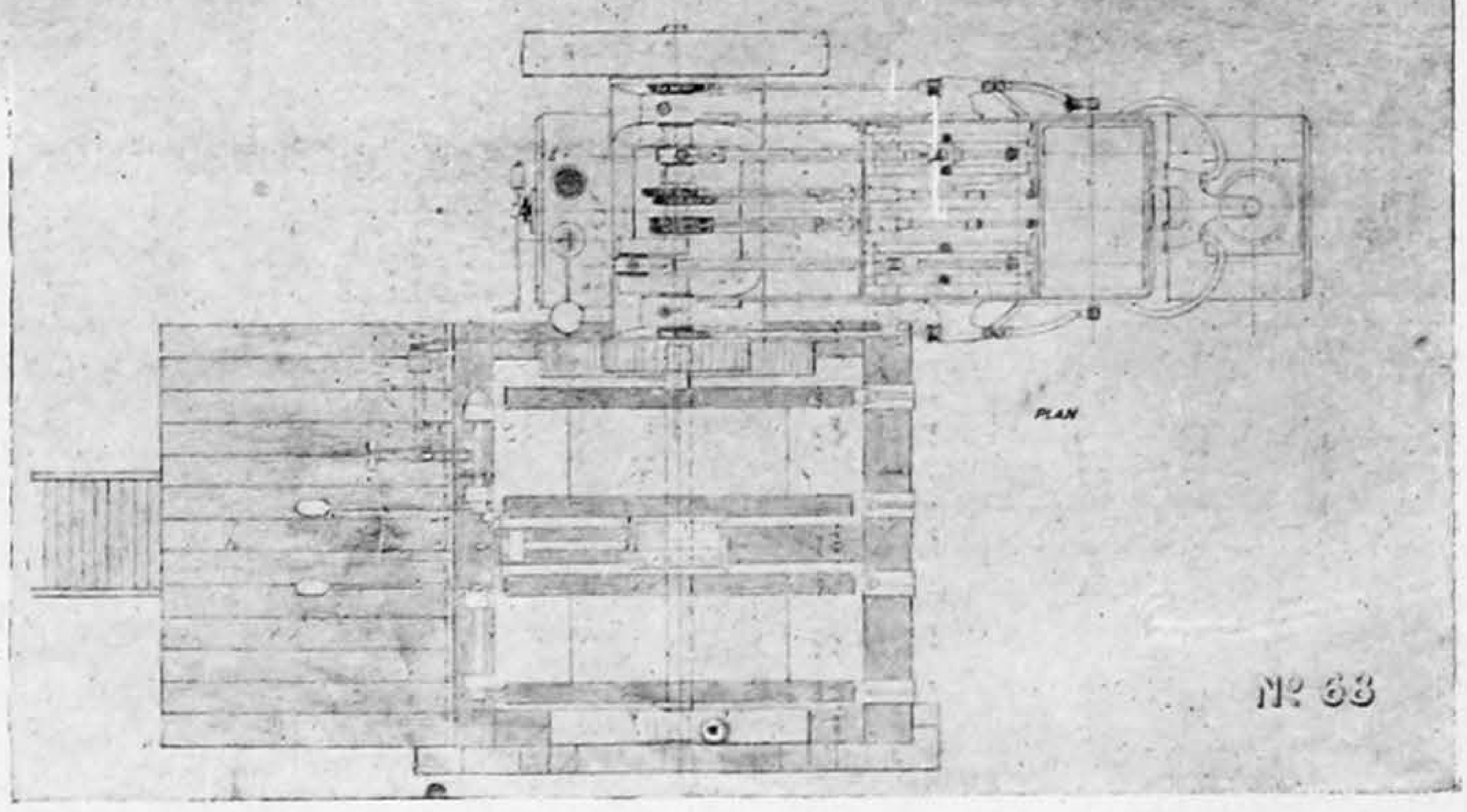
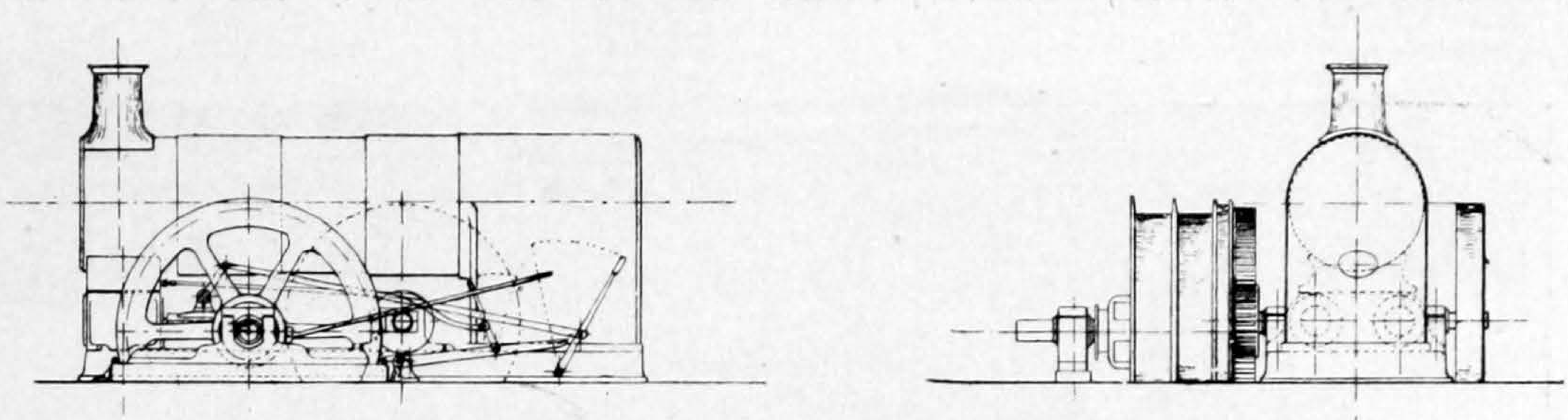



FIG. 3.—FRONT AND SIDE ELEVATIONS AND PLAN OF POWERFUL ENGINE BUILT IN 1872.

It was while this large semi-portable winding engine, with its pair of 16in. × 24in. cylinders, was being erected that the writer was struck with the idea of the great improvement that would be effected by placing the working parts of the engine and the powerful gearing and winding drum at or near to the ground-level. Within a few hours the drawing of the undertype engine was made, and the following day saw it patented. This was in December, 1873, the three views in Fig. 4 being copies from the patent specification.

The manufacture of large winding engines up to say 200 h.-p. now went apace, one Welsh colliery taking six, and the same size of engine was used by the late Duke of Sutherland for sinking the Florence coal pit to a depth of 1,500ft.



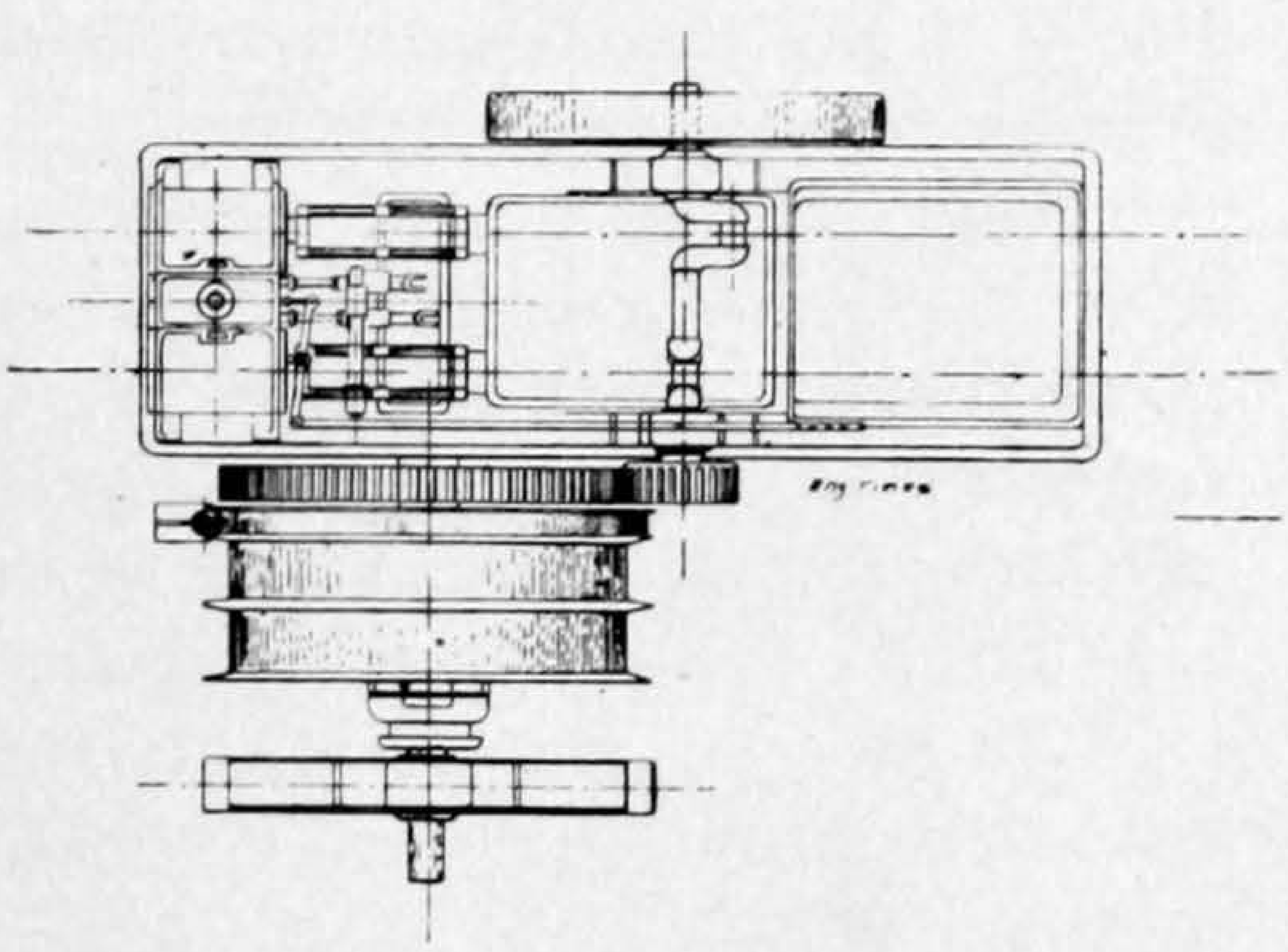


FIG. 4.—DRAWINGS FROM THE FIRST SPECIFICATION OF AN UNDERTYPE ENGINE FILED IN THE PATENT OFFICE.

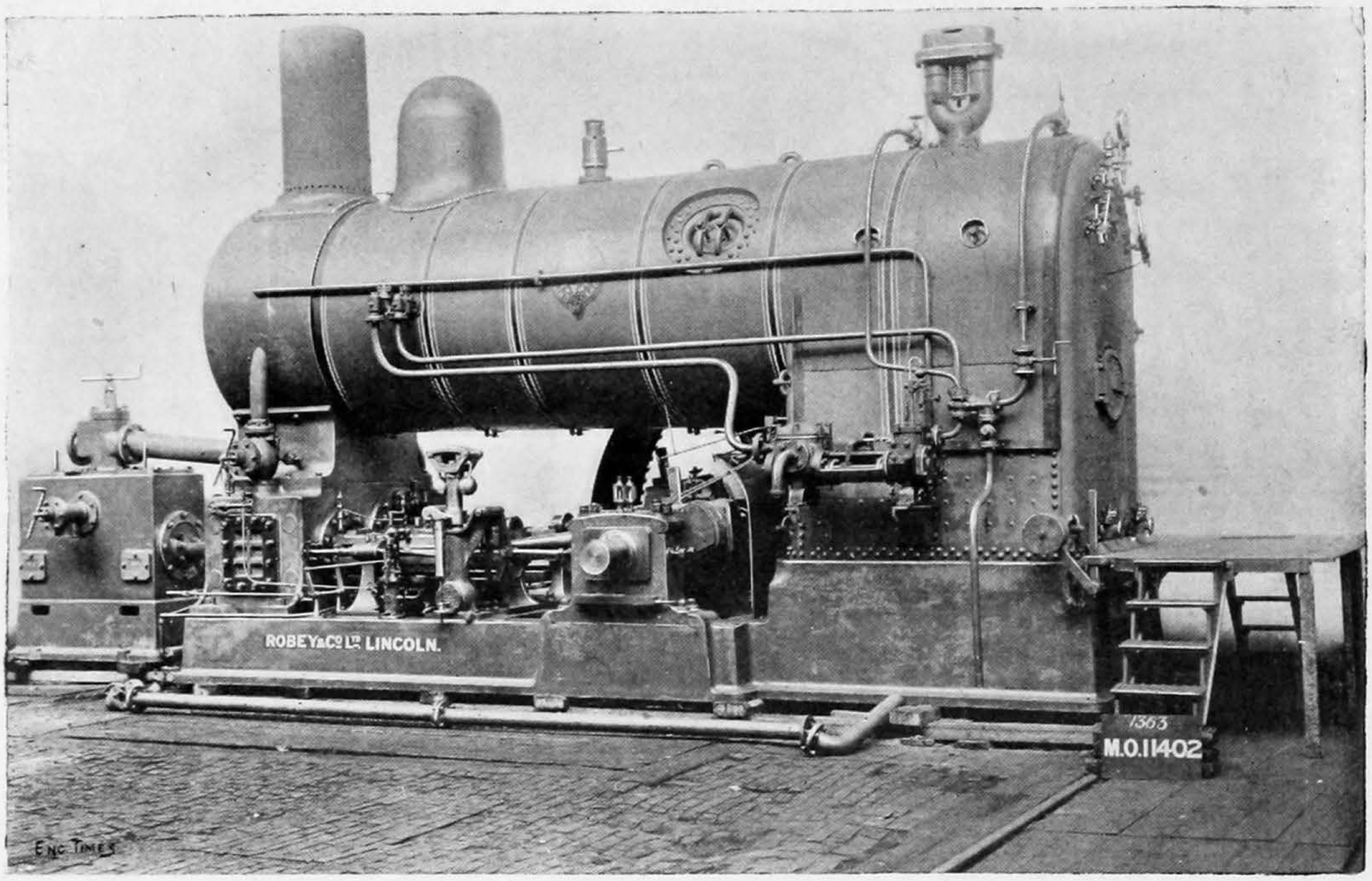
Though designed and patented principally as a winding and pumping engine, it was not long before it was seen what an admirable and convenient motor the undertype engine would make for driving purposes only; a clause in the patent specification covered this, but it was found necessary to disclaim this part as careful research showed that some time previous to the date of this patent, some locomotives had been packed up on their frames and thus used as stationary driving engines, belt pulleys being keyed on to the main axle in place of the driving wheels.

The popularity of this design induced many other makers to commence the manufacture, and thus a comparatively cheap and very compact and economical motor was placed within the reach of all engaged in industrial work.

The following are among the reasons for the popularity of this design :—Economy in prime cost, and cost of installation, and economy in fuel.

It is scarcely well enough known even yet, how large a proportion of the heat of a steam motor is lost in radiation from the surface of the boiler, steam chest, and cylinder, and the long lengths of steam piping often used. Now, owing to the relative position of engine and boiler in the undertype engine, this loss is very small, and the fact that most makers follow the original design, and carry the steam from the boiler to the cylinder through the smoke-box, turns the short length of pipe into a heater, rather than a radiator of heat.

In comparison with the large old-fashioned low-pressure engines with



ONE OF THE LATEST DESIGNS OF UNDERTYPE ENGINES.

single valves, slow moving pistons, and often naked cylinder, steam chest, and pipes, the high-pressure compact undertype engine was a marvel of economy, and when fitted as it frequently was with automatic expansion gear, it compared favourably with any single cylinder fixed engine, and was vastly superior to most.

The constantly increasing cost of fuel, and the severe competition which makes economical manufacturing essential, made a demand for engines of still higher economy and efficiency, and the demand was promptly met by compounding the engine, and further increasing the working pressure of the boilers, first to 120 lb. per square inch, and shortly afterwards to 150 lb., at which pressure most compound undertype engines now work. With this pressure an undertype engine of say 100 i.h.-p., when working non-condensing, will develop 1 h.-p per hour for 20 lb. of steam, and when condensing for 16 lb., or, taking good Welsh coal at 20s. per ton, say one-sixth of a penny per horse-power per hour, the popularity of the undertype engine is easily accounted for.

A further advantage is the small space required, such an engine requiring a space of 18ft. 6in. by 9ft. 3in., in which to accommodate both engine and boiler.

The illustration, Fig. 5, shows one of the latest designs of such an engine, and while there are other types which are better suited for their special work, yet doubtless for many years to come the undertype variety will continue to supply a large proportion of the steam power we require.

John Richardson

THE HISTORY AND DEVELOPMENT OF MOTOR CARS.

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

I.—SOME HISTORICAL MOTOR CARS.

IN the following papers no attempt will be made to give a complete history of motor cars, such a work would occupy more space than can be devoted to the subject. Moreover, the history and development of steam road carriages has been fully dealt with by the writer in other publications.*

It is our intention to supplement what has already been advanced, and to produce some missing links in the history of motor cars. It may be of interest to mention some of the early speculations respecting road locomotion by mechanical means. Roger Bacon 600 years ago wrote :—" We will be able to construct machines which will propel carriages with incredible speed without the assistance of any animal ; and we will be able to make machines which by means of wings will enable us to fly into the air like birds." Dr. Wilkins, Bishop of Chester (a person of rare gifts), thought that it not at all improbable that some of his posterity would find out a means of journeying to the moon. Wooden eagles are proposed, the chariot's wings are to be propelled by a high pressure. The engineer, it is suggested, might find a corner that would do for a coal station near some of the " castles in the air." The flying chariot has been a pet subject with inventors for the last 200 years. Numerous plans for navigating the air have been proposed, some of the plans have been tried, but the realisation of the object appears to be as far off as ever.

It is related that Father Verbiest, a missionary among the Chinese in 1680, made some experiments at Pekin, with what we may call a steam engine. " He placed an æolipile upon a car, and directed the steam

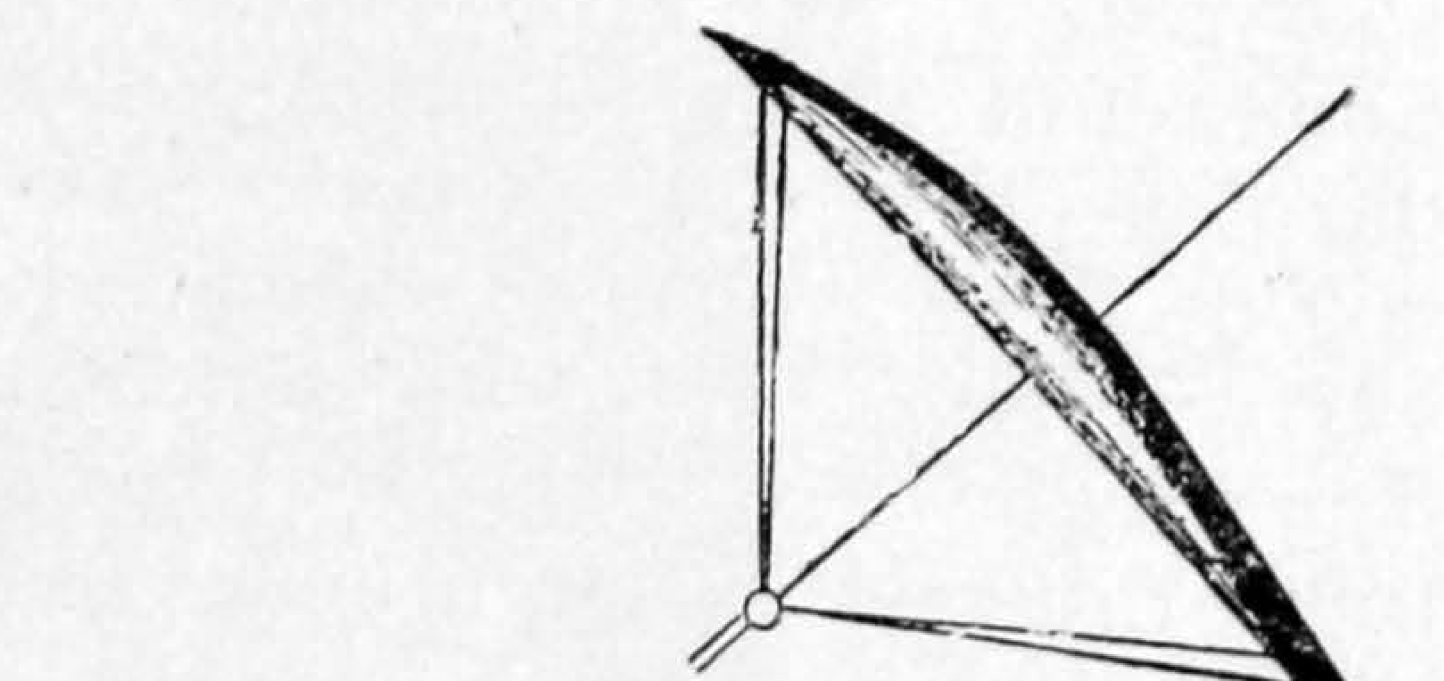


FIG I.—THE KITE CARRIAGE OF VINEY AND POCOCK.

generator within it upon a wheel, to which four wings were attached ; the motion produced was communicated by gearing to the wheel of the car. The machine continued to move with great velocity as long as the steam lasted. The car could be steered by

*" The History and Development of Steam Locomotion on Common Roads."—Spon, London.

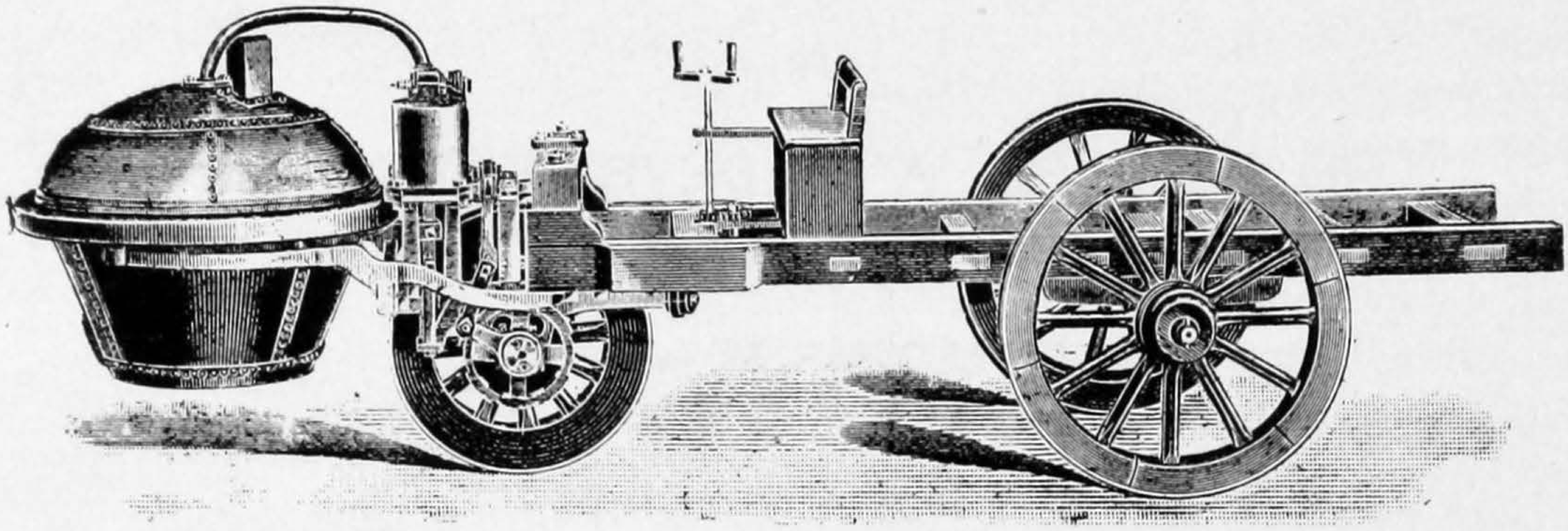
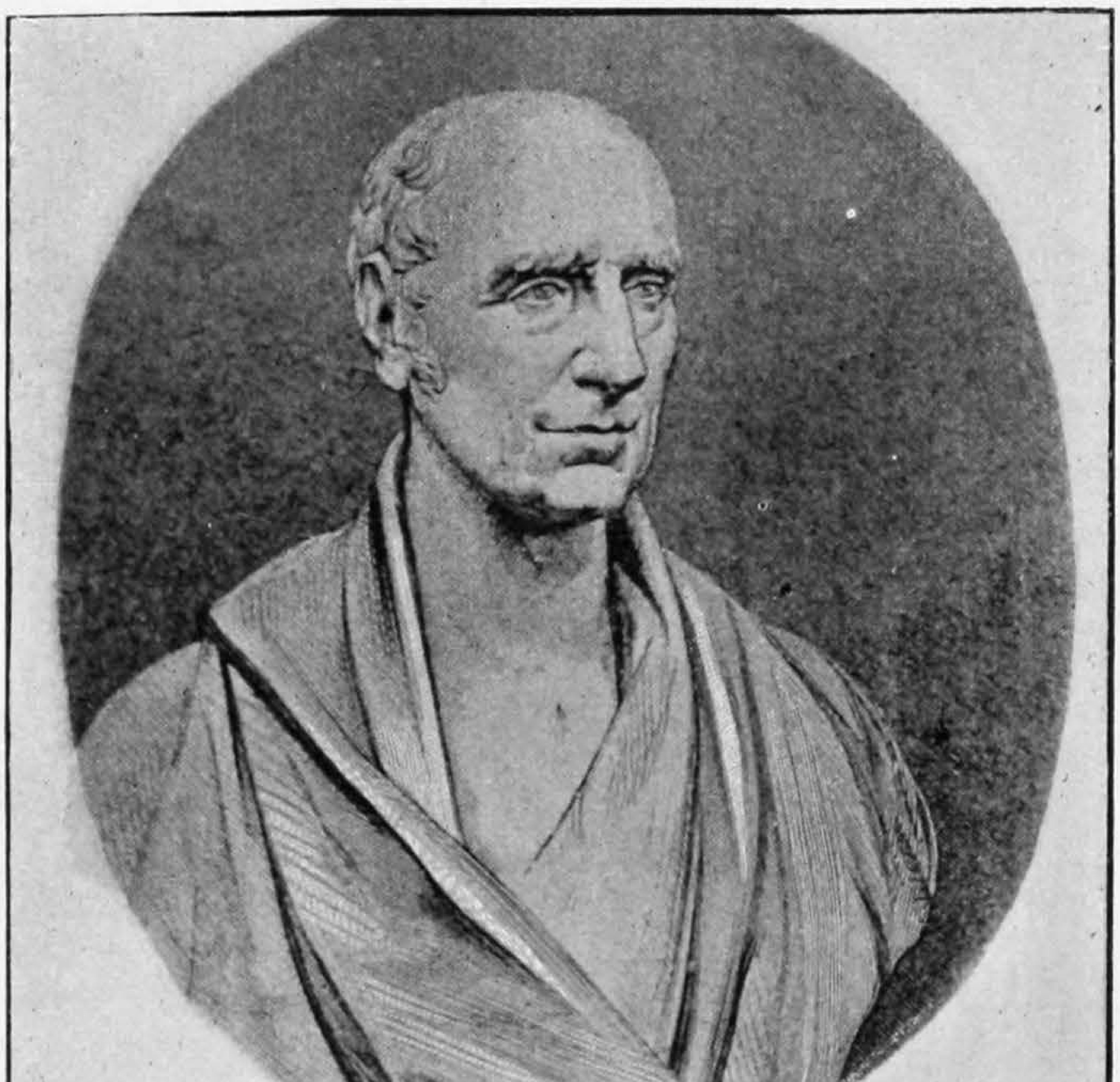


FIG. 2.—CUGNOT'S STEAM DRAY.

means of an apparatus termed a helm." A century later R. Lovell Edgeworth, father of the celebrated Marian Edgeworth, revived the sailing carriage scheme, and, after having patented one, he carried out a number of experiments; but like his predecessors, he very soon found the wind to be an unsuitable power. Sometimes there was no wind, at others it blew from the wrong quarter, and when it so happened that it blew strong in the right direction his carriages travelled too fast. Towards the end of the last century, there is an account of a journey made by an Englishman in a sailing carriage from Alexandria to Bassora. In 1786 there was a trial of another at Blackheath, at which Sir Joseph Banks and several members of the Royal Society were present. It is related that this carriage went at a great speed until the mast broke.



WILLIAM MURDOCH.—EARLY MOTOR CAR INVENTOR.

In 1820 a sailing carriage was used near Newmarket, and doubtless there were many other attempts made in different parts of the country in the early part of the century.

The kite carriage of Viney and Pocock may be briefly referred to. This made the journey from Bristol to London, and was seen on several occasions in Hyde Park, and in the suburbs of the Metropolis. The carriage was drawn along by one or more kites arranged in tandem. In the accompanying illustration, Fig. 1., the lowermost kite is brought down close to the carriage. A spring drag, operated by a lever, was employed to retard or arrest the motion of the carriage. A speed of a mile in three minutes was attained on several occasions, even upon heavy roads, and on one occasion the mile was covered in $2\frac{3}{4}$ minutes.*

Leaving the sailing cars, flying chariots, and omitting any mention of the carriages propelled by windmills, we must notice some of the early motor cars propelled by steam.

Cugnot's steam dray came out for a brief airing 120 years ago, and unhappily met with an accident during one of its journeys, which brought the trials to an untimely end. Running upon three wheels only, with the weight of the boiler and engine overhanging in front, it was by no means a steady machine, and in passing along a street in Paris at the rate of three miles an hour, when turning a corner it overbalanced itself, and fell over with a crash, for which offence the machine was locked up to keep it out of further mischief; Cugnot was also imprisoned. Fig. 2 shows the machine, although it can hardly be termed a motor car, it appears to be the first of the motor vans.

Murdoch's interesting little motor car merits some attention. We can only refer to a trial of this model. One night, after returning from his duties at the mine, Murdoch went with his locomotive to the avenue leading to the church, about a mile from the town. The walk was narrow, straight, and level. Having lit the lamp, the water soon boiled, and off started the engine, with the inventor after it. Shortly after Murdoch heard shouts of terror. It was too dark to perceive objects, but he found, on following up the car, that the cries had proceeded from the worthy vicar, who, while going along the walk, had met he hissing and fiery little monster, which he declared he took to be the Evil One in person. The celebrated James Watt's ideas on road carriages were crude, and, had he attempted to put his ideas into practice, the machine would have been a failure. Watt displayed a dog-in-the-manger spirit; he could not, or would not, make a motor carriage himself, and he was determined that no one else should succeed. He wrote threaten-

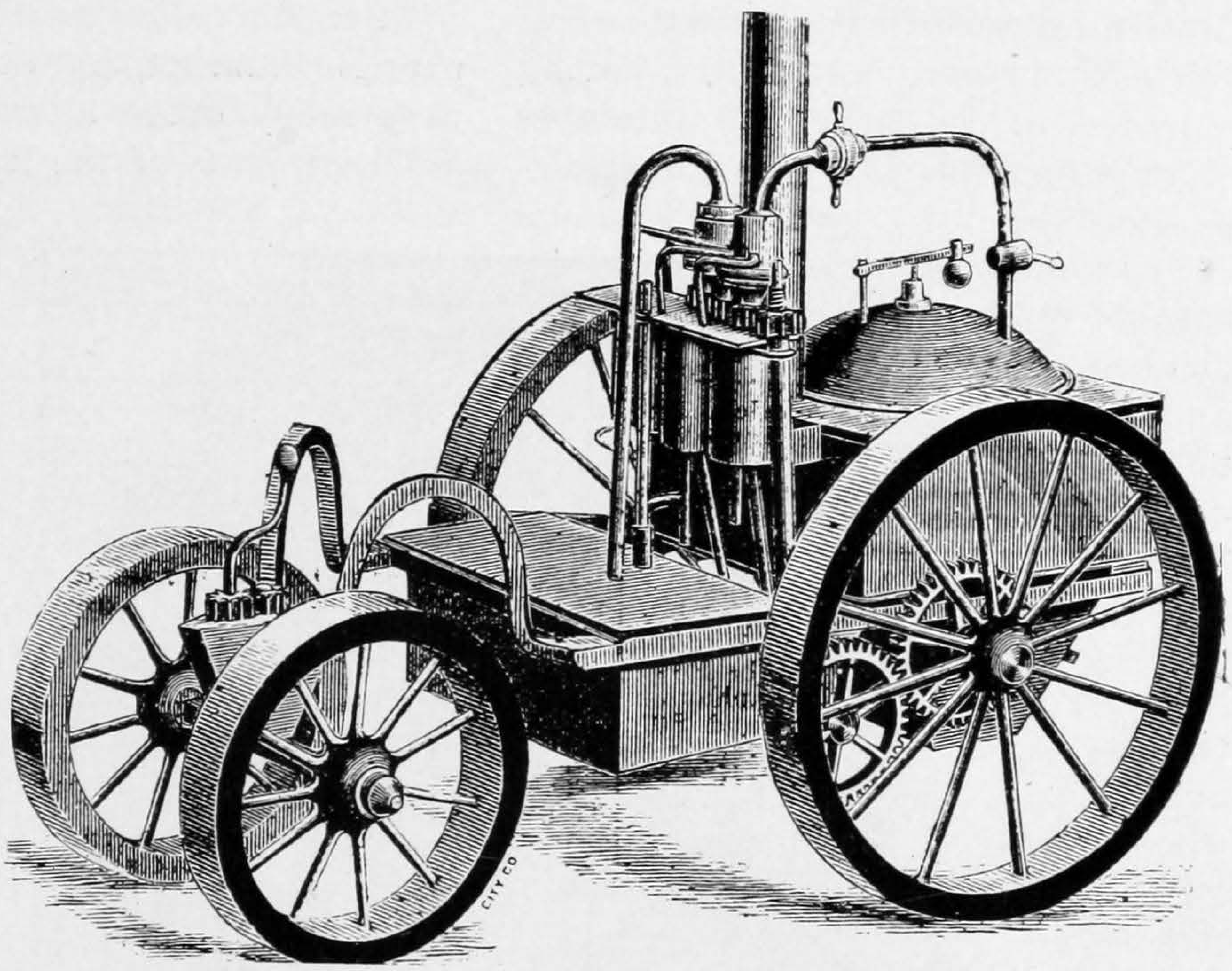


FIG. 3.—THE FOURNESS MOTOR CAR, BUILT IN 1788.

* "The Antiquary," September, 1896. Article by Mr. Rhys Jenkins

ing letters to Symington and others, who were making road engines, to the effect that "the sole privilege of making steam engines had been granted to Mr. Watt by Act of Parliament"; he had specified the application of steam for driving wheel carriages in a patent which was taken out in 1784.

We now wish to notice an early motor car which has received but scant attention. In 1788, R. Fourness and J. Ashworth took out a patent for the machine shown by the three illustrations. Fig. 3 gives a general view, Fig. 4 represents a side elevation, and Fig. 5 an end view.

Motion was communicated from the pistons of the three inverted open-ended cylinders to the crank shaft, one or more spur wheels were keyed upon the crank shaft gearing into others on the driving axle, for giving the various travelling speeds on the road. Steam was admitted to the cylinders through a "rotative cock" into the barrel of which was introduced three branches for the three cylinders. The cock was worked by a vertical shaft which received motion from the engine. A similar cock was adopted for dealing with the exhaust steam. Fig. 5 shows the two cocks; the exhaust steam was conducted into the feed water tank as shown by Fig. 4. A few words respecting the inventor may be of interest here. Robert Fourness was a native of Otley, Yorkshire, his first invention was a hide splitting machine for use in his father's works, who was a maker of fancy leather for bookbinders. The hide splitting machine was not patented, and in order to keep its construction a secret, three or four half-witted men from the

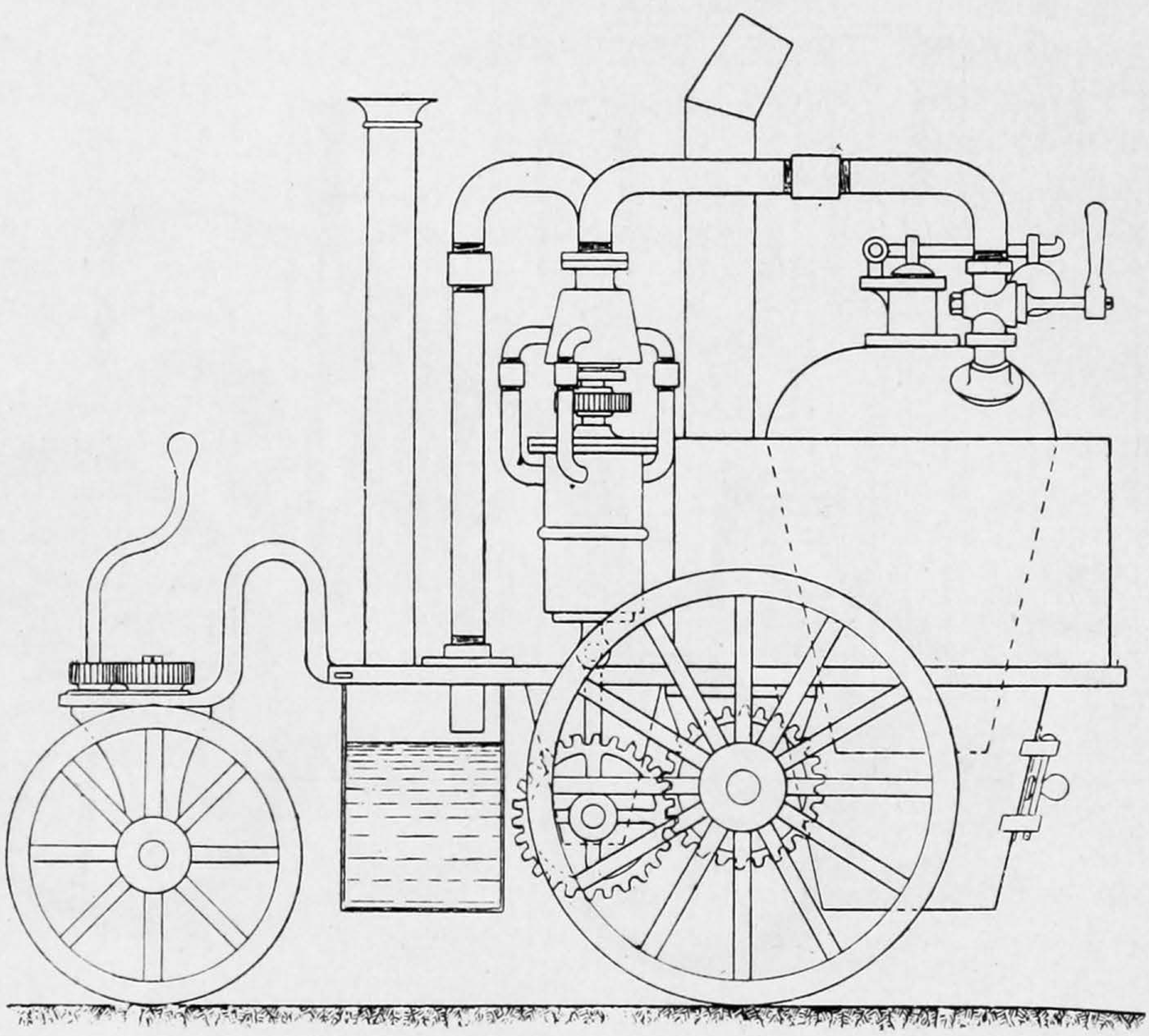


FIG. 4.—SIDE ELEVATION OF THE FOURNESS CAR.

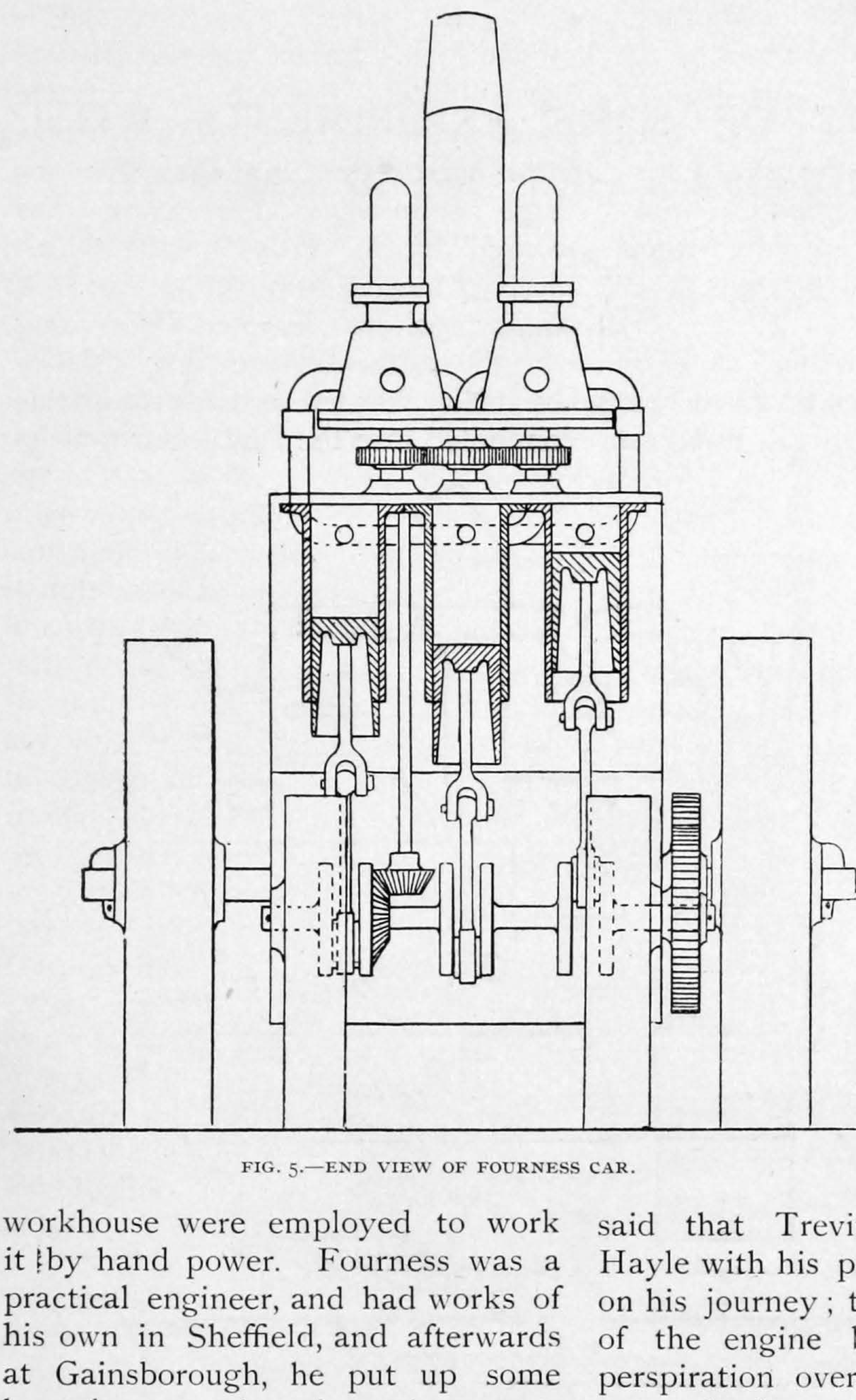


FIG. 5.—END VIEW OF FOURNESS CAR.

workhouse were employed to work it by hand power. Fourness was a practical engineer, and had works of his own in Sheffield, and afterwards at Gainsborough, he put up some large beam engines in various parts of the country. Like other mechanics of his day he received threats from Boulton and Watt, causing him to relinquish some of his later engineering undertakings. Among his inventions there was one relating to steam boats. Fourness died at an early age, and we are unable to say what became of his motor car. R. Trevithick was one of the greatest inventors who ever lived, he has been justly termed the "father of the high pressure engine," and he was undoubtedly the "father of the railway locomotive engine." Trevithick made the first motor car which carried passengers on an English highway. Cugnot had 20 years previously carried passengers on his dray through the streets of Paris; but there was no comparison between these two machines. Full particulars of Trevithick's road vehicles are given in the author's book on Road Locomotives. We will close with a story related by Dr. Smiles:—"It is said that Trevithick started from Hayle with his puffer, and proceeded on his journey; the anxiety and heat of the engine brought a flood of perspiration over him, which served to catch the smuts from the engine fire, until poor Trevithick appeared in Satan's livery. In this state he suddenly pulled up at a toll-gate and called out, 'What's to pay?' The toll-keeper, more timid than wise, stood shaking in his shoes, and replied with a stammering tongue, 'No—nothing to pay, Mr. Devil, drive on as fast as you can.'"

(*To be continued.*)

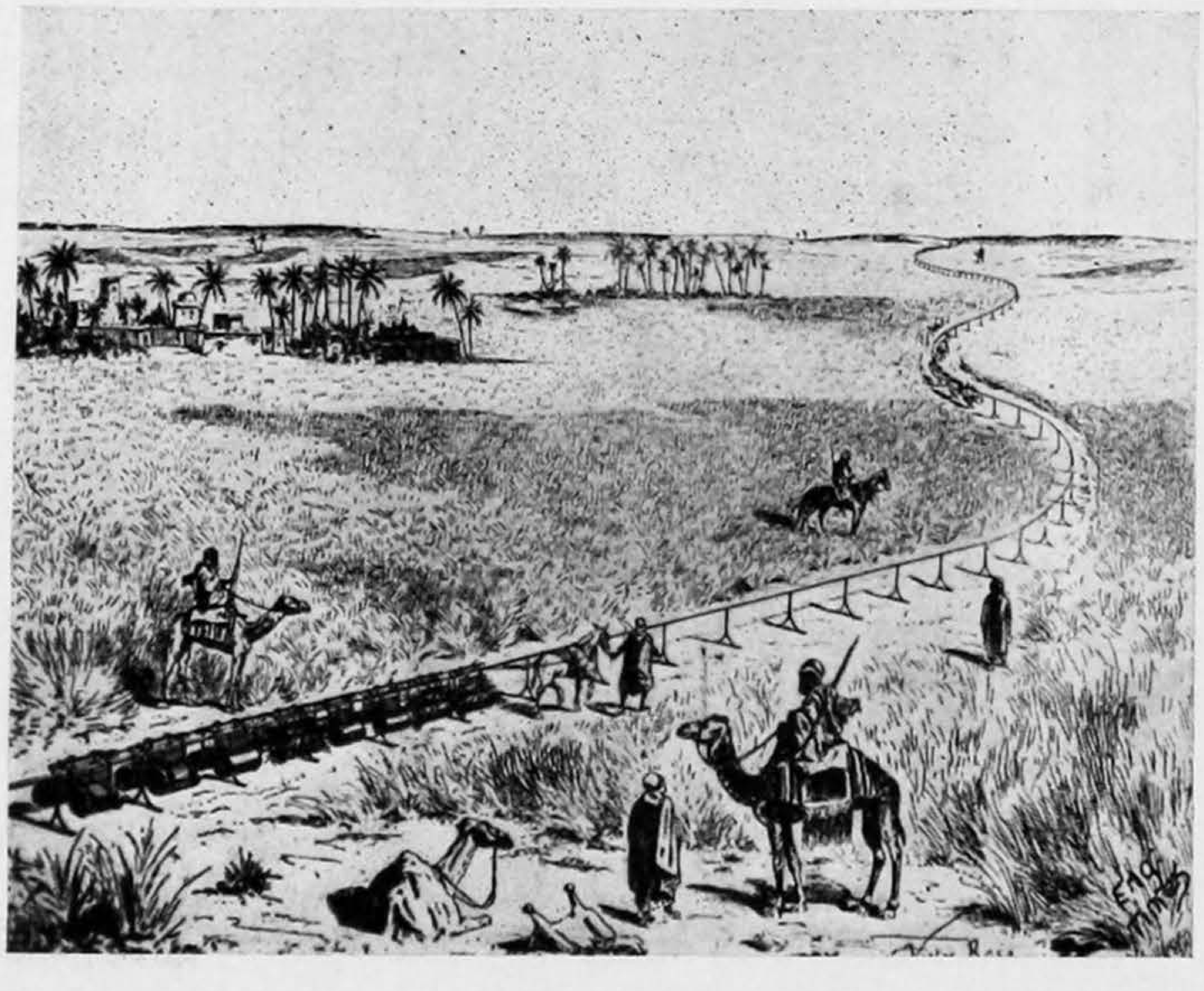
W. Fletcher.

AN ACCOUNT OF SOME EXPERIMENTS WITH BEHR'S MONORAIL HIGH SPEED RAILWAY.

By F. ROBINS.

ANY safe and practicable scheme for facilitating the means of rapid communication between large industrial centres would be largely welcomed, and now that such a scheme is about to be put on its trial between Liverpool and Manchester, a short sketch of its history and development, with an account of experiments that have taken place. should be interesting.

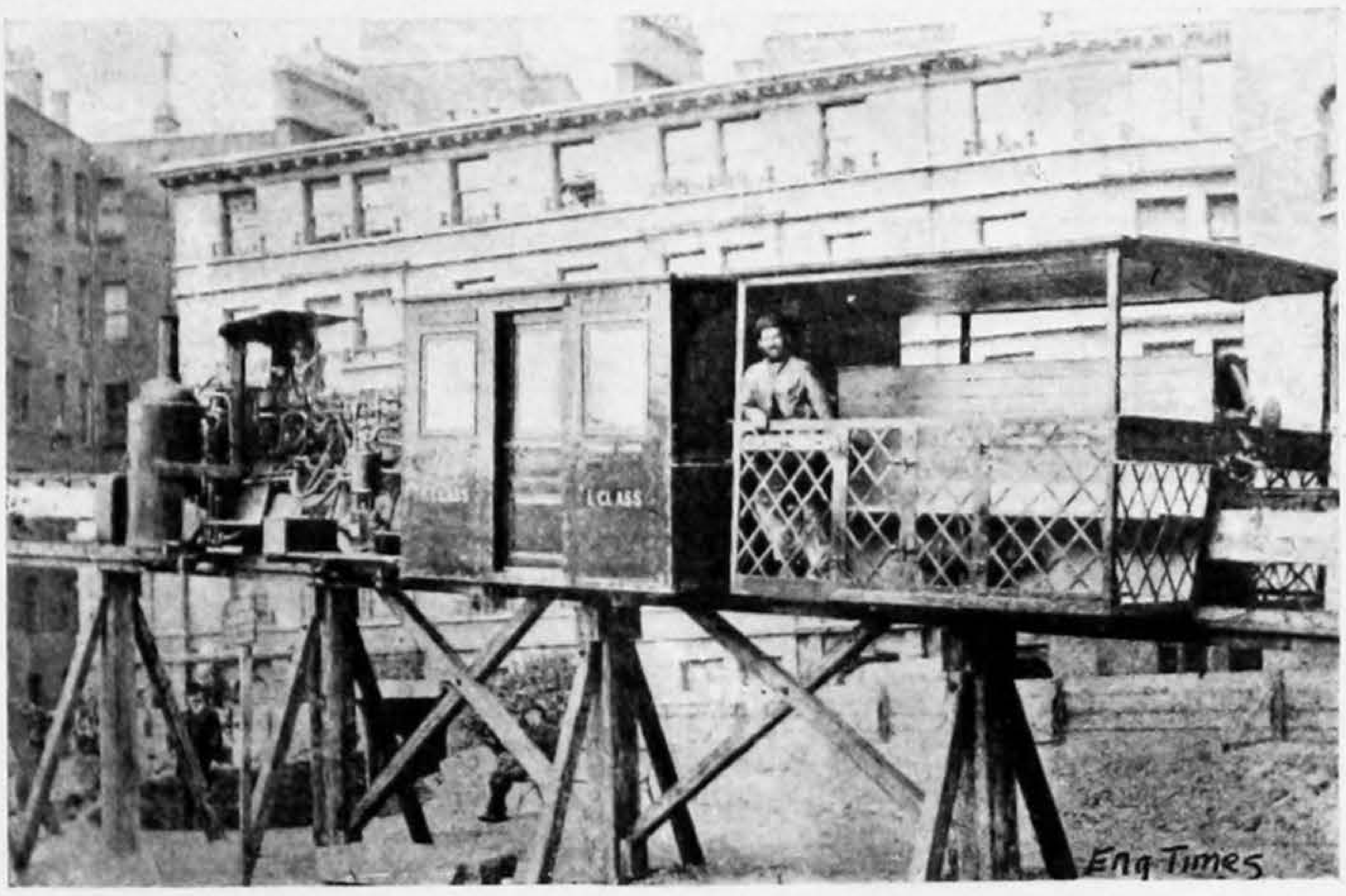
Caillet's Monorail System (which has been described in a recent number of the ENGINEERING TIMES) is perhaps the monorail in its simplest form. This is mainly used for agricultural work. A development of this simple monorail is the Lartigue elevated single line.



VIEW SHOWING LARTIGUE MONORAIL AS USED IN ALGERIA.

Charles Lartigue, a French engineer in Algeria, found that terrific sandstorms sometimes completely covered the rails of a small, narrow-gauge line which he was working, thus rendering it useless at certain times of the year. He sought a way out of the difficulty by building a single line mounted on triangular tressels about 3ft. high, and balancing panniers on wheels on the top rail. His experiment was generally successful. He exhibited his line afterwards both at Rouen and Paris in 1884. It was here that Mr. F. B. Behr, whose name is now so closely associated with the system, first became interested in it, and he immediately set about widening its scope, and making use of it in a more extensive field.

An experimental line was built by him in Westminster in 1886, and its practicability was so obvious that a company was formed, and the necessary powers were obtained, to build and equip a monorail railway between Ballybunion and Listowel in Ireland. This railway has been in operation for over ten years, and from its novelty, it forms no inconsiderable attraction for tourists in the summer



EXPERIMENTAL LINE BUILT AT WESTMINSTER. ENGINE ASCENDING GRADIENT OF 1 IN 10.

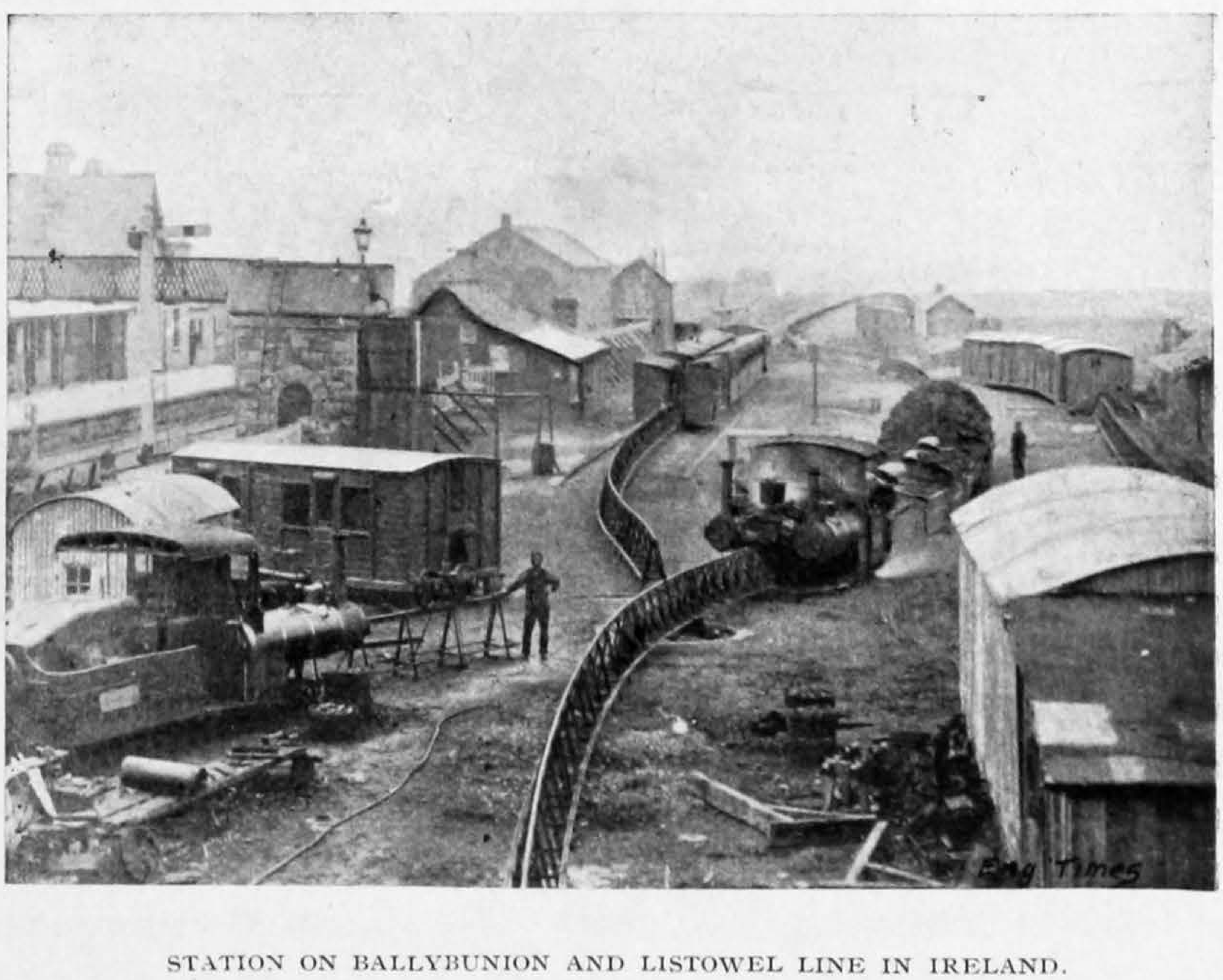
Government, and permission was obtained for erecting a line. The Exhibition Committee, seeing that the project was going to be unique in its attractiveness, promised to find motive power to the extent of 1,000-horse. The line was commenced about October, 1896. On account of the undulating nature of the ground, embankments about 18ft. high, and deep cuttings, had to be made to ensure moderate gradients; the winter weather was unfavourable for building earthworks and the work being hurried, was generally scamped. The line, about three miles long, was a closed curve of elliptical form, or, more strictly, two short parallel lines united by two curves of about 540 yards radius.

For one-and-a-half miles there was an up-gradient exceeding 1 in 100; and about three-quarters of the whole circuit was a curve. The station was situated on a curve, thus rendering

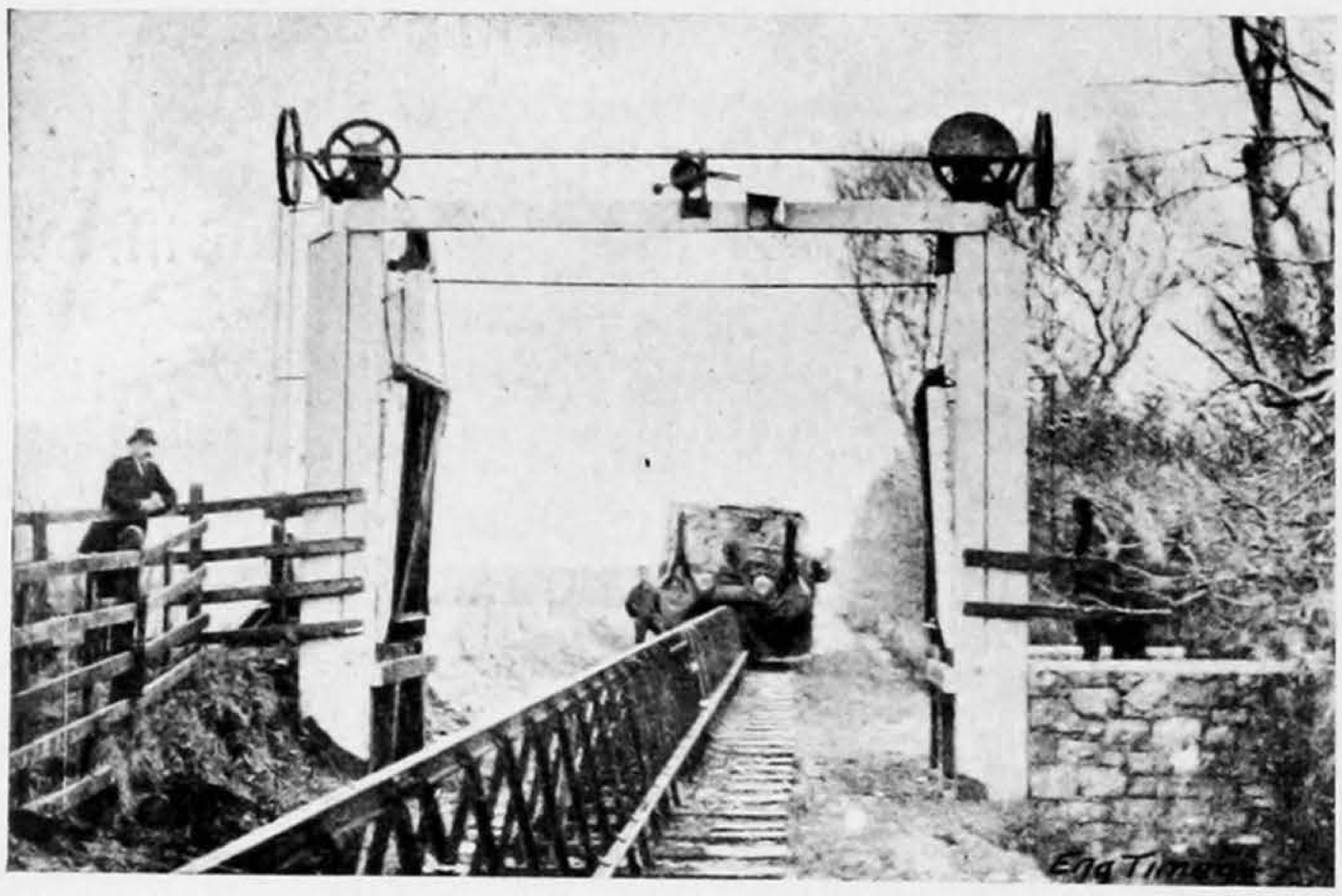
season. In the South of France, too, one of these unique little railways is at work.

There is, however, a wide gap between these modest applications of the single line idea, and the huge experiment about to be described. Until the Behr improvements, it was never pretended that the monorail system could attain to high speeds, coupled with comfort and security; and this short history of the infancy and youth of the invention is interesting only as a connecting link between the unpretentious little line in Algeria and the daring project at Brussels.

The success of the Irish line emboldened the inventor to make these trials. The Brussels International Exhibition was coming off in 1897, and that seemed a favourable opportunity. Arrangements were made with the Belgian



STATION ON BALLYBUNION AND LISTOWEL LINE IN IRELAND.



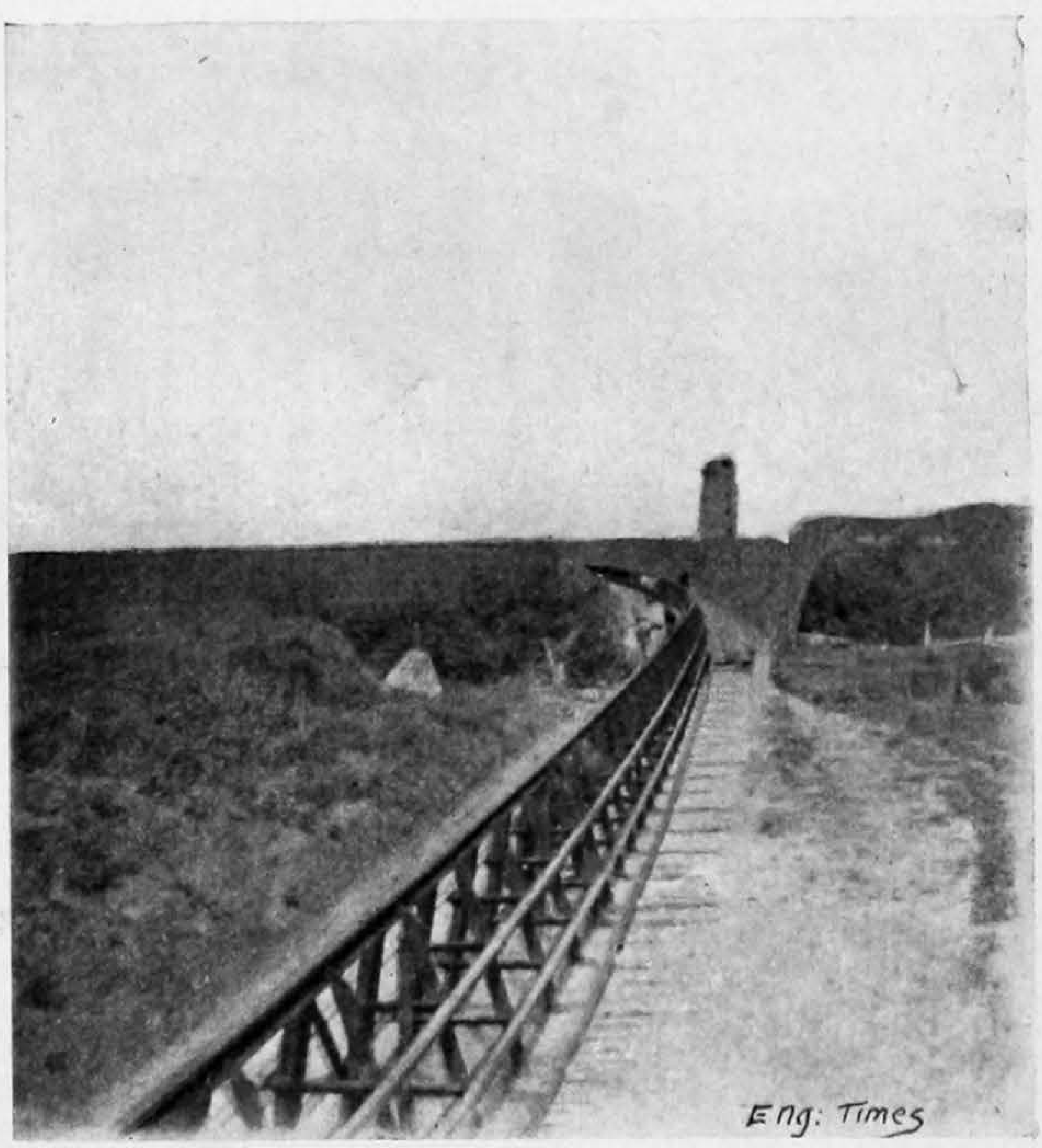
BALLYBUNION AND LISTOWEL LINE. VIEW SHOWING DRAWBRIDGE ON LEVEL CROSSING.

the conditions for starting and stopping unfavourable.

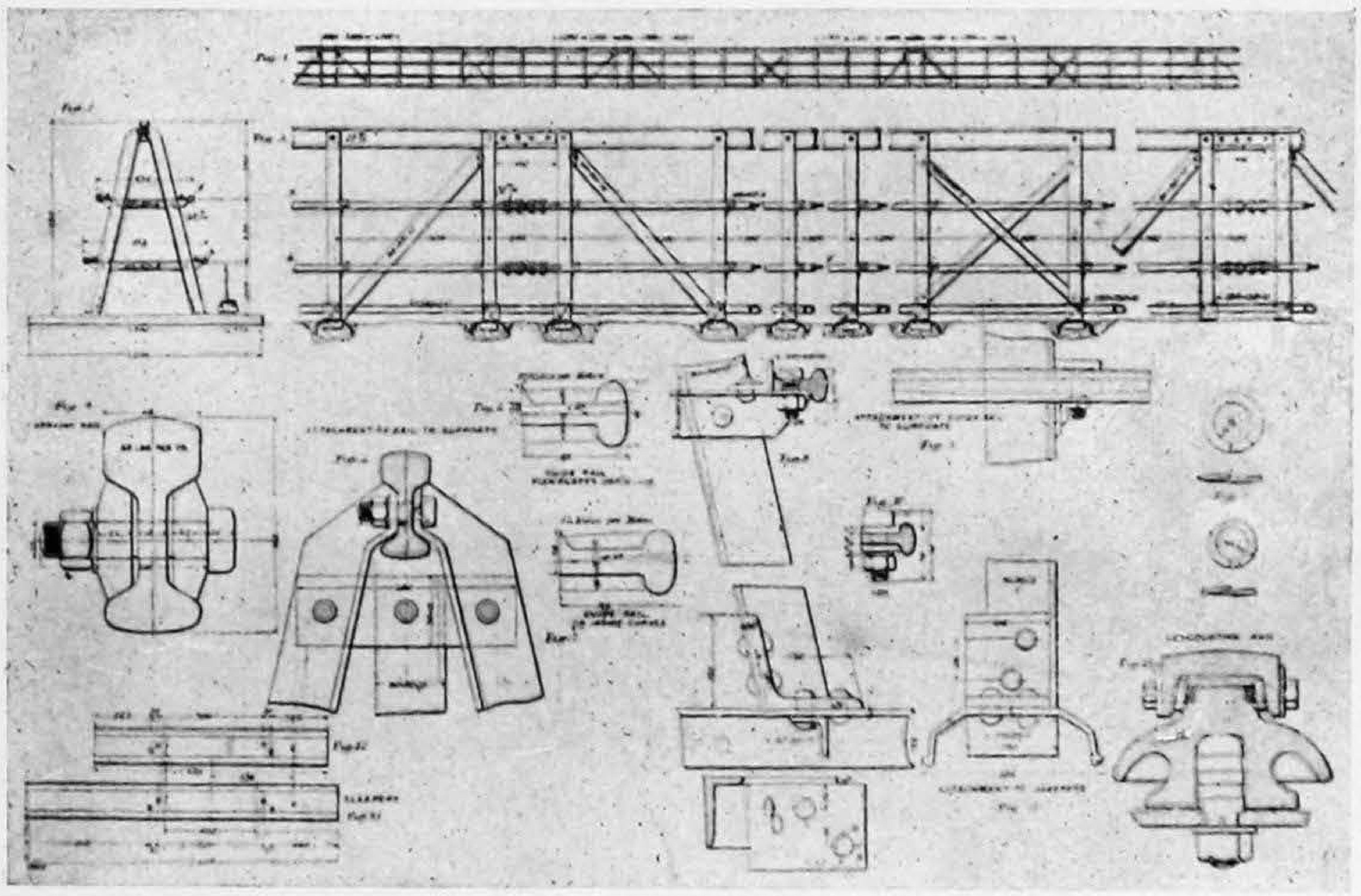
The structure itself consisted of a single rail elevated about 4ft. and supported on strong A-shaped steel tressles, the legs of the tressels were riveted to steel sleepers which simply rested on the ballast. These triangular supports were spaced about 3ft. 3in. apart, and at each side were fixed laterally two rails of special section, one about 18in. above the other. The function of these guide-rails was threefold:—(1) to brace the whole system together and guarantee its stability, (2) to engage the horizontal guide wheels of the car and prevent oscillation, (3) to counteract the effect of centrifugal force, when rounding sharp curves.

The electrical conductor was also a steel rail of channel section, resting on porcelain insulators fixed in the sleepers. These rails were jointed together by copper fish-plates to preserve electrical continuity. The return circuit for the electric current was made through the line itself.

The car was 60ft. long, 11ft. wide, and weighed about 64 tons. It consisted of two bogies flexibly coupled together; these had the appearance of riding astride the rail. The lower part of the carriage enclosed the driving mechanism. There were four electric motors of about 200 h.-p. each. These were suspended from the girders and were connected to the axles of the driving wheels by "Hans Renold" chains. A rigid iron piece was interposed between the body of the motors and the axles to which they were coupled. This made the propelling force an absolutely self-contained system which could not be affected by any shocks which the car might receive. A set of 32 horizontal double-flanged wheels, which take their bearing on the guide rails described, preserved the equilibrium and prevented excessive vibration.



SHOWING CURVE ON LINE AT BRUSSELS.



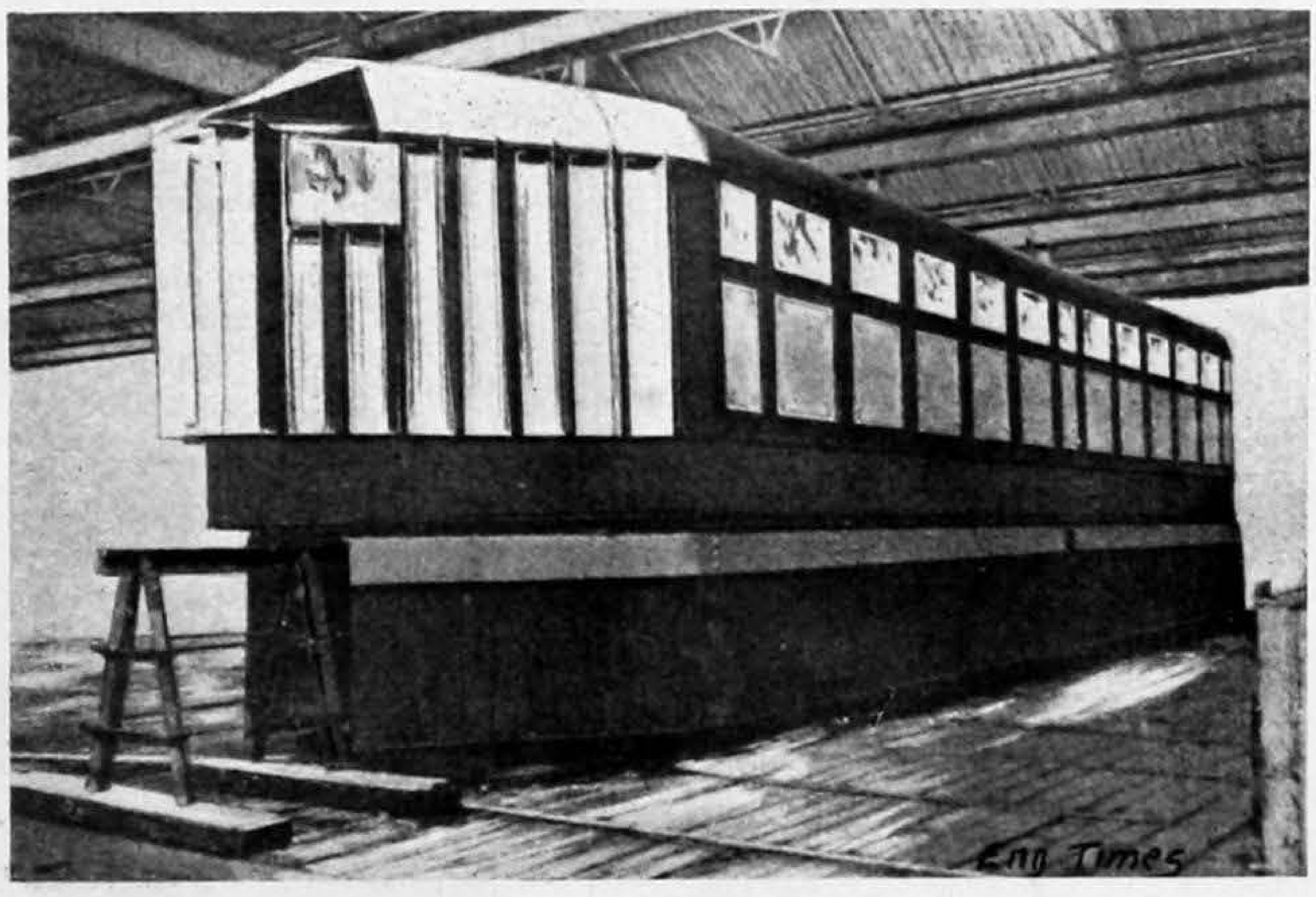
DETAILS OF LINE AND CONDUCTOR RAIL.

when open, these presented a large resistance to the air, and could be manipulated at will by the driver.

The interior of the car, with seating room for 100 passengers, was luxuriously appointed; the seats were upholstered, some in Utrecht velvet, some in Morocco leather, and the Royal Compartment was a perfect exhibition of the upholsterer's art. Each person had a separate seat specially arranged so as to avoid the slightest discomfort while passing round sharp curves. The electric current was picked up by insulated trolleys fixed to the bottom irons of the bogeys. Owing to the excessive weight of the car and also to the imperfect state of the generating plant, only a speed of 65 miles an hour on the curves was obtained during the exhibition.

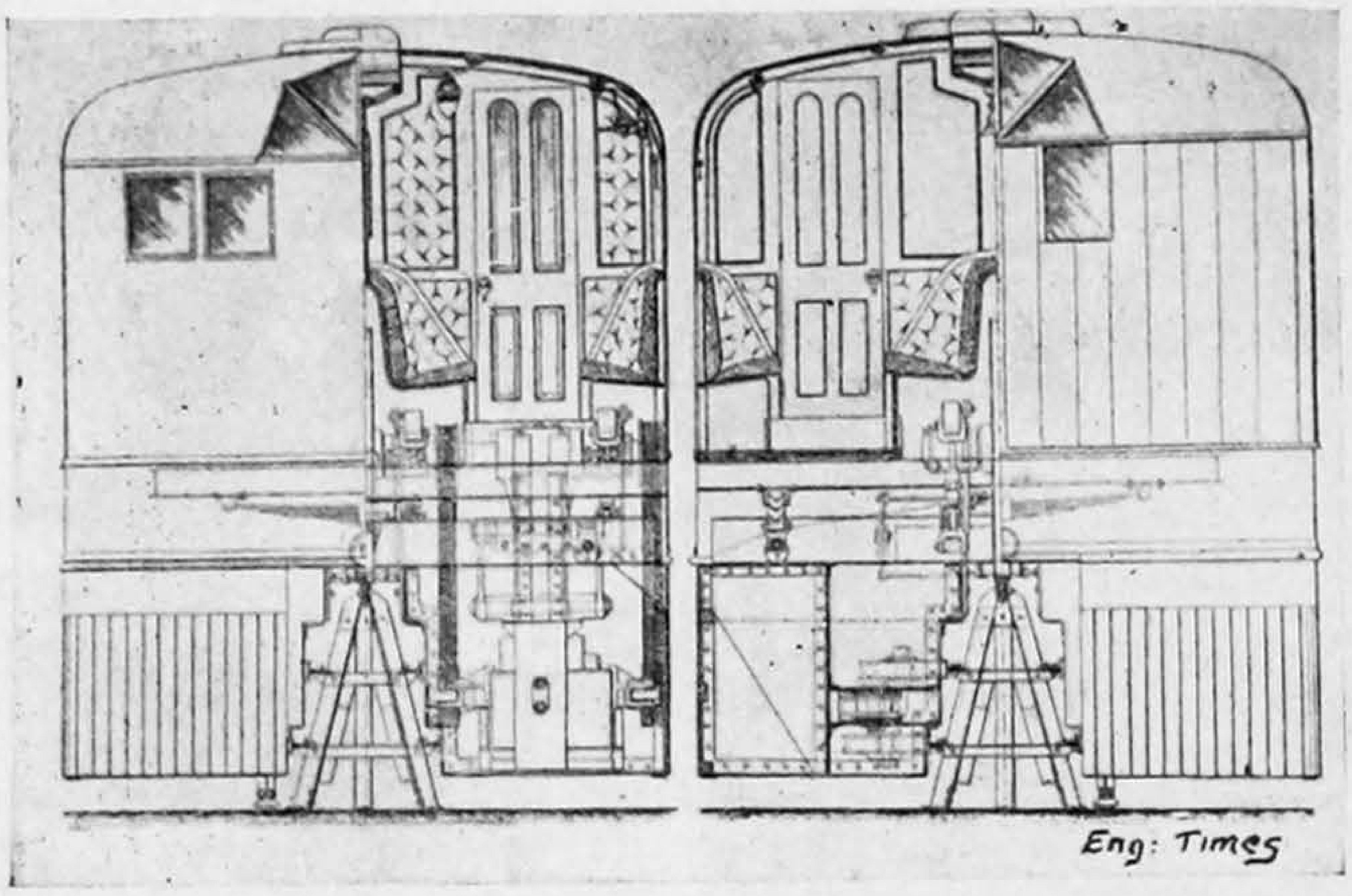
The whole weight of the car was distributed amongst eight double-flanged main wheels, $4\frac{1}{2}$ft. in diameter, that is, four wheels to each bogey; the centre wheels were driven, the two outers were leading and trailing respectively.

The car had pointed ends to diminish the air resistance, which, at high speeds, is no unimportant factor. The triangular spaces enclosed in these pointed ends were reserved for the driver and conductor. The driver had, under his hand, devices for starting, regulating the speed, and stopping. It was surmised that at a high rate of speed the ordinary friction brakes would be inefficient; this foreseen difficulty was obviated, however, by an ingenious device of the inventor. The bow of the car was provided outside with vertical louvre plates turning on spindles;



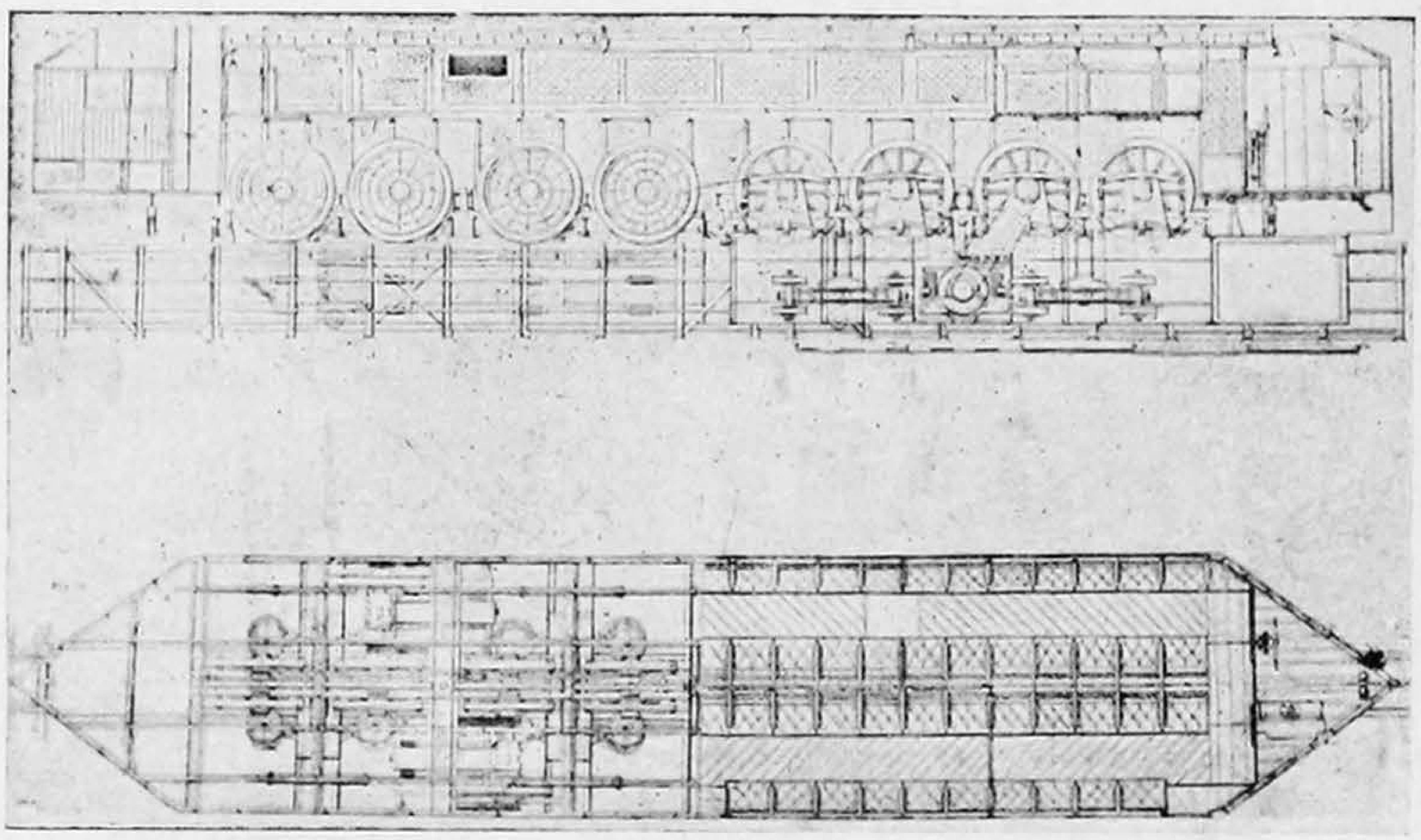
VIEW OF CAR SHOWING AIR BRAKE OPEN.

The engineers to the Belgian Government were so struck with the possibilities of the scheme if carried out under more favourable conditions, that they advised their Government to appoint a special Royal Commission, with the object of continuing the trials when the exhibition should be finished. In view of these future trials, Mr. Behr decided to profit by the experience gained during the first



CROSS SECTION OF CARRIAGES.

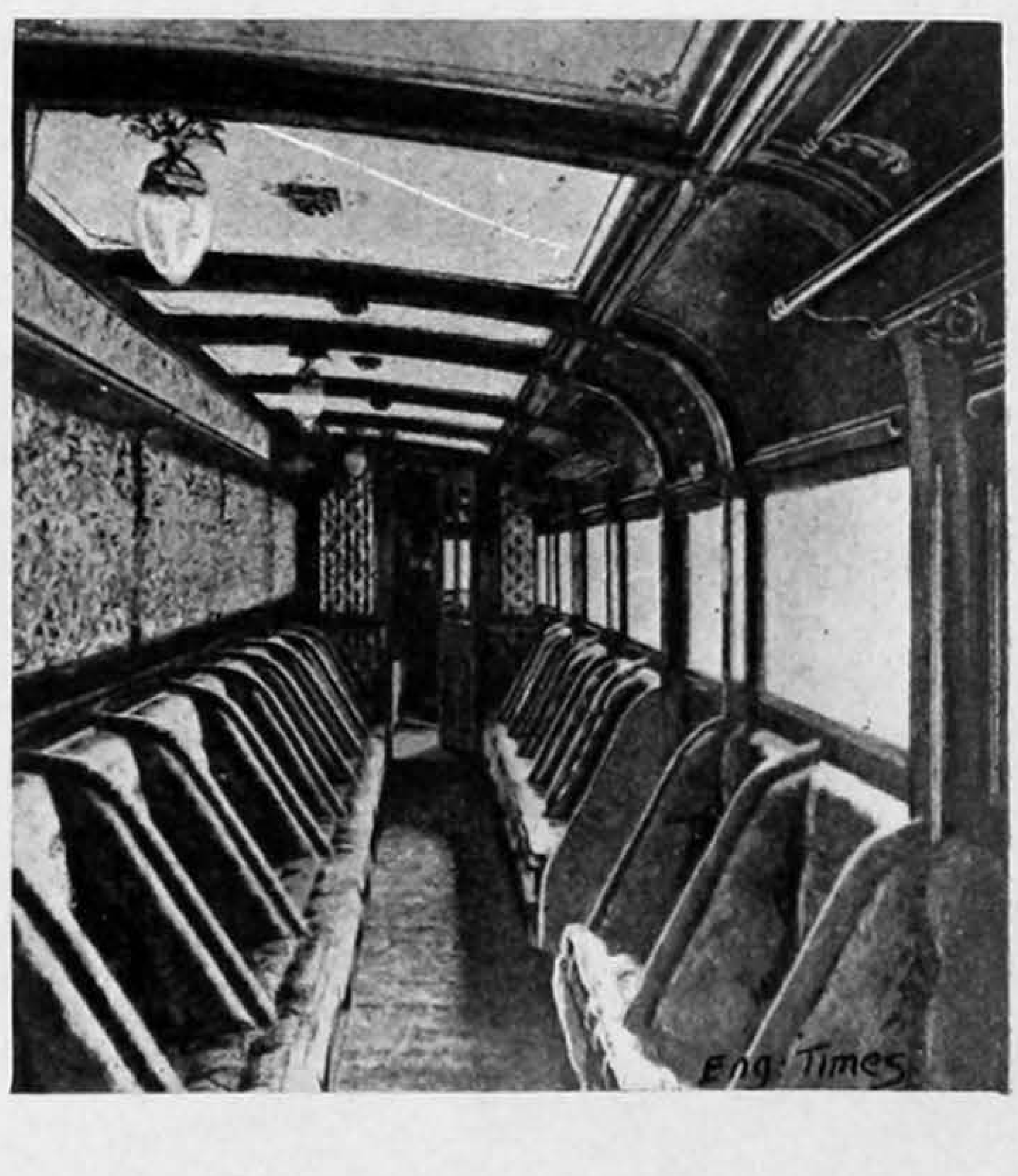
trials, and to partially reconstruct the car during the winter months. Trouble arose now in an entirely unexpected quarter. One stormy day in November the whole of the generating station was levelled to the ground, and while those in power were endeavouring to shoulder the responsibility on somebody, the whole of the valuable machinery was left exposed for weeks to the wind and weather.



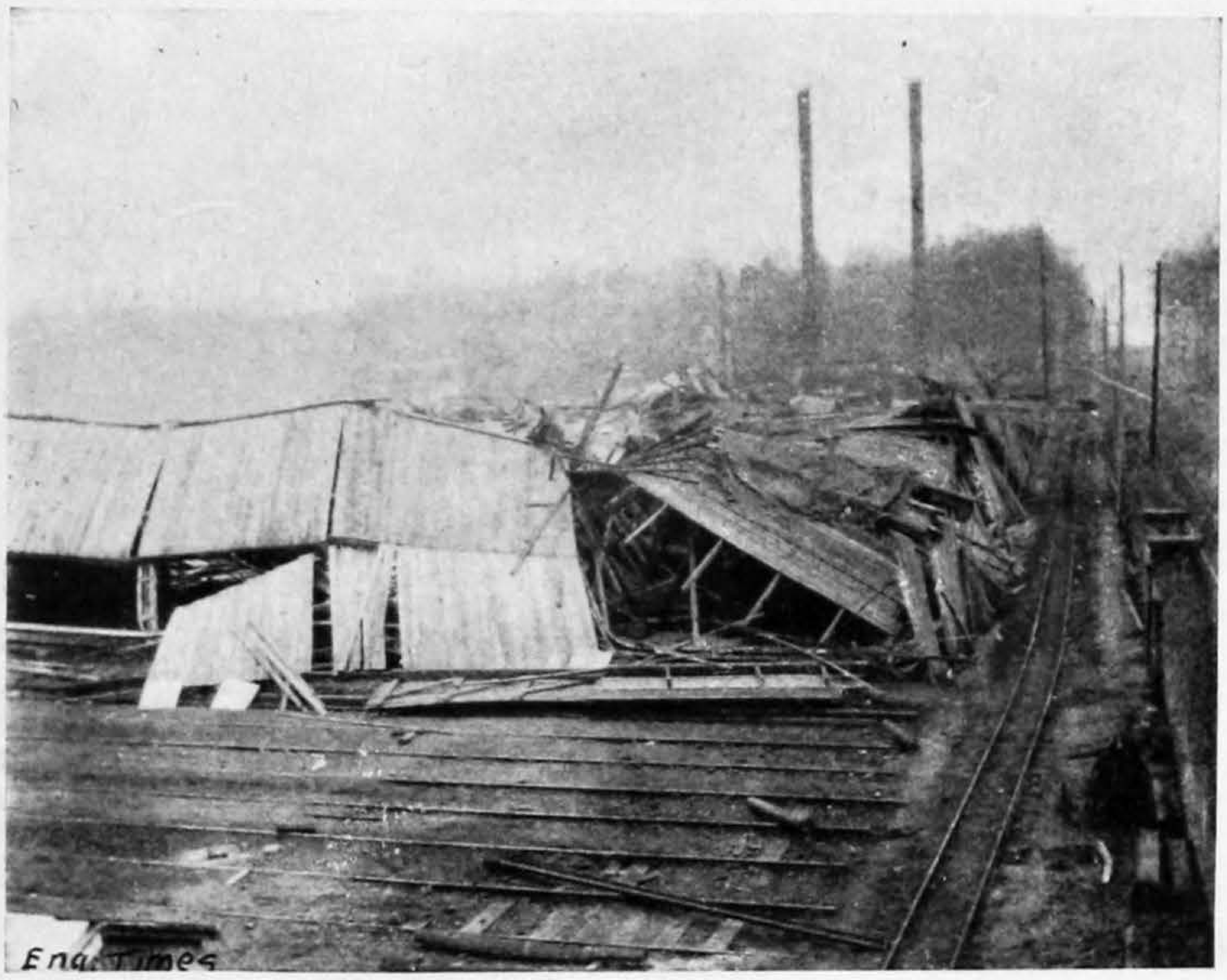
LONGITUDINAL PLAN AND SECTION OF CAR.

In April, 1898, all was in readiness again. The reconstructed car weighed about fifty tons, and took far less power to move it. The Belgian Royal Commission, with engineers sent by the Russian and French Governments, paid daily visits of inspection, and made an exhaustive series of experiments. Every possible measurement was taken—rate of acceleration, maximum speed, deflection of rails, etc.

Runs were made with half the guide wheels in action only, and even the car had to be divided into two parts and run half at a time. From this it can be seen that the tests were of a very severe character, and the several engineers expressed their highest satisfaction at the results obtained. The highest speed recorded officially was at the rate of 83 miles per hour on a curve of 540 yards radius. This was no mean result. Travelling at that speed the sensation was extremely pleasant, and there was a feeling of perfect safety. The absence of vibration or sway was remarkable The object of the



INTERIOR OF CARRIAGE SHOWING ARRANGEMENT OF SEATS.



VIEW SHOWING WRECK OF THE GENERATING STATION, BRUSSELS.

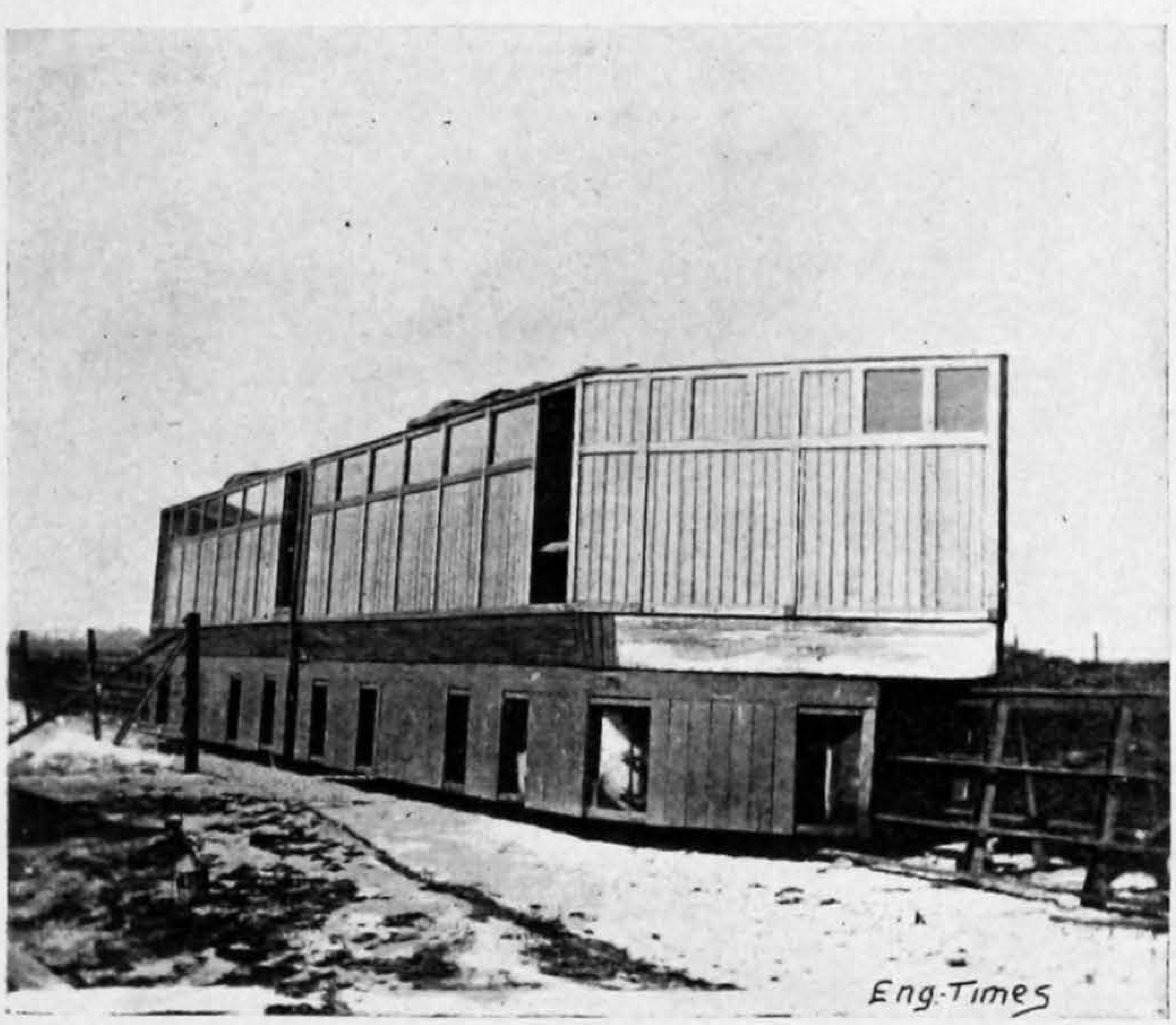
inventor is to use his system as an adjunct to existing trunk lines where very high speed is desirable. And there are several reasons which go to prove that the monorail system is the most suitable. Except on long straight lines, no train in England or America has ever approached the speed attained at Tervueren on such a severe curve. When Zipernowsky—a celebrated Hungarian engineer—proposed to build an electrical railway which would make Vienna about an hour's journey from Buda-Pesth, he designed a line built on special raised steel sleepers bedded in concrete, and no curve was to have a radius of less than 3,250 yards. His car was 130ft. long, with accommodation for forty-five passengers only.

In America an experiment has been tried on a bi-rail line with an electric car weighing 10 tons. The line was a closed curve, and at a speed of over 75 miles an hour the car simply jumped the track and was smashed into atoms.

The main driving wheels of a Monorail car, as well as the horizontal guiding wheels, being double-flanged, prevents any possibility of derailment; and the unpleasant effect sometimes felt when going round sharp curves (due to the super-elevation of the outer rail) on ordinary railways is not at all experienced, or is, at least, reduced to a minimum in cars on the new system.

Electric traction, which substitutes continuous rotary motion for the reciprocating movement of engine connecting rods, tends to lessen the chances of derailment.

A committee of enquiry has been for some time considering the feasibility of a Behr railway, for fast



SHEWING RE-CONSTRUCTED CAR WEIGHING 50 TONS.

express traffic between Liverpool and Manchester. Their report, which has only recently been issued, is favour-to the scheme. It now remains to get the necessary Parliamentary powers before things assume a practical shape.

The following figures show Mr. Behr's estimate of the cost of construction and equipment of the proposed Manchester and Liverpool line :—

	£	£
Iron work and permanent way	406,237	
Land and buildings ..	394,750	
Bridges and earthworks	63,000	
Laying of line........	20,659	
Stations	40,000	
Rolling stock	32,000	
		956,646
Contingencies, 10 per cent.	95,665	
Engineering expenses	60,000	
Patent dues..........	60,000	
Interest	45,000	
Parliamentary exs. ..	50,000	
		310,665
Cost of central station and cables		220,000
Total....		£1,487,311

F. Robins

FIG. 1.—THE CABLEWAY AT VAUXHALL BRIDGE: PASSENGERS TAKING A TRIP ACROSS IN THE CAGE.

THE DEVELOPMENT OF CABLEWAYS IN GREAT BRITAIN.

By JOHN M. HENDERSON, Junr.

NEVER has the conservative nature of the English business man been more strikingly illustrated than in his connection — or, rather, disconnection — with cableways. The advantages attending these means of transporting goods and passengers have been demonstrated so clearly during the past 30 or 40 years, that it is nothing short of astonishing that cableways have, until quite recently, made little or no progress in this country. In America they have been treated very differently. At the outset their labour-saving and time-saving merits were recognised and eagerly appropriated, but it is only during the past and present years that cableways have become serious factors in the equipments of English contractors, quarry-owners, etc. And there is little room to doubt

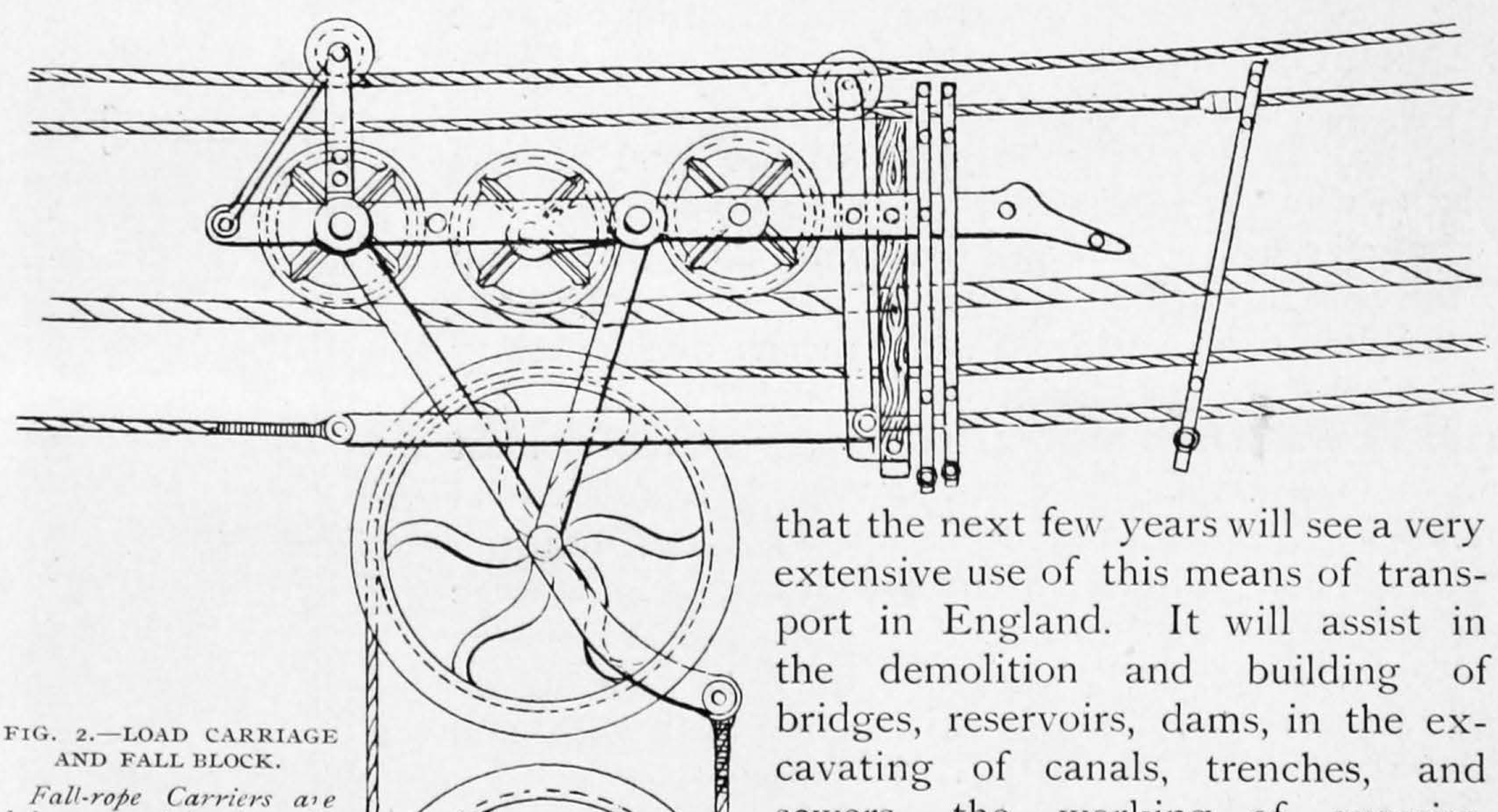
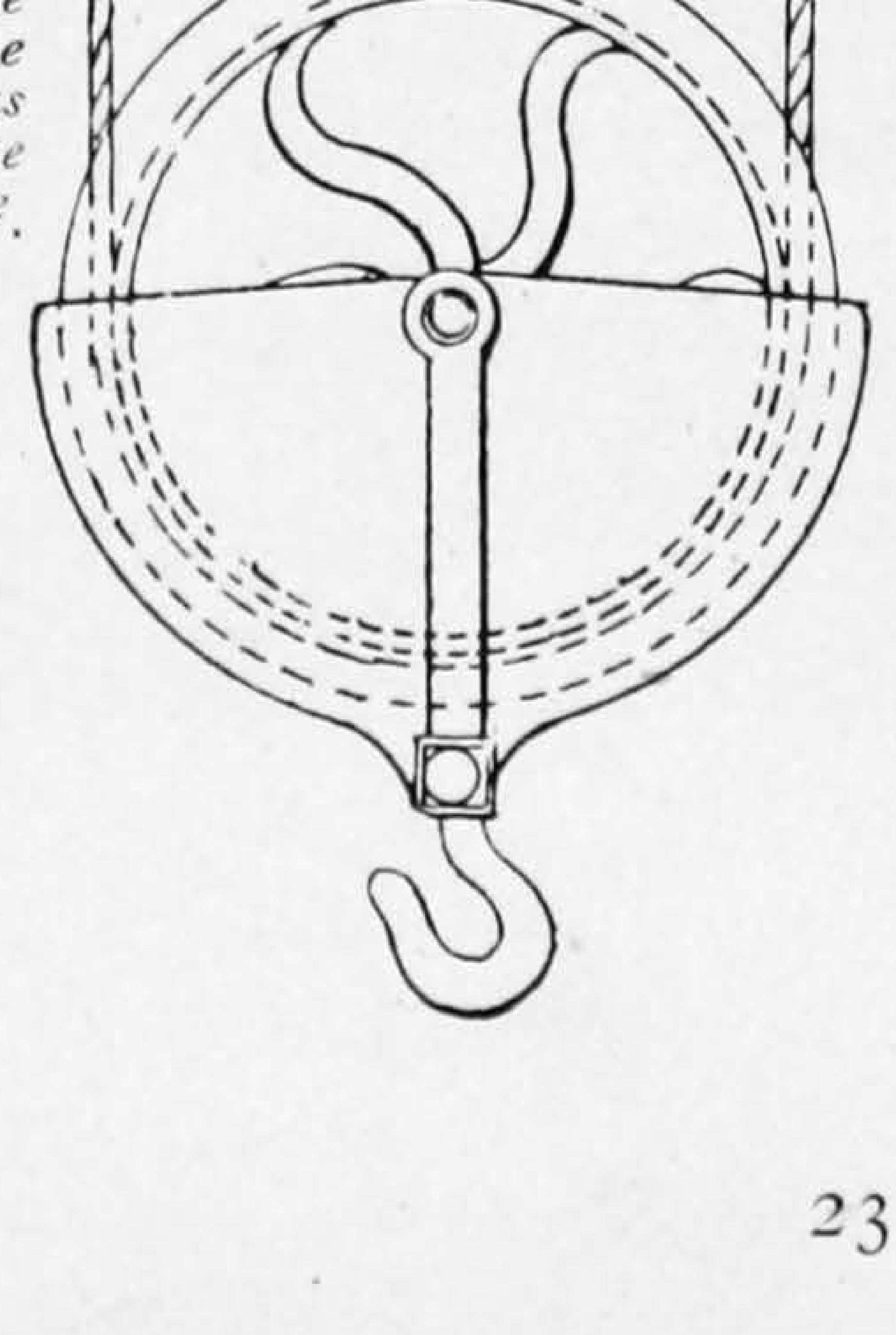



FIG. 2.—LOAD CARRIAGE AND FALL BLOCK.

Fall-rope Carriers are being carried by the "Horn." A carrier has just been displaced by the Button on the Button-rope.

that the next few years will see a very extensive use of this means of transport in England. It will assist in the demolition and building of bridges, reservoirs, dams, in the excavating of canals, trenches, and sewers, the working of quarries, mines, plantations, farms and factories, and it will revolutionise to a very considerable extent the methods of hoisting and conveying.

The first cableway to be used in this country was erected in a granite quarry in Aberdeenshire. Previous to this crude wire rope inclines were in use in the same undeveloped state in which they at present exist in some of the Welsh slate quarries, but they could in no way compare with the cableway as now constructed.

The writer has had considerable experience in the construction and erection of cableways, and deems it would be of interest to give here some particulars of a modern cableway, and of some erections carried out under his own supervision.

Fig. 3 is a diagram showing the construction and method of operating a "Henderson" cableway. The two drums A and B of hoisting engine are of the same diameter; the one, A, carries the hoisting rope, and the other, B, is made with a curved surface and carries the endless traversing rope. The endless rope is wrapped around the drum a number of times, enough to prevent slip in the opposite direction to that in which the drum is turning, thence it is led over the sheave pulleys 1, 2, 3, and 4, on masts, and attached to front and rear of carriage at C and D. The hoisting rope is led from drum, over pulley 5, thence by two, in the diagram three, falls to load. The endless rope serves to hold the carriage in place whilst the hoist is being made. For horizontal motion both ropes are pulled in or paid out at same rate of speed. The load may be hoisted or lowered at any point under the line of cable. The horizontal motion may be given to the load at any point to which it is raised.

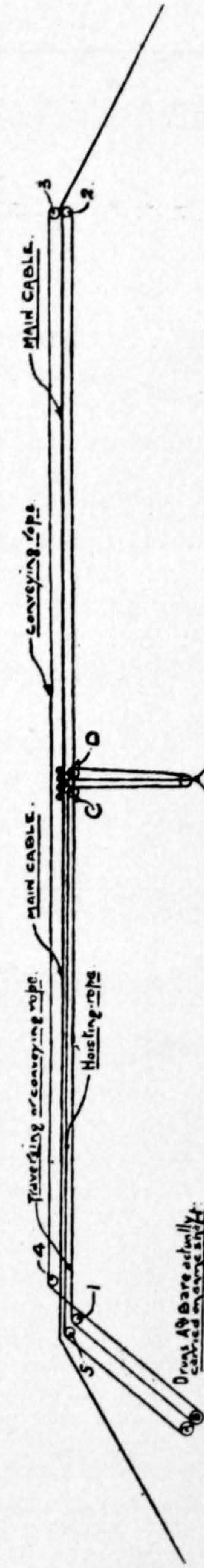


FIG. 3.—DIAGRAM SHOWING THE CONSTRUCTION AND METHOD OF OPERATING A "HENDERSON" CABLEWAY.

Many improvements and developments have led up to the cableway as now used. Long span cableways were impracticable without some means of supporting the hoisting rope, which, even in quite short spans, tended to fall slack between the pulley on top of mast and cable carriage. After various more or less successful attempts this has been overcome by using the fall rope carriers. These carriers are drawn out with the carriage by a horn (see Fig. 2), and each is stopped in its proper position by "buttons" fixed at intervals on the "button rope," which is hung parallel with and above the main cable.

Illustration Fig. 4 represents a Henderson double cylinder engine and winding gear, as specially designed for operating a 5-ton cableway of about 600ft. span. The engine cylinders are each 12in. bore for a stroke 20in. Drums, 66in. diameter. The speeds are, hoisting 400ft. per minute, of travelling 800ft. per minute.

An interesting piece of work recently carried out by my firm is shown in Figs. 1 and 5. It is a cableway erected to assist the demolition of the old Vauxhall Bridge. The span of the cableway

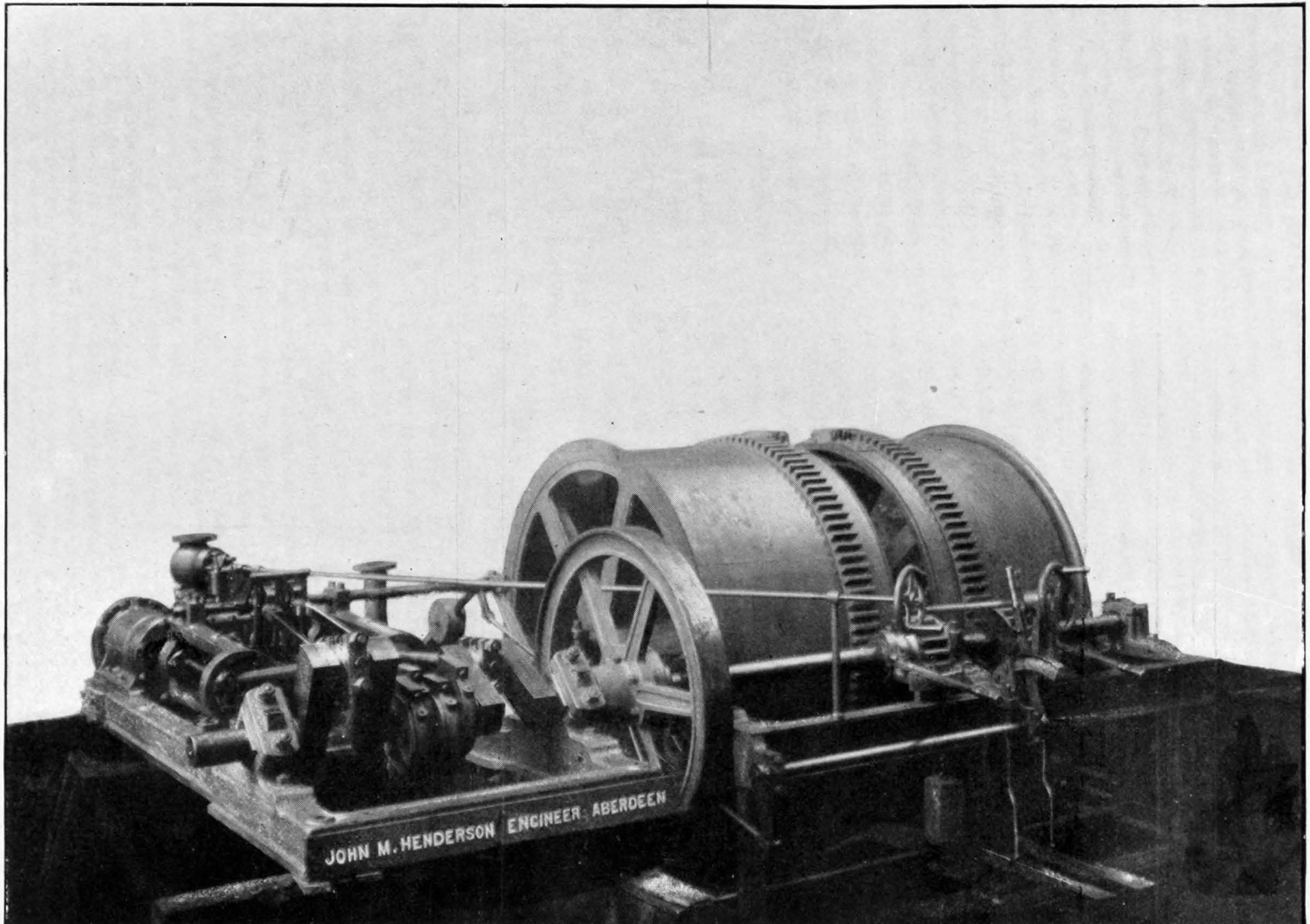


FIG. 4.—DOUBLE CYLINDER ENGINE AND WINDING GEAR.

is 932ft., and the masts on which it is supported are 77ft. high. The masts are constructed of timber of 24in. × 11in. rectangular section, and are each supported by five wire guy

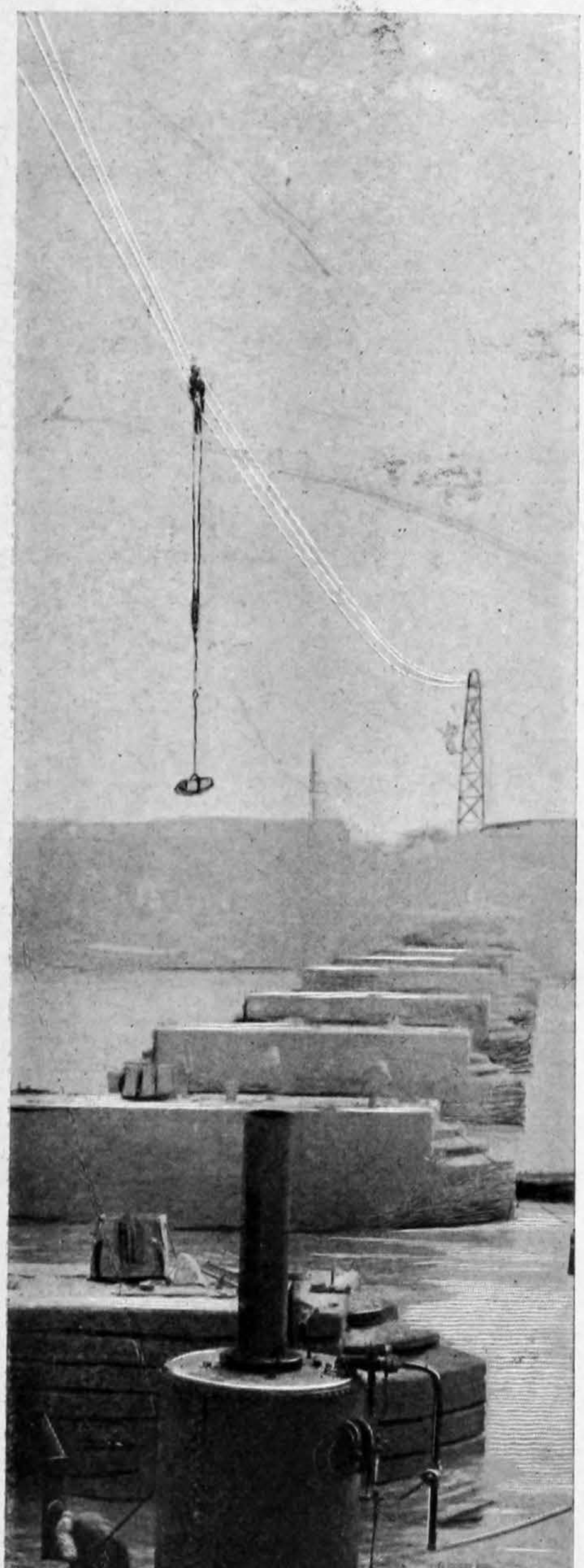
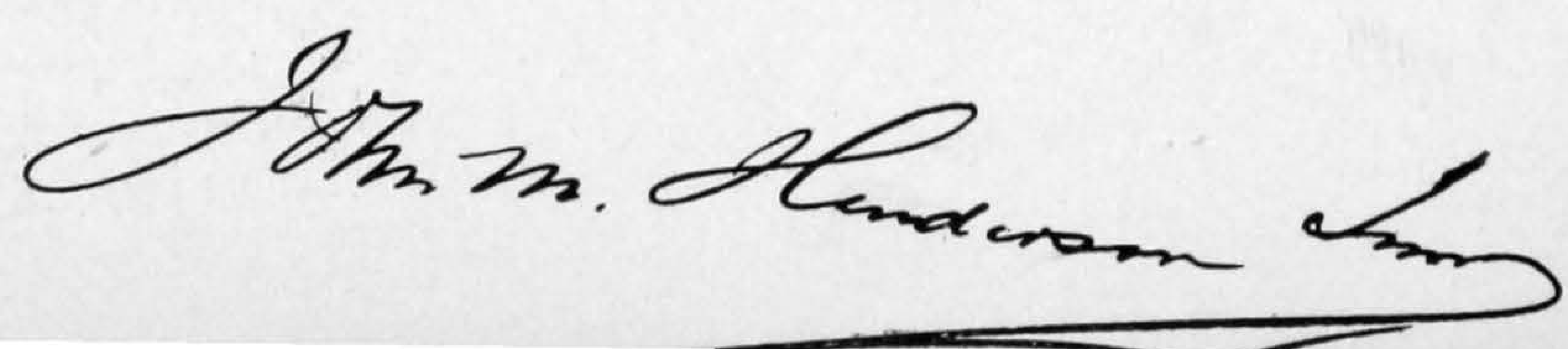


FIG. 5.—THE VAUXHALL BRIDGE CABLEWAY.

ropes, the main cable in each instance being anchored to a concrete block. The main cable on which the carriage runs backwards and forwards is $6\frac{1}{2}$in. circumference. The hauling engine, situated on the Middlesex side, has separate drums for traversing and for lifting. Engine cylinders, each 11in. × 21in.; drums, 66in. diameter. The ropes pass from these drums over corresponding drums, carried by a countershaft at the base of the mast shown, and thence over the pulleys at the top. The pulleys on the countershaft are 5ft. in diameter, and three in number—two for the endless traversing rope and one for lifting.

The cableway takes the place of gantries, posted up and strutted from the river bed, and carrying travelling cranes, and it has been found in practice that this cableway has done the work of eight or nine of such cranes.

In conclusion, I will put, in a few words, what I consider to be the particular advantages of the cableway :—It can raise and deposit the material being dealt with on both sides of the excavation or works; it can be more economically constructed than any other machine of like capacity; it is portable, and can be moved at very little expense; it saves the cost of sledging and blocking in quarries and mines, as large masses of material can be put into the skips or slung by chains; $33\frac{1}{3}$ per cent. more material per man can be loaded into skips than wagons; in quarries and in mine excavations the skips can be loaded at any desired point, whilst if wagons be employed, after the material nearest the wagon has been loaded, the other must be carried 10 or 15 feet, or cost increased by laying track; there are no vital parts in the construction which would cause delay for any length of time in effecting repairs; very little labour is required to operate the machine, making it possible to do night work economically as compared with other methods



HENDERSON INCLINE CABLEWAY, STONEY STANTON, LEICESTERSHIRE. SPAN, 495 FT.; LOAD, 3 TONS.

LIMITATIONS TO HEIGHT OF BUILDINGS.

By ROBERT S. BALL, B.Sc.

THE visitor to America, whether he be a civil engineer or not, cannot fail to be impressed by the height of the office buildings in the downtown districts of some of the cities of the west. A walk down State or Dearborn Streets, Chicago, or Broadway, New York, will reveal to him some truly astonishing samples of architecture, or to be more correct, of civil engineering, for as far as æsthetics or architectural beauty is concerned, he will be grievously shocked, and perhaps it is more correct to assign artistic qualities to the architectural profession, and leave the structural problems to the civil engineer ; moreover, the construction and design of these huge piles lie well within the domain of civil engineering, and the highest skill of the profession has been expended on their design and erection.

Our imaginary pedestrian will fancy himself at the bottom of a mountain gorge, and instead of cliffs towering up on one side and the other, he will notice vertical walls of brick, stone, or terra cotta, dotted over with symmetrically disposed rows of windows, row upon row, until a projecting cornice marks the summit, and the observer experiences a sense of relief when his eye has seen the last of the bare wall, only broken by the openings for lighting the interior. If he stops to count the stories by selecting a vertical row of windows he will find sometimes that the fingers of both hands twice counted will be insufficient to bring him to the end, and that there are several more stories to complete the sum. It is safe to suppose that each story is twelve feet, this means a total height of 240ft. for a building of twenty stories, and two such buildings, one on each side of a street 80ft. wide, make a cross section but little different in proportion from a narrow highway in an Arabian town bounded on each side by houses of moderate dimensions, the inconveniences, however, arising from such proportions are happily not as great in the one case as the other.

Though structures of twenty stories are not numerous enough to make a continuous line of buildings of that height, many office buildings in the congested centres of American cities are between fifteen and twenty stories along streets where the old style of architecture has given place to the new work of the civil engineer, where real-estate values are high, and the demand for offices or commercial rooms is such as to supply tenants for the hundreds of rooms which the modern office building contains.

The limitations which prohibit the extension of buildings of this kind skywards may be divided into two classes, those which pertain to the financial or commercial side, and those which have their origin in the constructive or engineering questions to which large buildings give rise, with which are associated the conditions of safety to life and limb within and without the building, the danger of fire and facilities of escape therefrom, and other questions of a like character, which find expression in most municipal building laws and regulations.

Some of the largest of these buildings in the American cities have been failures from a financial standpoint, the returns on the enormous capital invested not being sufficiently large to justify the expenditure. The expenses of maintaining buildings of this character are very large, and unless divided up amongst many tenants will prove to be too heavy to bear. The Masonic Temple on State Street, Chicago, for instance, of twenty-seven stories, is in itself a small-sized town, provided with an elaborate sewage system, elevator system, water works, electric lighting and power plant, and heating apparatus, for the icy winter winds off Lake Michigan penetrate even the double windows of exposed buildings, and a very efficient heating system is needed to keep the rooms at a living temperature, especially those on the upper stories exposed to the full sweep of the winds. The fact that it is difficult for the owners in some localities to find tenants for the rooms in the upper stories, and that the rent for these rooms has been lowered to a point of doubtful profit, suggests that from a financial point of view the limit has been reached. The tendency for business men to flock to one locality in American cities to facilitate intercommunication, and to condense into a small area what in European cities is spread out, added to the disposition of owners to make the real estate yield as large an income as possible, is responsible for the enormous growth of this species of architectural engineering. The argument that the limit has been reached in consequence of failure to let upper rooms is not wholly valid, for doubtless time will overcome the dislike of many for having their offices on high, and the pressure for space will force them into rookeries which they now reject as being too far out of the world of commerce, and too far from the busy haunts of men. The structures of more moderate height, as such go—from ten to fifteen stories—are generally well filled, and, if in a favourable locality, are good paying investments. They were not so at first, but necessity has overcome prejudice to a great extent, and doubtless will have the same effect on buildings of greater height. It is not, therefore, possible to assign a limit to the height on such grounds as these, for it is possible with present values to rent rooms at a fair price and for the landowner and capitalists to make encouraging returns on their investments. Leaving out of the question such objections as the above, and assuming that rooms can be rented up to the top floor at a price which will not drive men out into the suburbs of the cities where land is cheaper and rents are less, let us see what other considerations are left in the enquiry. It might be suggested that public feeling against the architectural destruction of the business districts of the city would be a safeguard against the erection of buildings which can only be compared to mills and factories in this respect, but such sentiments, if they existed, would have made themselves felt before through municipal regulations prohibiting the erection of such monstrosities, and the fact that they are still encouraged shows the preponderating influence of utilitarian claims over mere questions of taste. It is a difficult if not wholly impossible thing to render high buildings pleasing to the eye and possessing architectural beauty. When compared to the area on which they stand they assume shaft like proportions, and the principles on which they are constructed do not permit the employment of any order of architecture, and outward adornment or embellishment seems to relieve but little the harsh outlines of their lofty sides, and in most cases no attempts of this kind are made. The portals are often handsome and some of the interiors exquisite. The richest work of the decorator may be seen in many, and the materials of the finest marble and most costly metal work, a striking contrast to the exterior.

It has been said that for structural reasons it will be inexpedient to build much higher than some existing examples, but while the difficulties of design and construction are increased with every additional foot in height, there is yet ample room for increase without endangering the safety of the structure or overstepping the bounds of good engineering, but the limit of economy would be reached long before any such technical considerations would weigh heavily, the limitations are therefore imposed by a combination of constructional and financial considerations leading to the most economical result. A structure like the Eiffel tower would be very wasteful if provided with offices from top to bottom, and yet from a purely engineering point of view would be pronounced a success, for it is perfectly stable and capable of resisting the highest wind.

We have not yet, even in the highest buildings, approached the limit of compressive stress which divides absolute safety from uncertainty. The steel columns on which the great system rests are strained to a small fraction of their ultimate strength, and such care provides a wide margin for contingencies which arise during the life of any structure. The highest wind acting on the enormous broadside is provided for in the design and eccentric loading, or the loading of one side of a column to the exclusion of the other, is met by increased section of metal to compensate for the severe strain to which engineers are aware that such members suffer under conditions of this kind.

The cheapest brick would resist crushing under a uniform column of eight hundred feet high of the same material, and inferior granite would sustain a column of four thousand feet without giving way. When we come to steel, we find that a column of uniform diameter three miles high would resist crushing if made of the poorest product of the open hearth furnace when the effect of bending is neglected, so that, though the columns and walls of a building transmit the floor loads, in addition to their own weight, to the foundations, we need have no apprehension concerning the materials which the builder of to-day has at his disposal. Structural steel, never so cheap as at the present time, forms the basis of these large structures, and to the great skeleton of this material is attached the external coating of terra-cotta, brick, or stone, which hides the real and essential part of the structure, and gives it the appearance of being wholly the work of the mason or bricklayer.

The foundations for such buildings require more than a passing notice, for sometimes the inability to obtain adequate bearing power from the soil of the locality has had an influence in shaping the size of the structure, and the engineer has to give this part of his work much careful consideration, and often take great chances besides. The bearing power of the soil is a matter of much uncertainty, and can only be determined approximately by the exercise of judgment. In some places it has been found necessary to drive thirty foot piles two deep, making a depth of 60 feet from the bottom of the lowest pile to the grillage of steel rails laid in concrete which surmounts the piling, and on which the columns rest. The skill of the engineer lies in so disposing the loads on the foundations that equal settlement shall take place over the whole structure, for to avoid settlement altogether is an impossibility. The very serious nature of unequal settlement can be appreciated when the height of the building is considered, a fact which renders it imperative that special care shall be taken with the foundations. Such difficulties as these have been successfully overcome, and there is evidence from experience to sustain the belief that no special difficulties of this kind would threaten the engineer if he were to carry his buildings further upwards, and that these troubles, which he has so successfully defeated would, though augmented, yield to the exercise of his skill. Other considerations of an economic kind would thrust themselves into prominence before we would be seriously affected by structural difficulties such as these, but let us see what they are.

The problem of transportation of people to and from the ground floor to their offices throughout the building confronts the designer at the outset of his work, and is one of pressing importance. A building of twenty stories with fifty offices on each floor (and some of the high structures exceed this moderate number) will contain not less than one thousand persons, and for which means must be provided for carrying them up and down between the street and the floor on which they do their business. In addition to the tenants there is a constant stream of busy, hurrying men and women entering and leaving the building, all of whom have to be carried aloft also, for some of these buildings contain offices and show rooms continually visited by customers. It is rare that any one of these makes use of the staircase—time is too precious, and climbing up to great heights too fatiguing even for the young and strong. All take their places in one of the great elevators, and in a short time are landed at the desired floor by the silent car, which moves at a pace too fast to allow the man who for the first time is experiencing the sensation to be entirely at his ease. Thus the system of elevators is a very important part of high-building economy, and it would be impossible to find tenants for rooms without an adequate means being provided for reaching them from the ground. To facilitate traffic and make the journeys as expeditious as possible, various devices, not unlike railway regulations, are resorted to. Certain cars out of the whole number which comprise the elevator system are express to the tenth floor, and stop at all floors above the tenth; others are specially set apart to deposit and take up passengers between any floors from the ground up to the tenth; extra accommodation is provided during the hours of the day when the traffic is heaviest, as in the morning and evening and at lunch-time, by operating more elevators to assist in disposing of the the crowds of people who push and scramble for room when the attendant opens the door to deposit and receive passengers.

The area covered by the elevators necessary for an adequate system in the sky-scrapers as are seen in Chicago is by no means a small proportion of the entire ground plan, and the higher the building on a given area the greater is the number of elevators necessary, for the system is unlike a railway in this respect that increased traffic on the latter can be met by the simple expedient of running more trains, while with an elevator system increased capacity means additional shafts, for the speed of the cars cannot be materially increased beyond what is now considered safe, and even if it were the time expended in stopping, starting, loading, and discharging is the greater part of the time consumed on the journey. A glance at the ground plan of one of the large buildings will convince one that this is a real difficulty towards extension, or, as some might say, a blessing in disguise, for the high value of the property on which such buildings are erected will prevent the utilisation of ground space for elevators which would be available for rooms if the necessity for the elevators were absent, and the cost of operating an elaborate system of machinery would be saved. To recapitulate, it would seem that this problem of transportation is the one above all others to be studied by the engineer who wishes to build loftier structures than those which hold their thousands of busy workers in the great cities of the United States, and which have no parallel in the older cities of Europe.

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