INSTITUTION OF ENGINEERS IN SCOTLAND

WITH WHICH IS INCORPORATED THE

SCOTTISH SHIPBUILDERS' ASSOCIATION.

TENTH SESSION 1866-67.

Introductory Address. By Mr. J. G. LAWRIE, President.

Read 31st October, 1866.

GENTLEMEN,—In resuming business this session we have reason to be encouraged to continued industry by the success which attended our labours last session.

During last session we had papers on the strength of materials that are extensively used by engineers; papers explanatory of certain ingenious mechanical contrivances; papers on the propulsion of ships; papers on the mode of perfecting the action of certain tools and instruments; papers on the strength and construction of ships, both iron and composite; papers on the construction of ships with reference to sea-worthiness; papers on new applications of iron, and on the most efficient mode of using iron in various structures; papers on the policy of certain laws affecting shipping property and those who use it; and besides, papers on various other subjects.

The papers on these subjects, and the discussions which followed were of great value to the engineer. Throughout these papers and discussions the desire plainly was to treat the subjects both practically and scientifically, and to consider them in a way dictated by a knowledge of principles rather than empirically. Several of the subjects of these papers were of singular interest and importance. Of these there is perhaps no subject that better merits the attention of such institutions as this than the construction of ships in respect to sea-worthiness, and we have reason to be gratified with the reception that our views on this subject received in the most influential quarters. Our attention was particularly drawn to this subject by the recent occurrence of disasters at sea, attended with the most lamentable results in the loss of human life; and the views which we persistently advocated to the Government in a contemplated change of the Board of Trade regulations, would certainly have already become law but for the change of Ministry at the time. The delay will, however, we believe, be only temporary.

We trust that by continued perseverance during this and future sessions the proceedings of this Institution will ever be of equal interest and utility; and that an important object of the business of this institution will always be to trace the relation of practical mechanics and scientific principles, and to investigate in what way the operations of the engineer can be advanced by the application of pure science, so that in the performance of the work which he seeks to accomplish his progress may be the result of an intelligent application of Nature's laws.

The progress of scientific engineering has of late years been rapidly extending, and has received during last summer a most signal illustration in that great work, the Atlantic Telegraph Cable. The accomplishment of this work, the construction and the laying of the cable, required a greater breadth of scientific engineering than any other that has, perhaps, ever been performed. The design of the cable required an extensive acquaintance with the principles of that subtle and powerful agent electricity. The construction of the cable required an experience, the result of many years' practical study, at an expense measured by millions sterling; and the task of laying the cable could not have been accomplished at all without the assistance of these powerful machines, steam ships, which involve a knowledge of the principles of steam. Thus, without a knowledge of the principles of electricity, without a knowledge of steam, and without a mechanical ability to carry into effect the requirements of these scientific principles, the electric cable could neither have been made, nor could it ever have been laid across the Atlantic. No engineering work has certainly ever been performed of a higher character, not only in the result sought to be attained, but in the means employed for its attainment. To recapitulate the process and progress through which this great work has been accomplished is unnecessary in this place, as scarcely anything can be added to the copious information on the subject supplied in the public prints. Familiar as we are, however, with the various steps through which this work has passed, and simple as they now appear, no words can express the wonderful nature and the wonderful advantage of the results which this work is destined to confer. Wherever and whenever the action of mankind is based upon information possessed, the means by which distance—the impediment hitherto to the transmission of information—can be eliminated becomes of paramount importance. No man can be engaged in the business and pursuits of life without desiring at times expeditious communication with those at a distance, and by the electric telegraph a correspondence amounting to a conversation is easily effected with an economy of time that it is impossible to calculate. The electric telegraph not only quickens the steps of events by quickening the transmission of information, but introduces at the same time an altogether new and in a sense opposite element in the progress of events, by arresting as it were their passage, which but for the telegraph would have gone out of reach before they could be otherwise utilised. This compound advantage of the telegraph obtains in the whole intercourse of the human family. Events are not only hastened by its means, but, by the more perfect information it gives, other events are crowded forward, for which no motives would otherwise have existed.

The success, both physical and commercial, that has attended the Atlantic cable, puts it now beyond a doubt that all populous places on the globe will very shortly be within almost instant reciprocal communication.

Such is the memorable result attained in this the greatest effort of scientific engineering in modern times. Other recent illustrations, however, are not awanting to show the services rendered by science to the engineer, and of these in the instrument which has recently received so much attention, and which is now popularly called the needle-gun, these services are prominently apparent. The transition in point of utility from the muzzle-loading flint-gun to the breech-loading needle-gun is scarcely less than from the stage coach to the railway train. The stage coach is of no use whatever when within reach of a railway train, nor is the flint-gun of any greater value in comparison with the breech-loading needle-gun. Upon the railway train depends almost the existence of modern commerce, and upon the needle-gun depends to a considerable extent apparently the fate of modern warfare. The effectiveness of the British needle-gun depends upon the efficient breech by which breech-loading is rendered satisfactorily attainable; it depends also upon the construction of the cartridge, which is made to explode by a part of the end being indented; and it depends upon the coating of the cartridge which prevents the fouling of the barrel. In this cartridge no opening in the case is necessary for the explosion to be produced, but simply that a part of the case be indented inwards, and hence the certainty of the explosion when desired. In other cartridges, as in that used in the well-known Prussian needle-gun, the cartridge case requires perforation, which opens the way for the admission of moisture, and introduces uncertainty in the explosion. For the production of this gun—the British needle gun—the services of the scientific engineer are indispensable to elucidate the construction of the barrel, the construction of the bullet, and the construction of the necessary cartridge, without which efficiently constructed the barrel and the bullet, though perfect in themselves, would be wholly a failure. The rude instrument by which a bullet may be thrown by the explosion of gunpowder is a very different one from the British breech-loading needle-gun; in the latter, the rifle barrel is a highly ingenious contrivance to give the bullet a rotation round a longitudinal axis, in order to prevent rotation round any other axis which would cause the bullet to deviate from a direct path, or rather from a perpendicular plane passing through the bore of the barrel. The construction of the bullet, having its centre of gravity properly situated in relation to its figure, is no less essential in order that the bullet may travel in the proper trajectory, with a minimum disturbance from the action of the atmosphere. The construction of the cartridge, by which the explosion being effected without perforation of the case, and without external fire, is of paramount importance, in order that the action of the gun may be independent of the weather or moisture. The coating of the cartridge, which is contrived to prevent the fouling of the barrel by the passage of the bullet or by the explosion, is essential in order that the gun may not become useless in action; and, lastly, the gunpowder—both that which projects the bullet and that which produces the explosion—have all been subjects of scientific investigation, and the results of scientific knowledge.

Another illustration of the services rendered by science to the engineer exists in the modern improved steam-engine. Great as were the advantages derived from the original form of the steam-engine, in which the same vessel performed the duties of steam cylinder and condenser, it is nevertheless an instrument immensely behind the modern engine. The invention of a mechanical prime mover, which should be independent of the action of the wind, and which, not being fettered to situations where falls of water existed, could be placed anywhere and extended indefinitely, possessed plainly advantages wholly unattainable without such a prime mover, and was therefore fitted to produce an entire revolution in operations dependent on the exertion of dynamic force. Beyond the applications falling within the scope of a prime mover, such as the original form of steam-engine, there existed even a wider range to which such a prime mover could not be profitably applied, and which consequently were as entirely shut out from that class of prime movers as if it had not existed. For these, the more perfect instrument in the modern steam-engine is peculiarly adapted. In steam navigation, for example, the improved steam-engine is rapidly becoming indispensable. For that purpose the difference betwixt an engine which uses 4½ lbs. of coal per horse power per hour, and one which performs the same work with 2 lbs., is so great that in many cases while the one is very much what the circumstances and conditions, require, the other is absolutely worthless. With the former the expense of the fuel would alone in many cases be a bar to its use; but when to the expense of the fuel is added the incompatibility of burning 4½ lbs. of coal per horse power, with the requirements for carrying cargo, the application of such a prime mover is wholly out of the question, and brings into prominent contrast the advantages of the latter. And these advantages are most prominently services rendered by science to the engineer. The advantages obtained by expanding the steam, the advantages of surface condensation, and the advantages of moderate superheating, which constitute the improvements of the modern steam-engine, are due altogether to the scientific engineer. No one of the three has been the result of accidental observation, but has been due to elaborate and patient investigation. It is true that the amount of advantage derived from any one or all of these improvements has not yet been by common assent definitely ascertained, the experience of different engineers showing different results, arising, probably, to a large extent from inaccuracy of observation, and also to the different modes by which the advantages are sought to be arrived at. While, however, these different results are being discussed, questioned, and not unfrequently discredited among the doctors, the users of the steam-engine, the public, are plainly in practice answering all doubts by a steadily increasing demand for the improved steam-engines, showing that, although different forms may yield different amounts of advantage, they all, in every practicable form, yield results of sufficient advantage to induce their extended application. The progress made by these improvements points palpably to the time, and at no distant period—within, probably, fifteen or twenty years—when in steam navigation, for every work, except it may be the shortest coasting voyages, the injection condensing steam-engine will be entirely obsolete. On a vast variety of stations the question is not one with a consumption of 4½ lbs. of coal per horse-power of more or less profit, but it is whether there is to be or there is not to be steam navigation at all, and the advantages of steam navigation compared with sail navigation are so tangible and so great as to insure the unremitting attention of engineers to the entire removal of the remaining difficulties in the way of the improved steam-engine. The great ocean race from China, which has received so much notice within the last few weeks, and which reflects so much credit on the shipbuilders of this neighbourhood, whom we are proud to number in our list of members of this Institution, will undoubtedly, in a very few years, lose its prominence, and be eclipsed by a race of far higher speed.

The great and prominent improvement in the steam-engine, as applied more particularly to steam navigation, is the economy of fuel, and without that improvement all the others that have been made would have been worthless, but with that improvement others have been of immense value, as in the change from the paddle wheel to the screw propeller. For many services, the paddle wheel was a most clumsy, inconvenient, and undesirable mode of propulsion. For all services, except, as yet, in shallow water, the screw propeller is nearly all that can be desired.

Recently, however, a method of propelling ships by the reaction of water issuing from turbine water wheels, now commonly called the Ruthven mode of propulsion, has been revived, and has lately been tried in one of her Majesty's ships called the *Waterwitch.* This method of propelling ships is not without advantages peculiarly its own. For example, in many ships, and perhaps in all, the great power which a ship so fitted possesses in discharging an immense quantity of water, the result, it may be, of a leak or injury, is of no inconsiderable importance. Probably, a facility of manœuvring a ship so fitted is another advantage. But there are no good grounds for believing that this mode of propulsion will be more economical in the application of dynamic effect or power, or in fuel, than the screw propeller, nor even that it will be so economical. In a comparison of the two modes of propulsion, there are three elements which fall to be considered:—

1st, The consumption of the power of the machinery due to the friction of the propelling instrument.

2d, The consumption of the power of the machinery due to that part of it which is carried off by the water projected from the ship.

3d, The consumption of the power of the machinery due to the propulsion of the ship, or that is developed in the propulsion of the ship.

To compare minutely the friction in the two methods, it would be necessary to know the surface, in each case, of the propelling instrument; in the one case the surfaces of the screw propeller, and in the other the surfaces of the turbine wheel and the surface of the water passages. Even, however, without these measurements, it is plain that the screw propeller has the advantage to a large extent in this respect. The surface of the propelling instrument itself is manifestly in favour of the screw propeller, and the loss arising from the friction of the water in the water passages with the turbine wheel has no counterpart at all with the screw propeller.

With regard to the consumption of the power of the machinery in that part of it which is carried off by the water that is projected from the ship, it is to be observed that with the screw propeller, if there be a sufficient number of blades, the whole water in the cylinder, of which the diameter is the diameter of the propeller, and the length the speed or space passed through by the ship, is driven off with a certain speed which measures the reactionary power obtained in that way for the propulsion of the ship. If this cylinder be reduced in diameter the water must be driven off with a higher velocity to maintain undiminished the reactionary power derived from that source; and, inasmuch as the power carried off by the water and wasted not being developed in the propulsion of the ship increases as the square of the velocity, plainly the higher the velocity with which the water is projected from the ship the greater the power carried off to waste. Consequently, in this respect the turbine wheel plan, adopted in the *Waterwitch*, in which the discharge orifices are of small dimensions, comparatively, and, therefore, the velocity with which the water is projected necessarily considerable, is inferior to the screw propeller.

With respect to the consumption of the power of the machinery due to the propulsion of the ship, it is to be observed that with the screw propeller the power of propulsion is derived from two sources—the one being the reaction due to the water which is projected backwards from the ship, and the other due to the reaction of the water in having imparted to it the velocity with which it is projected from the ship. For example, suppose the ship be propelled through the water by a propeller working in a solid, as it could be by having for illustration a propeller shaft of great length, then all the power of the machinery, with the exception of that required for friction, would be employed in propelling the ship, and none would be carried off by water being projected backwards from the ship, because none would be so projected. When, however, the propeller works not in a solid but in water, there is plainly reaction obtained for the propulsion of the ship, first from the inertia of the water in having velocity imparted to it, and then there is reaction corresponding to that velocity. The reaction due to the inertia of the water in having velocity imparted to it is measured by the rapidity with which that velocity is imparted, and is represented by a quantity proportioned directly to the velocity, and inversely to the time in which the velocity is imparted, or, in other words, is represented by the expression the velocity divided by the time; and if, therefore, the time during which the velocity is imparted be reduced to one-half, or one-fourth, or one-tenth, or is infinitely reduced, then the reaction obtained from this source is increased twice, or four times, or ten times, or is infinitely increased—that is, if the propeller imparts the velocity to the water with great rapidity, the reaction will be equal to that of the propeller working in a solid. With the turbine wheel the reaction obtained from the inertia of the water in having velocity imparted to it is plainly much inferior to that obtained with the screw propeller.

In all the three elements the screw propeller appears therefore to have the superiority.

1st, In the friction of the rubbing surfaces.

2nd, In the quantity of power carried off to waste by the water projected backwards from the ship.

3d, In the quantity of power which is developed in the propulsion of the ship.

And the extent of superiority depends upon the details of the manner in which the two methods of propulsion are carried out.

The *Waterwitch* has already been submitted to a trial on the Thames, and in the report on the subject which has appeared in the press, the performance has been greatly lauded. The method of propulsion has been lauded, and the machinery by which the method has been carried into effect has, as usual with many of our English friends, been also very considerably trumpeted. The facts, however, stated in the report do not afford the means of correct inferences respecting the result obtained, and the further experiments yet to be made are probably desirable to elicit in actual practice the true character of this method of propulsion.

The illustrations which have been adduced of the progress of scientific engineering could be multiplied to almost any extent. Within the last few years engineering has been rapidly changing character. Formerly engineering was not nearly so much as now a succession of scientific improvements. Then it was enough in a sense to be a hewer of wood and drawer of water and to travel in a beaten path ; but now it is far otherwise, engineering being in all directions full of novelties —the dictates of science. The mode of communication between distant places is, we have seen, entirely new, and is the result of laborious, patient, and keen investigation of the occult laws of nature. The mode of conveyance both by land and sea is full of the use of Nature's hidden laws. The material which the engineer employs is rapidly being changed, stone being superseded by iron, and iron in many applications being displaced by steel, produced in a manner entirely new and due to principles far from obvious. Defining an engineer to be an artificer on matter, the scientific nature of his employment is apparent, whether we consider him as a fabricator of machines for transmitting intelligence or for transporting the fruits of the earth; whether he be considered as a fabricator of food in high agriculture, which is now in reality a manufacture; or as a fabricator of coverings to protect us from the inclemencies of the weather in the beautiful materials now constantly produced; or as a fabricator adapting everything around us, beneath us, or over our heads, to the wants and comforts of man. It is no longer sufficient for the engineer to know by rote the successive steps necessary in the various operations which fall to be performed by him, and which, when known, may all be classed under the denomination of hewing wood and drawing water. He must be acquainted with the principles or laws of nature upon which these various operations depend; he must extend the applications of these principles in new developments if he would seek to keep abreast with the progress of modern engineering. It has been frequently alleged, and correctly so, that the task of deciphering Nature's laws, that is, of becoming scientific, is difficult of performance, and that any action taken upon a misapprehension of these laws is attended with disappointment and disaster. No doubt if erroneous steps be rashly made upon a misconception of the laws of Nature, the result will be disappointment and failure; and in proportion to the rareness of the capacity of correctly understanding these laws is the distinction of doing so, and the value of the reward due to success. These difficulties may furnish reasons for diffidence in undertaking the task, but they furnish no reasons for discrediting or undervaluing the labours of the successful explorers, which an inconsiderate view of the matter has not unfrequently encouraged.

To assist each other in deciphering the laws of Nature, to explain their application, to pick up Sir Isaac Newton's pebbles on the sea-shore, and to be enabled to practice our profession of Engineer with increasing intelligence, is our object in these meetings.

> "The search itself rewards the pains,
> So though the chemist his great secret miss,
> (For neither it in Art or Nature is,)
> Yet things well worth his toil he gains,
> And does his charge and labour pay,
> With good unsought experiments by the way."

TRAVERSING OVERHEAD CRANE BY Mr WILLIAM SMITH, EGLINTON ENGINE WORKS.

Fig. 5.

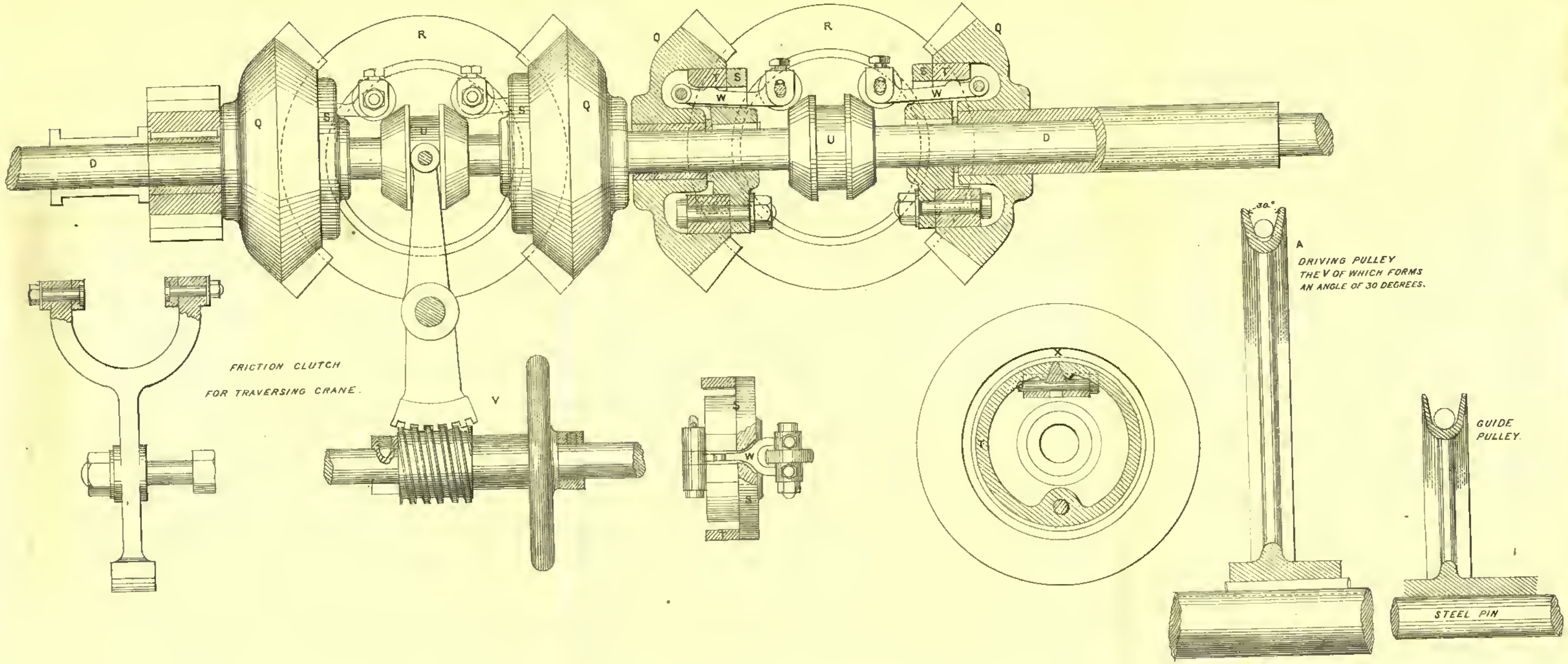

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Fig. 3.

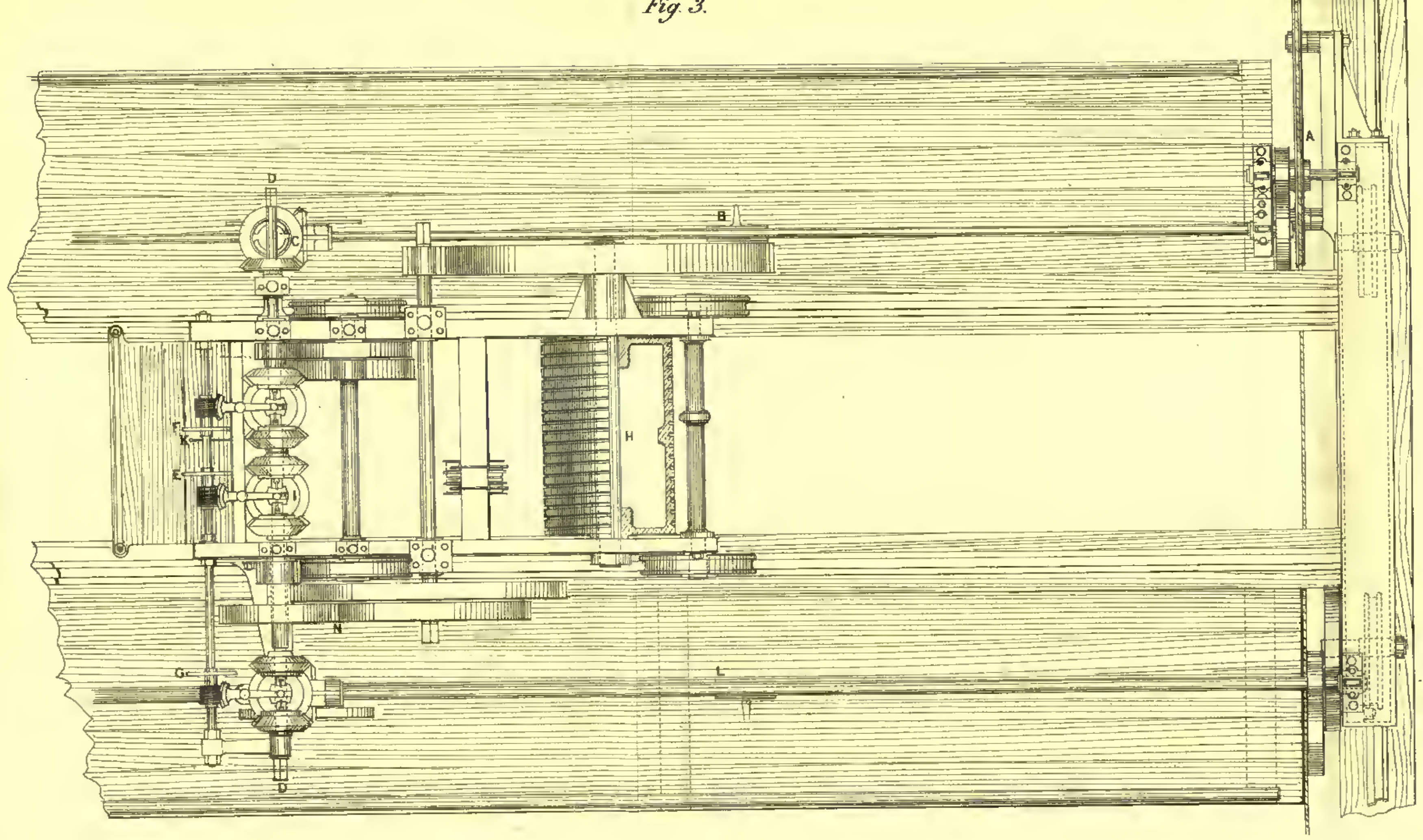
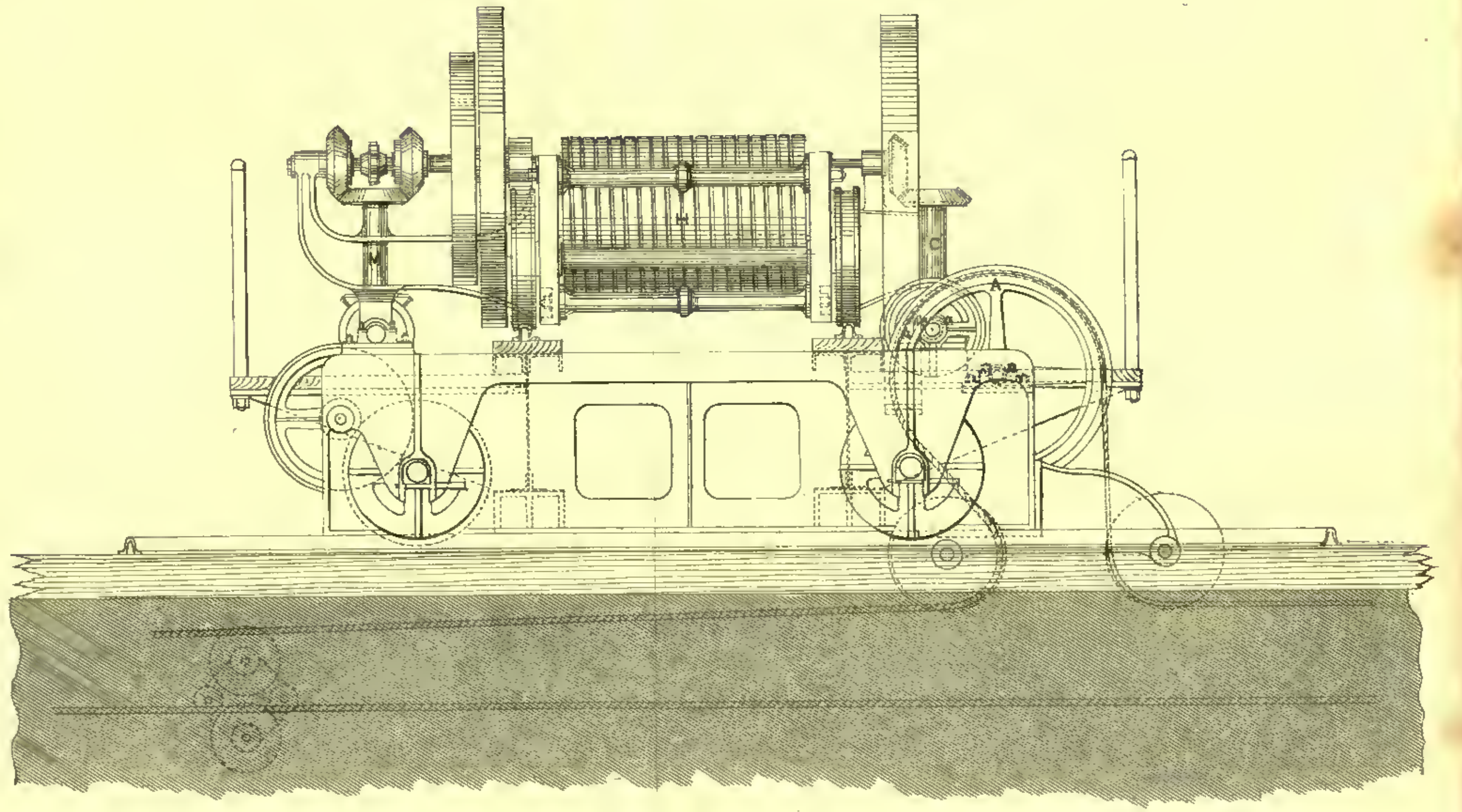


Fig. 4.



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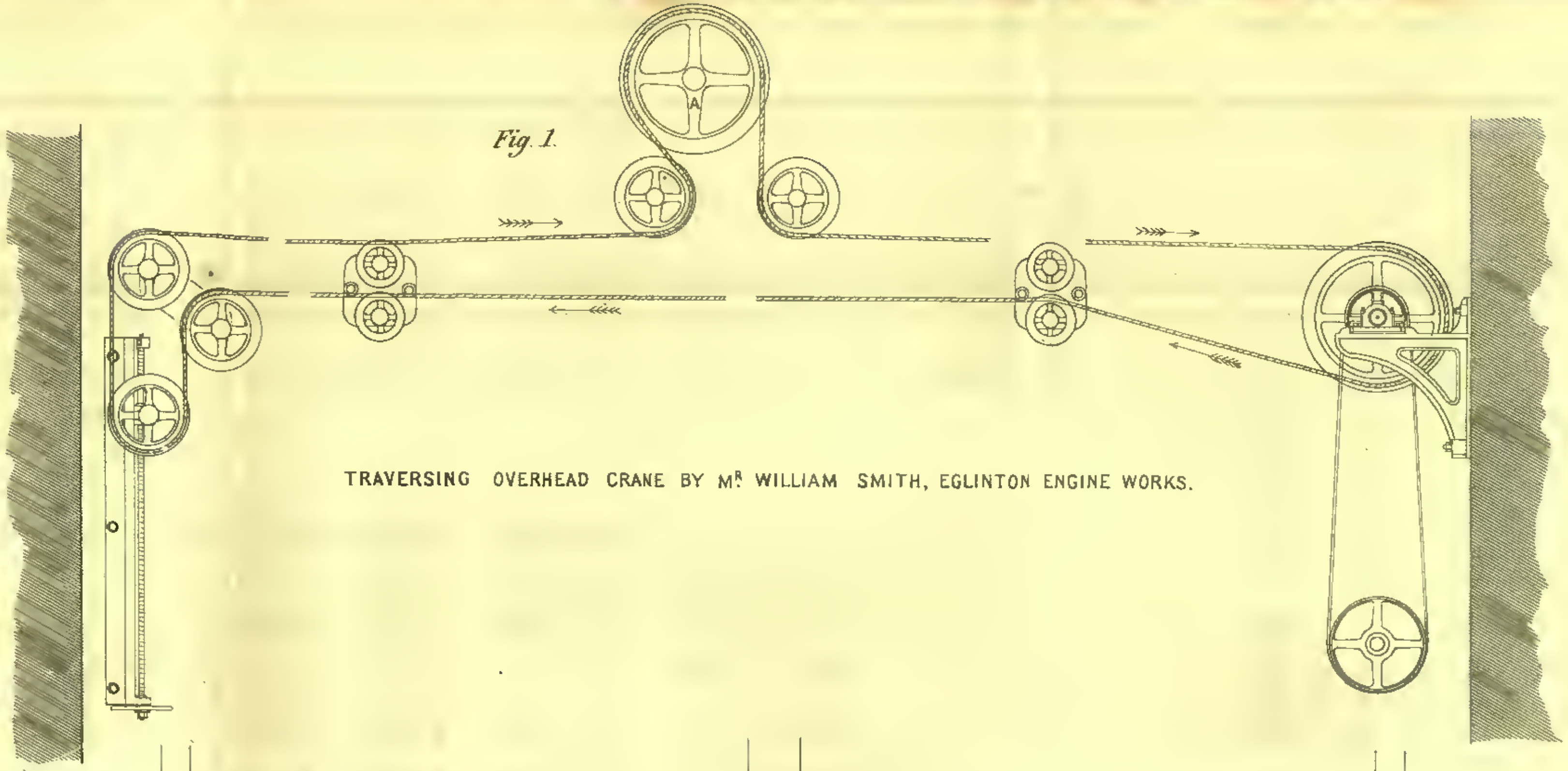
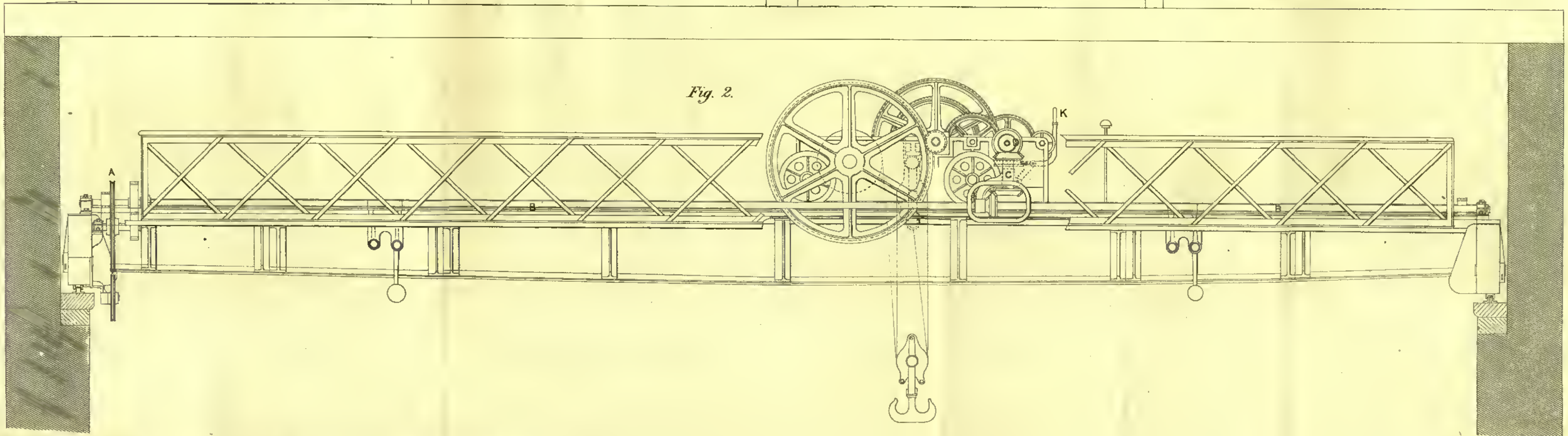
(Proceedings Institution of Engineers in Scotland with which is incorporated the Scottish Shipbuilders Association. Vol. X. page 13.)

Fig. 1.



TRAVERSING OVERHEAD CRANE BY MR WILLIAM SMITH, EGLINTON ENGINE WORKS.

Fig. 2.



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On an Improved Overhead Traversing Crane, Worked by Power.

By Mr. Wm. Smith, Eglinton Engine Works.

(SEE PLATES I., II., AND III.)

Received and Read 31st October, 1866.

The traversing crane which forms the subject of this paper, was erected at Eglinton Engine Works in this city, about eight months ago, and since that time has been regularly at work. The convenience and saving effected by its use has been so great that the writer has thought a description of the construction and mode of working it might be acceptable to the members of the Institution.

The erecting shop in which the crane is placed, is 200 feet long by 53 feet wide inside the walls, and, although the original intention was to place two cranes in this shop, the rapid manner in which this one does the work, makes it quite unnecessary, unless it might be for the purpose of lifting heavier loads than one crane is capable of doing.

The crane is driven by power by means of an endless cotton cord, $\frac{7}{8}$ths of an inch diameter, extending the whole length of the shop, supported at intervals by guide pulleys, and returned round a pulley at the one end, which is fixed in slides and tightened and adjusted by means of a screw and hand wheel, as shown in Fig. 1, Plate I. The slides and screw are nine feet long, and allow of adjustment until the cord has stretched 18 feet, after which it may require to be cut shorter and spliced over again. This tightening pulley may also be adjusted in some cases by means of a weight instead of a screw.

Fig. 2, Plate I., shows an elevation of the crane resting on the walls of the shop; Fig. 3, Plate II., is a plan; and Fig. 4, an end elevation of the crane. Two wrought-iron girders form the beams of the crane, and are fixed to two cast-iron carriages, each having two wheels for the longitudinal rails. The crab is constructed of two cast-iron cheeks, set on four wheels to move transversely, and