

wing, any more than that, in respect to propelling the Great Eastern through the water, they had imitated the structure of the duck's foot, but what they wanted to ascertain was the exact mechanical principles upon which the flight of the bird depended, such as the relation of velocity of flight to the strength and weight of the bird, and the shape and size of its wings: the same mechanical principles would apply in all cases, and at present we were lamentably ignorant of the laws of flight.

Mr. Hurry fancied that the stroke of a bird's wing was propulsive in the upward as well as in the downward stroke, and that unless this were so, a sort of impulsive or jerking motion would be observed to result from each downward stroke, which would be absent from the upward stroke; but, instead of that, the bird appears to float along in one continuous even course. He apprehended that the reason of the running motion of the bird in the earlier part of its flight was that it could not get at first a plane surface of air for the whole of its wing. Since reading Mr. Wenham's paper, he had taken considerable pains to watch the flight of birds, and he had noticed that where the bird started from a height, as from the twig of a tree, where it would be in the middle of a soar, so to speak, no exertion whatever was apparent. The effort of starting from the ground arose from the necessity of getting the wing sufficiently horizontal; some birds, indeed, such as swallows, could hardly rise from the ground at all, and they invariably ran to a little mound, or anything raised above the level of the land, before commencing their flight. As to the application of the screw, he thought it should be in the line of the supporting plane, as being that in which the least amount of force was required for sustaining weight. He believed that the screw would be found to be effective as a means of attaining propulsion, and if a motive power could be obtained, which would only weigh 20 lb. to each horse power, the thing might be considered as accomplished, as great power was not wanted so much as great velocity of motion.

Mr. Oliver Byrne thought that the vacuum created by the rush of the bird through the air had something to do with sustaining its flight, and he instanced the flight of bullets, where it was found that, by giving them sharply cut rims, greater velocity was attained.

Mr. E. W. Young remarked that there was no loss of power during the up stroke of the wing, that the bird propelled itself by the down stroke; and by altering the angle of its wing, it supported itself during the up stroke; that the air always impinged upon the under side of the wing. He also suggested that, for trying experiments in the art of flying, the safest way would be to fly the *aéronaut* and his machine on a windy day as you would a kite, then if the propelling power possessed by the machine were sufficient to slacken the cord by which the machine was held against the wind, the problem would be solved, and aerial navigation an accomplished fact. He suggested that a post, 10 or 12 ft. high, should be driven into the ground, and the cord by which the machine was to be restrained attached to its upper extremity, thus it could be managed that the *aéronaut* should be sustained by a horizontal pull, and the downward pull which an ordinary kite experiences avoided. He stated, moreover, that the flight of birds was still an enigma to him; that he could not account for the great ease with which their motions were accomplished; that the ordinary theory of the action of the wind seemed to show that mechanical flight by man was impossible. For instance, if we supposed a plane 1 ft. wide, inclined at a slope of one in ten, driven against the air at a rate of thirty-five miles per hour, we should apparently get the following result: A sustaining force of 12 lb. per square foot of the plane, and a horizontal force of .012 lb. for the same. Tables show that a velocity of wind equal to thirty-five miles per hour gives a pressure of about 6 lb. per square foot; the plane being inclined at a slope of one in ten, would present a vertical surface of $\frac{1}{10}$ th of a square foot, receiving a total horizontal pressure of .6 lb.; resolving this, by the parallelogram of forces, we get a vertical force of $\frac{1}{10}$ th or 12 lb. and a horizontal resisting force of .012 lb. This angle of wing was too great for practical purposes, for a continuous pressure would have to be exerted equal to one-tenth of the weight supported.

To show the difficulties of the problem, he supposed a case in which the slope of the plane was one in twenty only, and that a sustaining force of $\frac{1}{20}$ lb. per square foot could be obtained with such a low velocity as 80 miles per hour. He assumed the *aéronaut* and his machine to weigh 200 lb., that 400 square feet at least of wing were required; then if the resistance of the air to the man's body and working parts of the machine were neglected, a continuous horizontal pressure of $\frac{1}{20}$ lb., or 10 lb., would be needed to sustain the machine. Now 80 miles an hour is 44 ft. per second, and a pressure of 10 lb. exerted through a distance of 44 ft. equals 440 foot-pounds or units of work per second, which is more than any man could accomplish.

He suggested the advisability of trying some experiments on the sustaining force of the wind when acting against an inclined surface, which he believed would be found to be much greater than was commonly supposed.

Mr. Wenham thought that part of the investigation should be directed to ascertaining the force afforded by the currents of air; but in England this would be almost impracticable, owing to the diversity of the currents. He proposed shortly to try a series of experiments by the aid of an artificial current of air of known strength, and to place the society in possession of the results, as he thought that at present a great deal of time and labour was being lost and misapplied as a consequence of ignorance on points of this kind.

Mr. Henry B. St. Martin read the following paper on "A Novel Apparatus for Aerial Locomotion."

It may be remembered that, at the last meeting of the society, I described a project for aerial locomotion, based mainly upon the same general laws, and actuating elements that support and influence the movements of the kite. The peculiar novelty of this project, the novelty which in fact nearly absorbs the whole idea, was accepted by most of those present at the meeting as founded upon reasonable data, and in some measure upon actual experiment. I say actual experiment, because a pleasing reminiscence of our childish sports is no doubt cherished in the memory of the most of us, and therefore the movement of the kite must come within the range of our own personal experience. We are all aware that the kite is maintained in the air by

what may be termed an opposition of two forces—the impelling power of the wind and the restraining power of the string, at one end of which the kite floats. The former or impelling force is an ever-present and always effective existence; the latter or restraining power is an artificiality subject to innumerable modifications and conditions. The desired result produced by the combined action of these forces in the case of the kite is no proof, it may be said, that a conjunction of power apparently similar would be equally successful under other conditions. But the result furnished by the kite proves at least the feasibility of my project; for they elevate it above the rank of a mere supposition, and plant it upon substantial and practical data with which we are all more or less acquainted. My apparatus may therefore claim a motive power in the wind, and, at least, the basis of a restraining power, such as we see in a certain phase exemplified by the kite. It appears to me, then, that the chief if not the sole question which remains and claims attention is, Have I discovered a restraining power that will act as effectively as the string in the case of the kite?

I endeavoured on a former occasion to describe an apparatus which I propose to apply as a restraining and regulating agent for the support and guidance of a surface or sail sufficiently extensive to present a power capable of raising and supporting a single person in the air. As I am now able to present to the meeting a small model of my apparatus, I need not recapitulate any part of that description. But it should be distinctly understood that I do not offer this model as a perfect representation of my apparatus, still less as a working model. It simply stands in the place of a less evident verbal description. In this apparatus the screws represent the restraining and regulating power. It will probably be recollected that I described these screws as moving in a direction contrary to that in which they usually act.

They serve to check the inclination of the sail to follow the course towards which it is otherwise urged. They do not propel in the line of the intended flight, but exert a force in some measure contrary to that direction, and thus tend to sustain and balance the whole apparatus. This supposition appeared to receive the general concurrence of the meeting. The doubt was not as to the tendency of the power exerted, but as to the probability of concentrating and applying within certain necessarily prescribed limits a sufficiently efficacious restraining power. Towards dispelling this doubt, I am now enabled to place before the meeting a few calculations which, though not assuming the place of ultimate facts, may nevertheless presume to challenge a sufficiently satisfactory result.

The combined weight of the *aéronaut* and the apparatus I estimate at about 400 lb., and, as sustaining surface, I have calculated that the sail or plane should measure about 300 square feet. These figures are rather in excess of what I think will be demonstrated in practice.

We will now suppose that this plane assumes an inclination of 45°, and that the wind impinges against it at a velocity of about 21 ft. in a second, which is equivalent to a pressure of 1 lb. on every square foot.

That this sail, with its accompaniments, may, under such circumstances, be sustained and equilibrated in the atmosphere, a power represented by about 300 lb. will probably suffice.

The query then presents itself, will screws of practicable size and weight be sufficiently effective to supply this power? A practical essay alone can furnish the ultimate answer to this query, but I am disposed to believe, after careful calculations, that we shall not be far out if we assume that two screws, having a diameter of about 8 ft., and affording a working surface of about 45 square feet, and rotating at a velocity of about 3 revolutions a second, will supply an ample sustaining force. Then as to locomotion, I have computed that, as the resistance of the air to a surface moving in it is in proportion to the velocity at which the surface travels, a considerable, if not rapid, movement may be obtained by an addition of 20 lb. to the restraining power. I propose to affect this increase by reducing the angle of inclination presented by the sail, and thus relieve it of a certain amount of atmospheric pressure—a movement which will be equivalent to a positive addition of impelling power. This of course must be conceded—yes; but then it will be objected that I have stolen the force necessary to impart this impetus from my sustaining power—a power, by-the-by, which should somewhat exceed the ability of mere sustentation. I can hardly acknowledge the full justice of this impeachment. I have done no more than borrow a power which a moment after I restore, and before the apparatus can have suffered any appreciable declination. Thus it may be affirmed that with the ability to borrow sufficient force to effect a certain rapidity of locomotion, I want but little more power than what is sufficient to maintain the apparatus in the air in a state of equilibrium.

There will, therefore, be two movements, subjecting the two components of efficiency in the apparatus, not to simultaneous, but to successive flowing or rather undulatory action. The movement of the head or rather apex of the sail will be somewhat similar to that of the head of a person in the act of swimming. It is not necessary, however, that any definite time should take place between the intervals of advance, movements under such circumstances being controlled by and depending upon a variety of contingencies. Thus far then I think it may be affirmed that we arrive at two favourable results, first, that the restraining principle or rather method is sound both in theory and practice, that if sufficient power can be applied it will be efficient; and, secondly, that, admitting the possibility, I may say the probability, that the calculations I have just submitted to you are, to some extent, even to a great extent, erroneous, and that the estimated power will fall short of the amount eventually demanded, there must still remain the reassuring and very palpable fact that my apparatus will be satisfied with a mere fraction of the power demanded by every scheme hitherto projected for aerial travel. As to the question in what way it is proposed to propel the apparatus with the wind, I answer that this is effected in much the same manner as that already described, when the course of the wind is reversed, the apparatus. In this case the action of the screws is reversed, they pushing instead of pulling the sail, thus producing, as in the former case, a restraining and regulating power; but it would be encroaching too much on your time and attention to enter at present upon the discussion to decide what degree of certainty can

be shown of obtaining a directing or controlling power. I shall be amply satisfied if my apparatus has so far produced a favourable impression upon the meeting as to establish the conviction that in it there may be discovered a means, partial to all appearance, and even perhaps in fact, but still a practicable means of gratifying the long-desired human ambition of achieving aerial locomotion.

During the reading of this paper the Duke of Argyll, being called away by other engagements, proposed that Mr. Hurry should take the chair.

Dr. Smyth remarked that every experiment made with the screw-propeller showed that it required the expenditure of immense power in order to give it sufficient velocity, and at present no motive power had been discovered light enough to effect it.

Some discussion arose as to the adaptability of the proposed machine; and Mr. St. Martin explained, by means of a beautifully constructed model, the method by which it would be worked. The chairman remarked that he could not see in the model the very essential element of progression. The meeting could see the operation of three forces—that gravitation which would be towards the earth; the force of the wind, which would be blowing in the face of the person in the car—this would be horizontal; and these two being converted into one would bring the machine downwards and backwards. Where then was the means of progression through the air upwards?

Mr. Wenham said, whilst he protested against the screw as being utterly inadequate and useless for raising weights, he at the same time admitted its perfection as a propeller, both in air and water. In air it need not necessarily be of the large diameter generally supposed, for in a ship propeller the area varies from one-third to one-fifth of the immersed area of the midship section of the vessel, estimated as the entire area of the circle of revolution. In air the screw will not be greater, as the relative conditions of reaction and resistance would be similar in both cases. Until the vessel acquires some speed the screw has considerable slip and very little propelling power. This becomes fully developed with the maximum speed of the vessel.

Mr. Reda S. Martin observed that he feared the chairman had forgotten the substance of the first paper he had the honour of reading at the last meeting of the society. In that paper it was shown whence the elevating and, in some measure, progressive power anticipated for the apparatus would be derived; that an initial, very oblique ascensional impetus would be given to the apparatus by means of the car or velopede appended to the sail, which the *aéronaut* would urge with greater or less velocity, according to the amount of resistance he might experience from the wind; that, conjointly with this movement of the velopede, the screws would be brought into action, and at once steady and balance the sail, which would be made to assume whatever angle of inclination the pressure of the wind might dictate; and that a suitable elevation being in this way acquired through the simultaneous action of the velopede and the pressure of the air against the sail, a pressure always regulated by the screws, the apparatus might be maintained at any desired elevation and impelled in any direction, in the way and by the means indicated, with as much precision as I am at present able to explain in the paper just read to the meeting.

Mr. A. Stewart Harrison, in proposing a vote of thanks to the Duke of Argyll and to his grace's successor in the chair (Mr. Hurry), said he had no doubt the people outside thought it was very desirable that those present should be taken care of by their friends. He did not; but he thought that, as gentlemen risked something of their reputation for soundness of judgment by taking the chair when such flighty subjects were discussed, they could not do less than acknowledge their kindness by a vote of thanks.

A very ingenious model, upon a large scale, of an aerial machine, whose sustaining power was gas, partly assisted by the screw, was exhibited and explained by its maker and designer, Mr. Sadd.

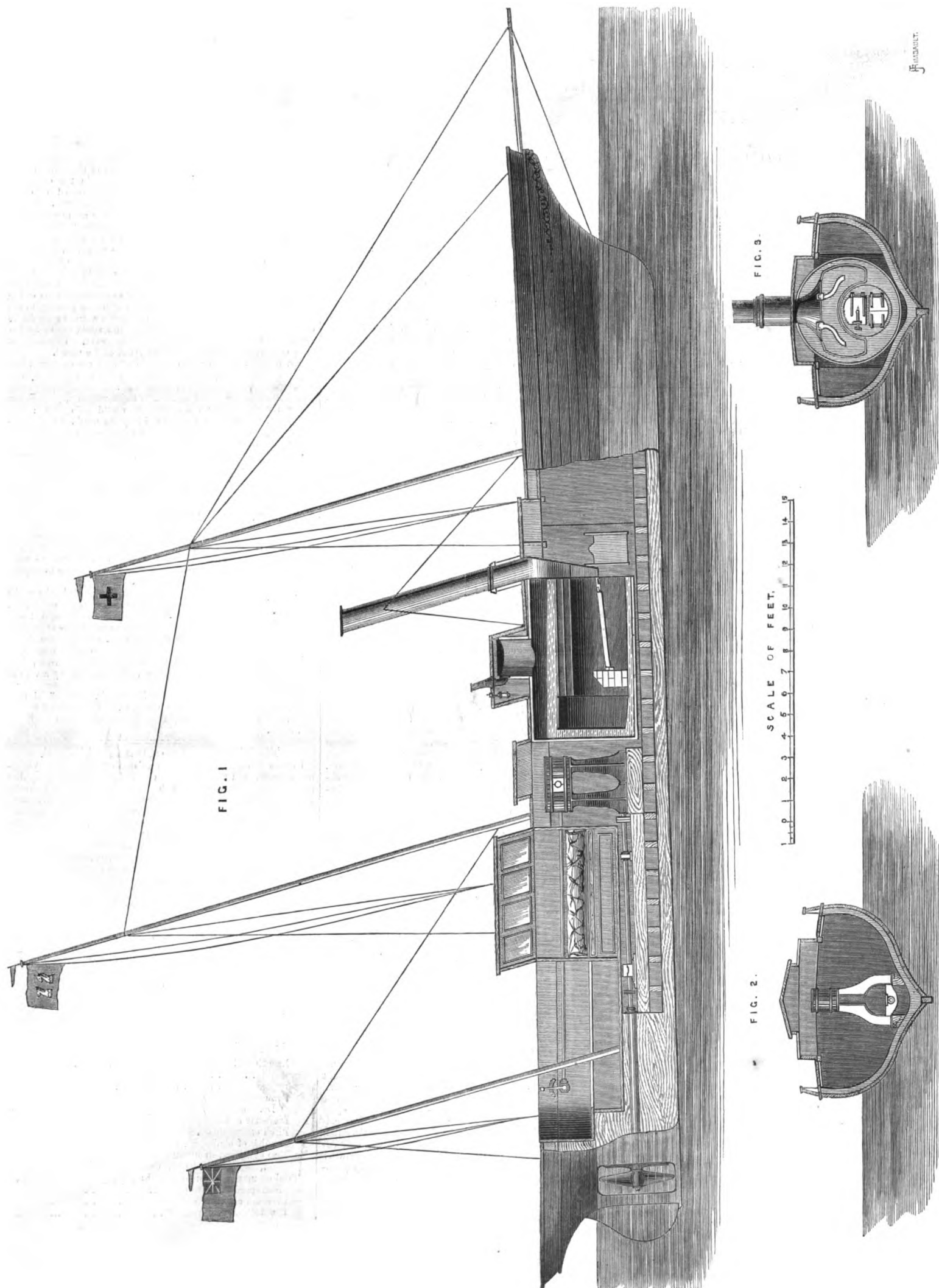
THE STEAM YACHT AVALANCHE.

Cowes harbour has long been celebrated as our chief yachting station; and now that steam power is so frequently applied to yachts, our illustrations, on the next page, of the latest novelty at Cowes will interest many of our readers. The engravings in question represent the steam yacht *Avalanche*, built by Halliday, for Messrs. Thornton, of East Cowes, and fitted with high-pressure engines by Messrs. C. A. Day and Co., of Southampton. The Messrs. Thornton, whose beautiful mansion at East Cowes adjoins her Majesty's landing-stage, determined to have the machinery of their yacht so arranged that they could steer and work their engines themselves, and the reversing and throttle valve-gear has therefore been brought to the after end of the vessel. This arrangement is found to answer admirably, as the owner sits in the stern steering and working his own engines, and obtaining all the pleasure which English yachting gentlemen are so fully alive to, of doing things with their own hands. The dirty portion of the work, of stoking, sweeping tubes, &c., is done by a fireman forward.

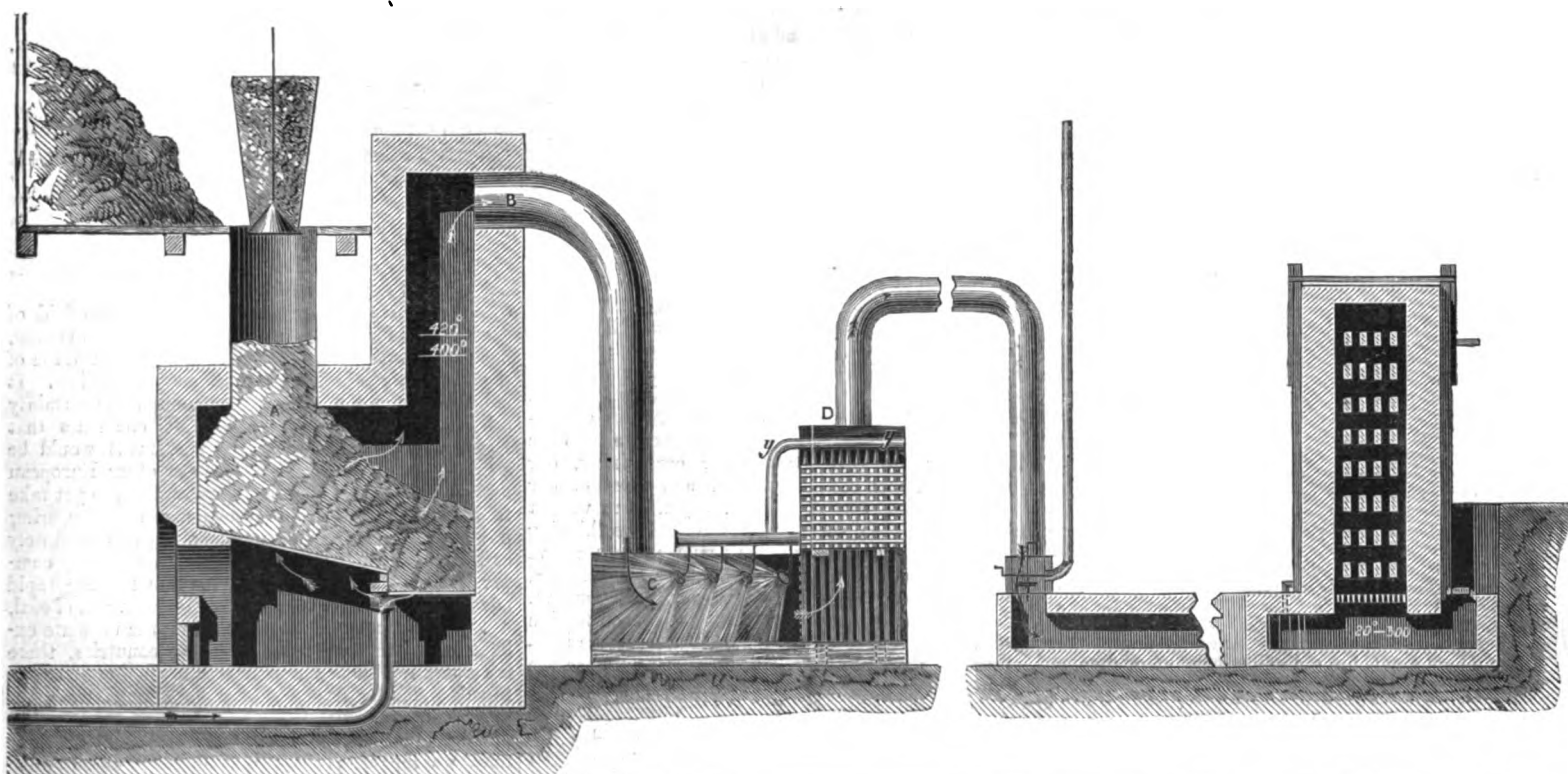
A small cabin between the engine-room and cockpit gives shelter in bad or rainy weather, and the fore-castle for the crew is also decked. The *Avalanche* is a first-rate sea boat, and very dry. When steaming 9 knots an hour, she appears to those on board to be going very much faster, the eye of the observer being so near the water level. Her consumption of coal is about $\frac{1}{2}$ cwt. per hour. Her principal dimensions are as follows:

Length on load water line	... ..	46	0
Beam	... ..	9	0
Depth	... ..	4	6
Draught forward	} with 1 ton of coal on board	2	10
Do. aft		4	2
Diameter of brass propeller	... ..	8	6
Pitch of do.	... ..	5	0
Number of blades	... ..	8	
Two cylinders, diameter of each	... ..	9	0
Do. stroke do.	... ..	9	0
Trial on measured mile in Stokes Bay:			
Mean speed in knots per hour	... ..	9	
Pressure of steam in boiler	... ..	50	lbs.
Revolutions per minute	... ..	280	

THE STEAM YACHT "AVALANCHE."
 BUILT BY HALLIDAY, AND ENGINED BY MESSRS. C. A. DAY AND CO., ENGINEERS, SOUTHAMPTON.
(For Description, see preceding Page.)



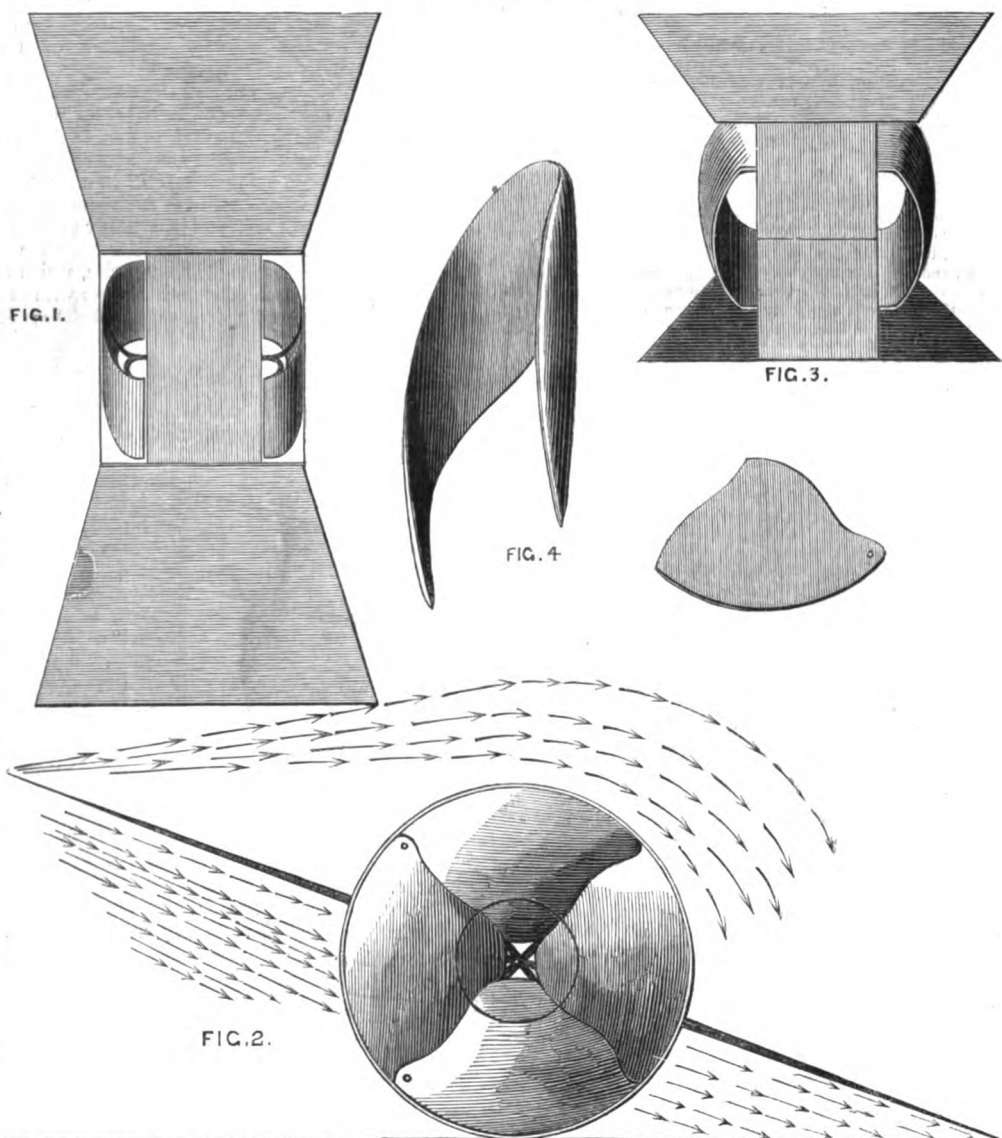
THE LUNDIN FURNACE, AT THE PARIS EXHIBITION.



THE Swedish department of the Paris Exhibition contains a small model of a reheating furnace made according to the designs of M. F. Lundin, of Carlstad-Munkfors, in Sweden. We have, on a previous occasion, stated that M. Lundin's invention consists in an improvement of, or addition to, the Siemens furnace, and that it consists in the injection of cold water into the gases when coming from the producer and before their entrance into the combustion chamber of the furnace, for the purpose of washing or purifying the gases, and, what is more important, for the purpose of condensing the steam carried with the gases, and withdrawing this component as much as possible from the mixture of combustible and incombustible gases which pass from the producer into the furnace. To make this more clear by an example, let us take the practical case carried out by M. Lundin, at Munkfors. A furnace for reheating puddled or bar iron is worked there, with no other fuel but damp sawdust as brought from the saw-mills in the vicinity. Now it is well known that such sawdust will not produce a welding heat when burnt even under the most favourable circumstance. Its chemical constituents do not allow of the products of its combustion acquiring the requisite temperature, since the quantity of steam formed takes up so much of all the available heat generated by the combustion that the temperature of the products cannot rise above a very moderate heat. The sawdust, when charged into the producer of a Siemens furnace, will produce gases which contain about 30 per cent. of steam by weight. For every 2 lb. of dry gases sent to a furnace 1 lb. of steam is carried into it at the same time. Of the dry gases again, only about one-half is combustible, the rest being nitrogen, carbonic acid, &c., all worthless for the combustion, so that practically with every pound of gaseous fuel sent into the furnace is mixed 1 lb. of steam and 1 lb. of incombustible gases. The gaseous fuel, during its combustion, generates a fixed and given quantity of heat, and this heat must be employed in heating, not only the fresh gaseous products of this combustion, but also the incombustible gases carried into the furnace and the steam which was sent along with the dry gases. Of these elements the steam is the most inconvenient portion, since the great specific heat of steam causes it to absorb a much larger proportion of caloric in being heated than an equal weight of the other gases would take up, so that under these circumstances it may be said that the heat absorbed by the steam is more than one-half of the total caloric generated in combustion. This fact explains the small heating power of sawdust and similar kinds of fuel when burnt under ordinary circumstances, and from this it also follows that the abstraction of the steam from the gaseous products generated from this fuel in the gas producer would at once render these gases fully as effective in the furnace as the gases generated from fuel which contains less water. This effect M. Lundin produces in his furnace by his injecting cold water into the passage between the gas producer and the furnace. He sacrifices a certain quantity of heat in doing this, since the gases come from the producer at a temperature somewhat between the melting point of lead and zinc, and they must be reduced down to the temperature of the atmosphere, or even below that, in order to condense the steam, but the ultimate gain is greater than the loss. The gases, after condensation, carry with them no more than two or three per cent. of steam, and consequently it may be said that their heating effect is doubled by this process of condensation. It is possible, therefore, to obtain a welding heat, or any other temperature which the Siemens furnace is capable of producing with the best kinds of fuel, even with the employment of the very inferior qualities of combustibles at command. The manner in which M. Lundin has carried out his plan in practice is illustrated by the accompanying engraving. The sawdust is charged into the gas producer through a hopper at regular intervals, air being admitted from below in the usual way. The gases in

ARTIFICIAL FLIGHT.

(For Description, see page 78 of the last number.)



their heated state, and charged with about 30 per cent. of steam, pass through a pipe, B, which leads into the chamber, C, where a series of jets of cold water are brought in contact with the gas. There is, further, a pile of iron bars at D, over which cold water is kept flowing constantly for the purpose of keeping them cold, and through this the gases are made to pass in their ascent. After this the dried and purified gases pass off to the Siemens furnace in the usual way. The furnace erected at Munkfors by M. Lundin has now been in operation for about two years. The economical results obtained with it during the year 1866 have been carefully tabulated and published at the Paris Exhibition by the Uddholm Company, at whose works this furnace is in operation, and these results speak very much in favour of the Lundin furnace. It is stated that the erection of a complete furnace costs about £504. The furnace at Uddholm is used for reheating bar iron for the purpose of its being drawn down under the hammer. The iron is heated twice, and this is effected by the employment of 0.16 cubic metres of fresh sawdust per cwt. of iron. The heat obtained is very high, and experience has proved that there is less waste of iron than with the ordinary charcoal fires or furnaces heated by mineral fuel. These results are well worthy of the attention of our readers. We are in this country less under the necessity of employing such fuel as sawdust than manufacturers in Sweden or in other parts of the world may be, but with the constantly rising prices of the best kinds of coal, which have hitherto almost exclusively been used in our manufactures, we shall be driven to the necessity of looking out for cheaper substitutes at no very remote period. In that search the employment of peat is one of our readiest suggestions; but to this there has hitherto been the objection that it is incapable of yielding a sufficiently elevated temperature in its air-dried state, and almost all attempts to convert it into coke or peat-charcoal on a large scale have commercially failed hitherto on account of the expense of manufacturing this second product. With the employment of the Siemens furnace, and M. Lundin's scientific addition to it, we see no improbability of a successful utilisation of peat for the purposes of iron and steel manufacture, and for any other processes requiring an intense heat. We are not aware whether M. Lundin has patented his improvement in this country, nor could we say how far this idea is or is not covered by the patents taken out by Mr. Siemens himself. Under any circumstances we expect that manufacturers in this country will try to avail themselves of the advantages which this scientific innovation seems to be capable of affording, and that, in case of success, they will not fail to do justice to those to whom they are indebted for its discovery.

CAUSE AND EFFECT.

SIR MORTON Peto, Crampton, and Betts in the Bankruptcy Court, and money at 2 per cent. discount in the Bank of England!

As Shakespeare says, "This effect defective comes by cause." Two per cent. discount means stagnation of enterprise, cessation of labour, and paralysis of industry. Peto, Crampton, and Betts in the Bankruptcy Court means reckless financing, contractors' lines, gulled shareholders, 100L shares at 17L, general distrust of railway enterprises, and general disgust with railway investments. We are a practical people. And we show it by accumulating the materials of a gigantic and general smash for every nine years, and having the smash in the tenth. We show it by encouraging speculation which borders on swindling, by floating enterprises which ruin the first generation of their promoters, by blowing the bubbles of trade and industry till they burst, and bespatter everybody within range of their influence. We proclaim it in those huge and hideous posters, which celebrate the apotheosis of puffery and humbug on every hoarding. We build it up into the acres of flimsy lath and plaster which disfigure every suburb, at once a monument of the bankruptcy of bygone builders and a purgatory for the discomfort of future tenants. We prove it by the much talk and little work of our public Parliamentary labours; the waste, dishonesty, and friction of our Parliamentary Private Bill Legislation; the verbiage and uncertainty of our law; the inertia and incapacity of our local self-government; the *laissez faire* of our boards of guardians, district and local boards; the snobbery and stupidity of our municipal government; the rascality which goes unpunished in our retail trade, and expands into colossal proportions in our larger enterprise; our worship of successful humbug; our neglect and contempt of fine art; the pretension and discomfort of our private social intercourse, and the kowtowing and bombast of our public hospitality.

It needs no M. Assolant, from the other side of the Channel, to paint us *couleur de noir*. We have only to get our blacking ready to look at our own faces as reflected in all signs of the times, and to go to work with honest hands and open eyes.

We are a practical people! Mr. Punch denies the assumption. We are not a practical people. We are about the most unpractical, wasteful, thriftless, and helpless people on the face of the globe. With our energy of temperament, our worship of money and success, our hardihood of frame, and our readiness to dispense with enjoyment and stifle conscience for considerations of profit, we ought, if we had practical wit in anything like proportion to our will, to be what we boast to be, but are not, the first nation of the world.

Even in our favourite Mammon worship how contemptibly we figure as gauged by the two facts we have put in the front of this article. Money to be had at 2 per cent., and nobody daring to use it! One of our hugest contracting firms bankrupt with an item in the accounts which stands 6,000,000L among the creditors' claim, and 350,000L among the debtors' assets! This is being practical with a vengeance.—Punch.

AUSTRALIAN MAIL COMMUNICATIONS.—A conference has just been held at Melbourne to consider the best means of improving mail communications between the Australian colonies and the mother country, and also with North and South America. The subvention professed to be furnished by the Australian colonies is to be allocated as follows: Victoria, one-fourth; New South Wales, one-fourth; New Zealand, one-fourth; Queensland, one-seventh; South Australia, one-twelfth; and Tasmania, one-fifteenth.

ENGLAND'S FUTURE.

To the patriot and the statesman the present time is fraught with no common anxiety. A question of the greatest magnitude and of the deepest importance awaits solution—"What is to be the future field of employment of British enterprise and British capital?" In these times, when even the rich experience an indescribable sense of poverty, when gold hides itself away, and enterprise, armed with all its courage or buoyed with all its confidence, sees little or no opportunity for profitable action, the thought that our commercial and manufacturing supremacy may be at last passing away comes home to us with painful force. It is not merely that more than twenty-two millions of gold are lying unused in the Bank of England, and that the bank rate is down to 2 per cent. with very little demand, for there are thirty-five millions now hoarded in the Bank of France; but the great ground of uneasiness is that well nigh every available opportunity for investment is withdrawn. We have wasted millions on unprofitable railways, some of which, yet uncompleted, are to be abandoned; we have pushed our coal-mining, our iron-making, our cotton-spinning, and most of our other industries, except farming, beyond the utmost demands of trade; we have overstocked the shipping markets with steam and sailing tonnage, and we have plunged millions of money into building speculations, of which many must long remain unremunerative. In many of our special industries, too, several foreign nations, once our best customers, have become independent of us, and we cannot yet perhaps realise the full force and results of even that foreign opinion which has been so industriously cultivated to our discredit at the Paris Exhibition. Even in our civil engineering, a department in which, thanks to the fear of causing jealousies in the Institution of Civil Engineers, no representation was made at Paris, we have the certainty that the French engineers are now held in higher estimation not merely in France, but in many other countries, as being not only more scientific, but more economical, and, if we may employ the term, more usefully skilful than our own. We are not speaking of the engineers of the Ponts et Chaussées, but of the new school of railway and industrial engineers which has grown up so rapidly in France.

After the collapse of our railway mania of twenty years ago, our commerce and industry were powerfully stimulated by the discovery of gold in Australia and California; a little later we were suddenly applied to for more than two million tons of iron for "ironing" the twenty thousand miles of American railways, built subsequent to 1853, and the larger proportion within three or four years; a little later came the full development of iron steam-ship enterprise, which has lined the Clyde and some of our other rivers with great shipbuilding yards hardly dreamed of before; still later the wonderful expansion of the Cleveland iron trade, and the reconstruction of our navy and our armaments.

We can hardly expect another gold discovery, nor that any one of our former incidents of good fortune will be repeated in the same form. If we reflect a moment, we perceive that, with the exception of the Australian gold, all the more striking instances of our commercial progress, within the last fifteen or eighteen years, have followed suddenly increased demands for iron, or its discovery in new districts, or, as in the case of the Bessemer process, its cheaper production in a partly manufactured form. Nearly three million tons of iron for America, and that at home for iron-ship building, for bridge building, for roofing, for gas and water works, and for iron armour-plates, with a great deal besides for Indian railways. Iron can never cease to be in demand for each of these purposes, but in each the cream of the trade has undoubtedly been taken off. It may be argued that new applications will arise, not more unlikely now than were foreign rail contracts, wrought-iron girders and roofs, or iron ships fifteen years ago. And we will not speculate either way, but we are bound to say that neither engineers nor the shrewdest manufacturers, nor even the most sanguine inventors have been able to discover the signs of any such renewed demand.

It is not improbable, however, that important changes are impending in our foreign commerce. Within a very few years the largest ships will be able to cross the Isthmus of Suez, and the direct route from London to China will be *via* New York, the Pacific Railway, and the Transpacific steamers. But will either of these changes in the means of our distant communications be especially beneficial to England? Or rather will not France (as the foster-mother of the Suez Canal) and the United States derive the greater

advantages? As for new routes for commerce, indeed, the railway will before many years be carried under Mont Cenis, and possibly under the Alps at one or more points further east; the interior of Canada will be connected by railway, through British territory, with the sea at Halifax; Bombay and Calcutta will be united by rail; and probably at a somewhat more distant time a line will be extended across the continent of South America, from La Plata to Chili. Later still there will no doubt be made a great line of railway to India *via* the Euphrates valley. But in none of these undertakings can be foreseen the great extension of British trade. They will all be upon foreign soil, and however their execution may be aided by English capital, foreign and probably rival nations will derive the greater benefit from them.

The question as to what is to be the future field of employment for British enterprise and British capital, beyond that engaged in the ordinary settled trade of the country, can of course be solved only by time. It is by no means a hopeless one, although it is certainly attended with much anxiety. No one fears that England will lose her existing trade, but it would be a great national humiliation were any other European nation, favoured by superior opportunities, to yet take rank above her as a commercial and manufacturing power. This may be most unlikely, but it is absolutely certain that, while we are at present standing comparatively at rest, other nations are making rapid advances. We have an abundance of iron and of coal, but whatever may be the prospect of the ultimate exhaustion of these minerals in other countries, there is enough in France and scattered throughout Europe to suffice for the demands of a prodigious trade for generations to come. Practically we have no monopoly of these great elements of productive industry, nor have we longer, perhaps, any monopoly of skill, and assuredly none of capital, and in the point of cheap labour we are undoubtedly beaten by the Continental nations.

LITERATURE.

A Handbook of Practical Telegraphy. By R. S. CULLEY. London: Longmans.

(SECOND NOTICE.)

MR. CULLEY adopts Javanett's theory of the function of the earth as a part of the circuit. It was at one time imagined that the earth completed the circuit precisely in the same manner as a return wire, only that it offered no resistance to the passage of the current. Many think so still. The arguments to the contrary are by no means conclusive. The explanation is purely hypothetical. The theory is, that when the extremities of a circuit are connected to the earth, which is an infinitely large conductor, their respective tensions are diffused in all directions without producing any appreciable tension in the earth itself, so that the current will continue to flow. We are of opinion that the earth figures a great deal too much in the explanation of electrical phenomena. It is a great petted monster that has been too much fondled by philosophers of all ages. The fallacy of its supposed functions has been fully exposed by Mr. F. C. Webb, in his book on electrical accumulation. The earth simply acts as an enormous conductor of infinite dimensions, with which, however, it is very difficult to make a good joint. But once make that connexion, and keep it good in the way Mr. Culley points out, and all difficulty vanishes.

Magnetism and electro-magnetism, galvanometers and electro-magnets, occupy the third part, and are very succinctly and clearly dealt with.

The very difficult subject of induction occupies part the fourth.

"161. If two lengths of 100 miles, or more, be placed on a dry floor, and if a needle instrument be inserted between each length, and one at each end, so as to form a circuit, when signals are sent in the usual manner, all the needles will move sensibly at the same time, sharply and distinctly.

"But if the wire be put in water, or buried in the ground, and the circuit be completed through the earth in the usual way, the needle at the battery end will move immediately the handle of the instrument is turned; the second needle will not move at the same instant, but a perceptible time afterwards; the third needle later still; and so on, showing that the current now travels more slowly than before.

"When the handle is caused to break battery contact, and put on the earth, a discharge will take place, and the needles will fall back one after the other, commencing with that at the battery end.

"162. To use a homely illustration, it may be said that we must *fill* (charge) the wire with electricity before a signal can be sent, and to reverse a signal we must empty it, and refill it with the opposite electricity. A suspended wire soon empties itself, a portion of its charge escaping at each support; but a well insulated buried wire cannot part with its charge anywhere except at the two ends. Hence a slightly leaky buried wire

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED
DATE 10/10/2001 BY 60322 UCBAW/BJS

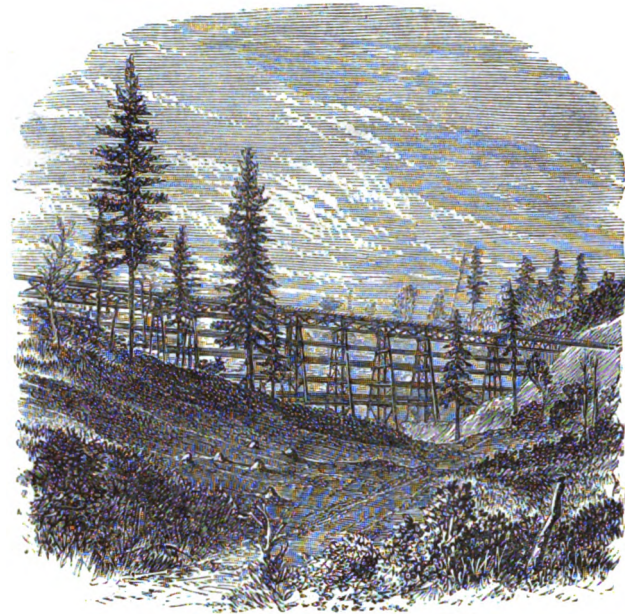
THE CENTRAL PACIFIC RAILWAY OF CALIFORNIA.

MR. SAMUEL S. MONTAGUE, CHIEF ENGINEER.

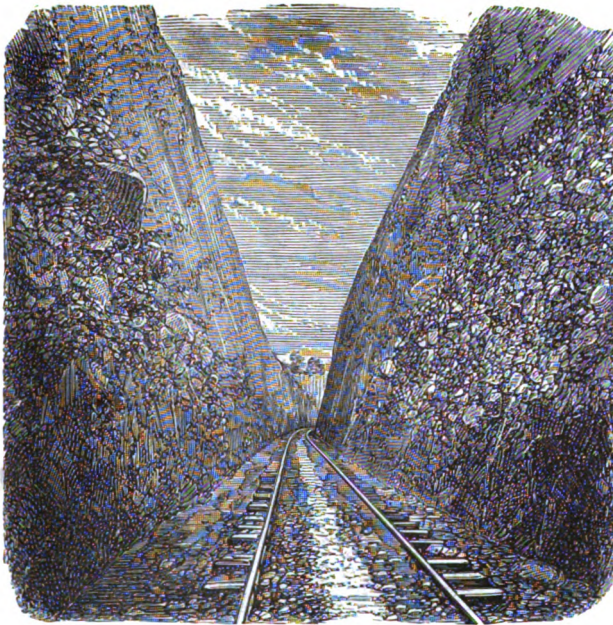
(For Description, see Page 80.)



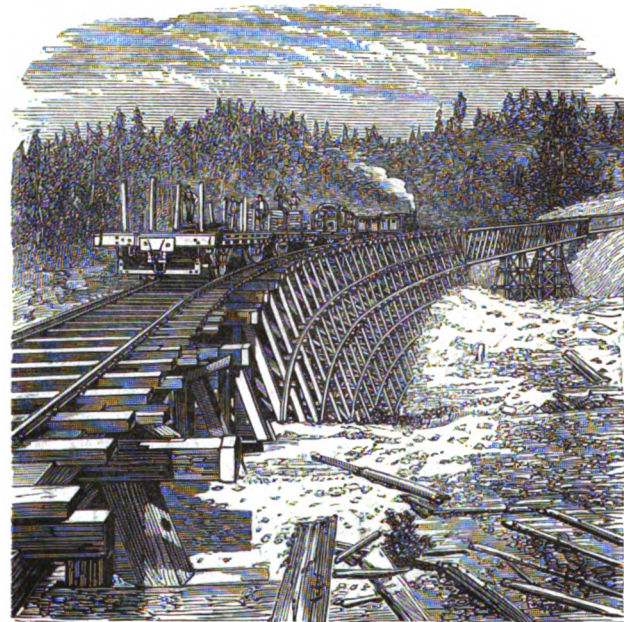
No. 1.
Trestle opposite Auburn.



No. 2.
Trestle and Truss Bridge, Clipper Ravine, 100 ft. high.



No. 3.
Bloomer Cut, 63 ft. deep and 800 ft. long.



No. 4.
Long Ravine Howe Truss Bridge and Trestle, 115 ft. high.



No. 5.
Trestle at Secrettown, 1000 ft. long, and 50 to 90 ft. high.

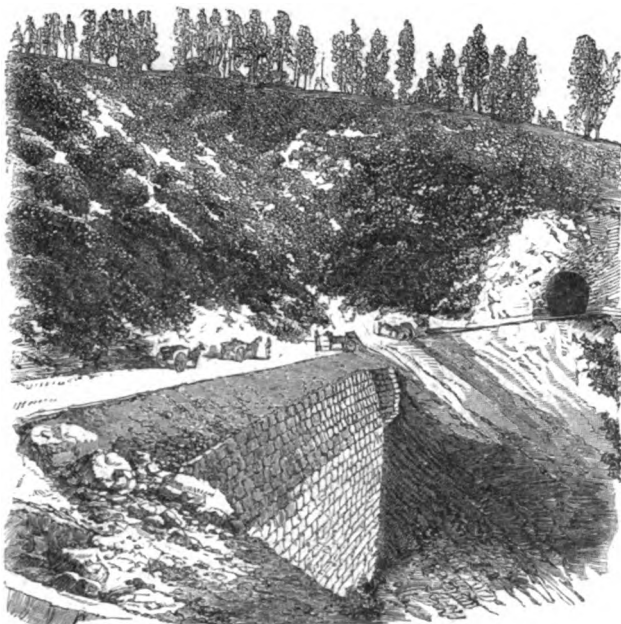


No. 6.
First Trestle in Clipper Ravine.

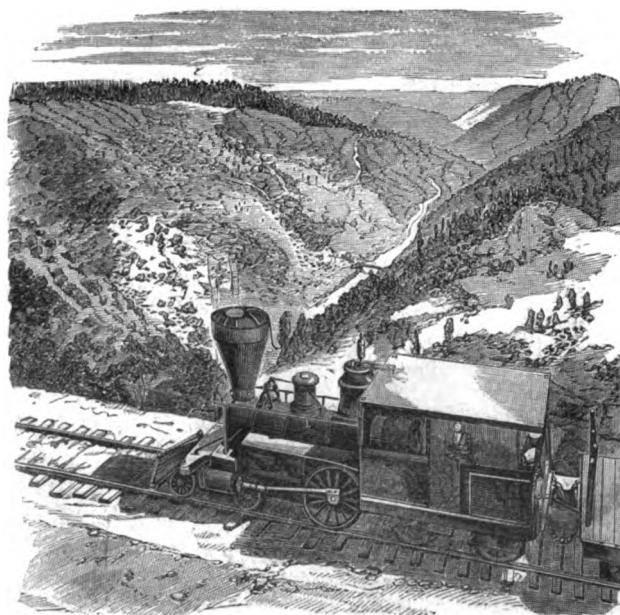
THE CENTRAL PACIFIC RAILWAY OF CALIFORNIA.

MR. SAMUEL S. MONTAGUE, CHIEF ENGINEER.

(For Description, see Page 80.)



No. 7.
Horse Ravine wall and Grizzly Hill tunnel.



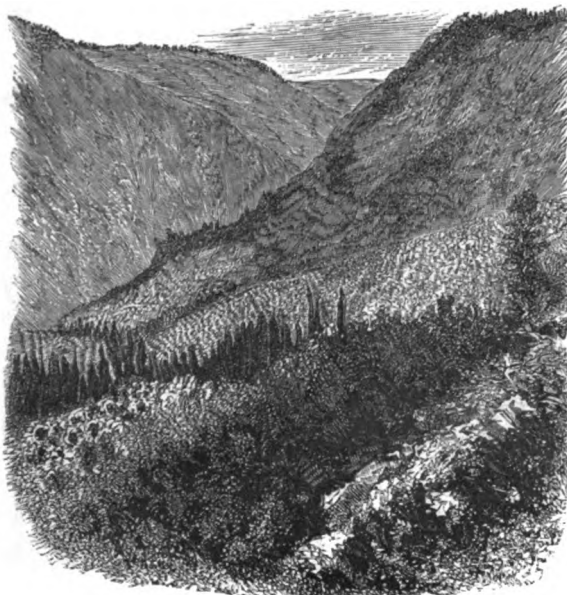
No. 8.
American River and Cañon from Cape Horn: river 1400 ft. below rail level.



No. 9.
View near Dutch Flat.



No. 10.
Hydraulic mining at Gold Run.



No. 11.
Green Valley and Giant's Gap, 1500 ft. below railroad.



No. 12.
Crystal Lake, 14 miles from the summit of the Sierra Nevada and 91 miles from Sacramento.

can be worked faster than one which is perfect, and a long and very perfectly insulated suspended wire would probably retard the extremely rapid signals of an automatic telegraph.

"163. Induction is thus the cause of *prolongation of current* and *retardation of signals* in cables and underground wires."

There is perhaps no branch of electricity so little understood, or so difficult to convey to the non-professional reader, as the effects of induction upon the transmission of currents of electricity. Mr. Culley does not enter deeply into the question of the velocity of electricity. He could not well do it in a handbook. It is an abstruse question that requires the use of mathematics to develop fully. The theory of the subject possesses this anachronism, that while it demands the conception of the infinite and indefinite velocity of electricity *per se*, it shows the finite and definite speed even to a walking pace of working electric currents. The mathematical development of the theory by Sir W. Thomson has received the most ample confirmation in practice by our leading electricians. Indeed, there is, perhaps, no instance in the applied sciences where the pure inductive reasoning of the mathematics has led to such grand practical results. Practice almost universally leads to theory, but in this instance theory has led to practice.

Atmospheric electricity, earth-currents, or deflexions as they are sometimes called, are carefully described.

"175. Occasionally, especially during the aurora borealis, strong currents, sometimes steady, at other times changing from positive to negative very rapidly, appear in the wires. These currents are not caused by atmospheric electricity, for they cease if a wire be disconnected at one of its ends, and they appear equally in buried and in suspended wires. They seem rather to be caused by currents flowing from one part of the earth to another, which enter the wires by one of their earth connections and leave them by the other.

"Lines running N.E. and S.W. are most frequently affected; lines lying N.W. and S.E. are not often disturbed, and, if affected, the currents are weak. It seems, also, that the direction in which the current flows changes with the hour of the day, so that one line may be more strongly affected in the morning, another in the afternoon. The current has frequently been seen to leave one circuit and to appear upon another previously free.

"176. The direction of the circuit is not determined by the actual course of the wires, but by that of a straight line drawn from one extremity, or earth-plate, to the other, modified by leakage to earth from bad insulation or faults. These currents are almost always passing, but it is only occasionally, during what are called *magnetic storms*, that they are sufficiently powerful to affect the telegraph, except in interfering with tests for the resistance of the wires. The currents are sometimes as powerful as that from eighty cells of the battery on short circuit, and will give sparks. They have a direct effect upon the magnet without the aid of a conducting wire, so that the delicately suspended magnets of a magnetic observatory are moved by them."

There is a long chapter devoted to insulation, the purport, value, and method of examining and testing insulators, whether for aerial or subaqueous purposes. The construction of a line of telegraph, whether overland, underground, or submarine, the methods of testing for faults and determining their position, receive ample illustration. A description is given of the different instruments used for the transmission of messages, viz., the small instrument, double and single, the Morse printing, with all its recent improvements by Digney and Siemens, single and double current working, open and closed circuits, sound apparatus like Bright's bells; Barns's ink-marker, switches and commutators, relays and translators, *et hoc genus omne*. The work ends with an appendix containing notes, formulae, and tables on many valuable and useful points. Indeed, the volume is one of those that is valuable both to the tyro and the adept, to the student and the professor, to the man as well as the master. The tables at the end make it a most valuable work of reference, and it fills a void that very much required filling upon the table of the telegraph engineer.

THE BAR OF THE MISSISSIPPI.—A company has been formed to remedy the obstacles which the bar of the Mississippi offers to navigation. The system which this company proposes to apply for the relief of ships consists of an apparatus of caoutchouc forming a kind of floating dock, which will be manoeuvred with the aid of two tugs. The company hopes by this means to raise to the extent of 8 ft. ships drawing 20 ft. water, and to enable them to get over the bar in less than three hours. The company has obtained from the legislature of Louisiana a privilege of four years on condition of commencing operations at once. The state named has carried out recently certain dredging works at the mouths of the Mississippi, which have opened out a channel of 18 ft. water; but the works having ceased, this channel has begun to fill up again, showing that dredging operations must be continuous in order to be of any service.

THE ISLAND OF OPARO.—In connexion with a line of steamers recently established between Wellington (New Zealand) and Panama, it may be noted that the company concerned has established a coal depot in the island of Oparo, about nine days' run from Wellington. The voyage lasting about twenty-seven days, coal occupies a considerable space on board the steamers, and it will be very advantageous to put in at Oparo, which possesses an excellent anchorage. The island, which is healthy and mountainous, contains only 500 inhabitants. It was discovered in 1791 by the celebrated Vancouver.

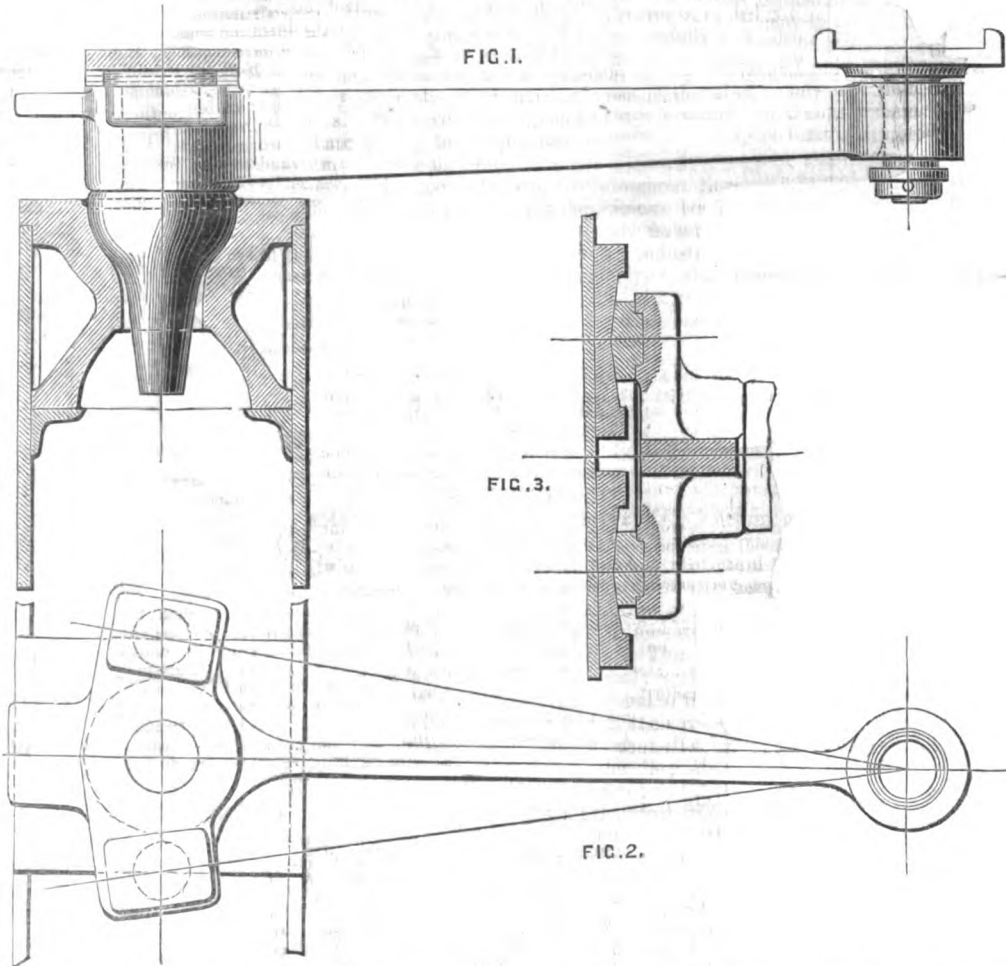
VAESSEN'S TANK LOCOMOTIVE.

We give, on page 90, a longitudinal section and plan of a ten-wheeled tank locomotive, constructed on M. Vaessen's system, by the Société St. Léonard, of Liège, and exhibited by them at Paris. This engine is similar in its general arrangement to those built by the same makers for the Isabelle II. (Alar-del-Rey and Santander) and Liégeois-Limbourgeois railways, and its main peculiarity consists in the means adopted for enabling it to traverse sharp curves with facility. As will be seen from the engravings, the engine has six coupled wheels, with a four-wheeled bogie in front; and the trailing-wheels have a lateral play allowed them of about $\frac{1}{4}$ in. on each side of their central position. The bogie-frame is connected to the main frame of the engine in such a manner that it can not only rotate on its central pivot, but can also move laterally so as to adapt itself to any curve on which the engine may be placed. The arrangement of the connections between the bogie and main frames is shown to an enlarged scale in the annexed Figs. 1, 2, and 3. By inspecting these figures and the longitudinal section on page 90, it will be seen that the bogie-frame carries a socket, in which the pin, O, fits, this pin forming the pivot on which the bogie turns. The pin, O, however, is not fixed to the main frame of the engine, but secured in the hind end of a link or radius bar, M, which is 3 ft. 3 $\frac{1}{2}$ in. long, and the front end of which takes hold of a pin, N, fixed to a strong transverse stay extending across the front end of the engine under the smokebox. The hind end of the radius-bar is widened out as shown in Figs. 2 and 3, and the

Diameter of tubes (external)	...	...	ft. i
Heating surface: tubes	...	1220	square feet.
firebox...	...	107	" "
Total	...	1327	
Pressure of steam	...	104 lb.	per sq. inch.
Contents of tanks	...	1430	gallons.
Weight of engine, empty	...	36	tons.
" " in working order:			
" " on coupled wheels	...	37	tons.
" " on bogie	...	11	"
Total	...	48	

As will be seen by the plan, the valve-chests are placed above and outside the cylinders; and the valve-gear is of the Walschaerts kind. We gave an engraving of it on page 33 of the present volume. The front and hind pairs of coupled wheels have their springs arranged over the axle-boxes in the usual way; but the middle pair of wheels are without springs, the spring pins resting on the tops of their axle-boxes, each bearing against the underside of a short beam, the ends of which are connected by links to the ends of the compensating beams, shown in the longitudinal section, the other ends of these beams being coupled by links to the springs of the front and hind pairs of coupled wheels respectively.

The feed-water is carried in a pair of side tanks, which extend



upper side of this widened portion is fitted with two pairs of double inclines, S S, which bear against corresponding inclines fixed to the underside of another transverse stay, as shown in the longitudinal section and in Fig. 3. The pin, O, can thus move laterally, its movements being governed by the radius link, M, and the inclines, S. The trailing-axle of the engine has a lateral, but no radial, movement, the side play being permitted by making the axle-box guides $1\frac{1}{2}$ in. narrower than the recesses in the axle-boxes in which they fit, and the movement being restrained by double inclines fitted to the top of each axle-box in a very similar manner to that adopted in the case of Mr. Burnett's St. John's-wood engines, which we illustrated and described last week. The trailing crank pins have spherical bearings.

The principal dimensions of M. Vaessen's engine are as follows:

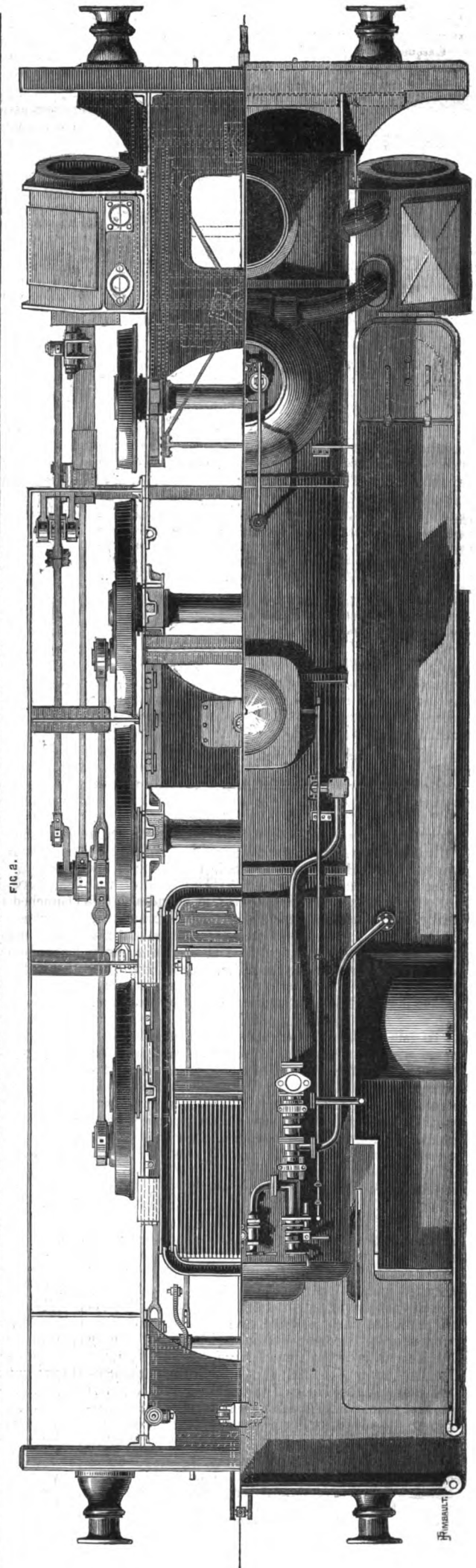
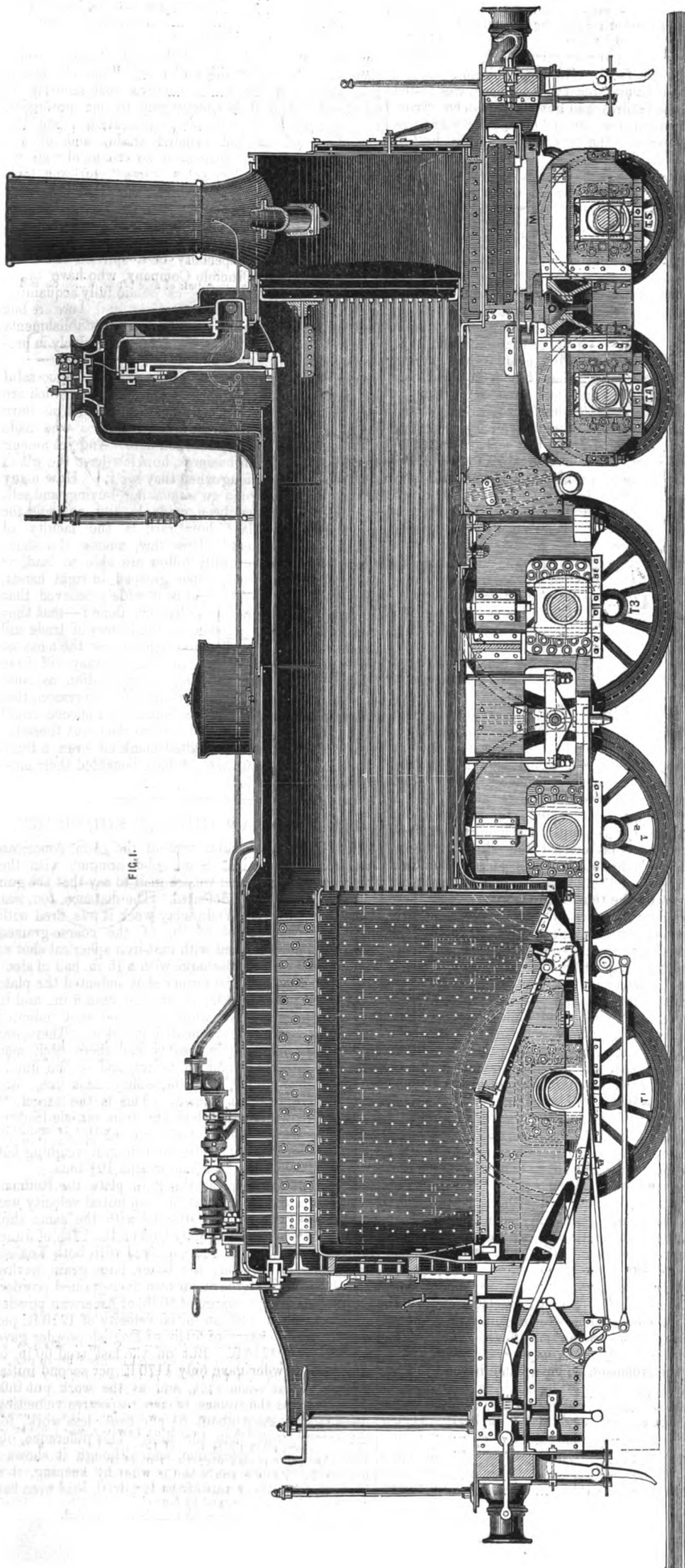
Diameter of cylinders	...	1	6 $\frac{1}{2}$
Stroke	...	1	11 $\frac{1}{2}$
Transverse distance between centres of cylinders	...	6	8 $\frac{1}{2}$
Inclination of cylinders	...	...	1 in 8 $\frac{1}{2}$
Length of connecting-rod between centres	...	8	2 $\frac{1}{2}$
Diameter of coupled wheels	...	4	3 $\frac{1}{2}$
Diameter of bogie wheels	...	2	7 $\frac{1}{2}$
Extreme centres of coupled wheels	...	9	10 $\frac{1}{2}$
Centres of two hind pairs of coupled wheels	...	5	3
Centres of bogie wheels	...	8	7 $\frac{1}{2}$
Total wheel base	...	17	8 $\frac{1}{2}$
Vertical diameter of barrel of boiler (smallest plate)	...	4	1 $\frac{1}{2}$
Horizontal " "	...	3	11 $\frac{1}{2}$
Height of firebox at front	...	5	1 $\frac{1}{2}$
" " at back	...	3	9 $\frac{1}{2}$
Width " at top	...	3	5 $\frac{1}{2}$
" " at bottom	...	2	10 $\frac{1}{2}$
Length " inside	...	7	2 $\frac{1}{2}$
" " of tubes	...	12	1

from about the middle of the length of the firebox to the smokebox, the spaces between the hind ends of these tanks and the footplate being used as coal bunkers. The boiler is fed by a pair of injectors placed on the top of the firebox casing, as shown in the longitudinal section. The draw-hook at the hind end of the engine, instead of being attached to the trailing buffer-beam as usual, is coupled to a long drawbar, A, which is cranked downwards, and is connected at its front end to the pin, B, which passes through a transverse stay carried across the engine between the front and middle pairs of coupled wheels. The pull is thus taken from a point near the middle of the length of the engine.

The firebox casing is of the flat-topped form now becoming common on the Continent, and the crown of the firebox is stayed to the top of the casing in a similar manner to the sides. The sides of the casing above the level of the firebox crown, are tied together by numerous transverse, as shown by the longitudinal section; and the back plate of the firebox casing, and the smokebox tube-plate are strengthened by gusset-stays. The remaining details do not require any special description.

A STRANGE TELEGRAPHIC FREAK.—A few weeks ago a couple of wires on the New York Central Railroad began to act very unreasonably. At ten o'clock in the morning they would "strike work," and resume at four in the afternoon. A careful examination of the line produced no result. The superintendent himself looked into the matter and saw nothing. It was a complete puzzle. An old Albany operator, however, was more successful. About sixty miles west of that city he found a point where the wires passed over the roof of a building, almost touching it. As the sun rose the wires fell, and at twelve o'clock they lay snugly together on the tin roof. As the sun fell they cooled and rose, and by four o'clock they were in their proper positions. Of course the trouble was rectified.

VAESSEN'S TANK LOCOMOTIVE, AT THE PARIS EXHIBITION.
 CONSTRUCTED BY THE SOCIÉTÉ ST. LÉONARD, LIÈGE.
 (For Description, see preceding Page.)



PUBLISHER'S ANNOUNCEMENT.

Advertisements cannot be received for insertion in the current week later than 5 P.M. on Thursday. The charge for advertisements is three shillings for the first four lines or under and eightpence for each additional line.

The price of ENGINEERING to annual subscribers, receiving stamped copies at places three miles away from the General Post Office, is 11. 1s. 8d. If credit be given, the charge is 2s. 6d. extra, subscriptions being payable in advance.

Cheques and money orders to be made payable only to Mr. Charles Gilbert.

Office for Publication and Advertisements, No. 87, Bedford-street, Strand, W.C.

ENGINEERING is registered for transmission abroad.

D. Van Nostrand, 192, Broadway, New York, is the sole American agent for ENGINEERING, and is authorised to receive all Subscriptions and Advertisements from America for this paper.

Le bureau d'ENGINEERING pour la France est 15 Quai Malaquais, Paris, chez E. Lacroix, Directeur des Annales du Génie Civil.

ENGINEERING.

FRIDAY, AUGUST 2, 1867.

MECHANICAL ENGINEERING.

AT one time during the mania for limited-liability companies there was a general readiness on the part of investors to share in the supposed large profits of old-established mechanical engineering firms. Of the concerns, however, taken over by companies, but few have paid fair rates of dividend, and a number are being wound up. Unless united with special skill (intrinsic, if not publicly acknowledged) or with singular commercial tact, or unless based upon some distinguishing, exclusive, and profitable specialty, mechanical engineering does not offer a promising field for the investment of money. The merchant can employ his capital in a hundred different ways, and can often "turn it over" in a day or in a week; but the mechanical engineer must first lock up a large sum in special plant, and although a marine engine, a locomotive, a planing-machine, a turbine, a loom, and a piece of ordnance might be supposed, by others than mechanics, to employ much the same class of machinery in their production, each really requires a distinct class of buildings and tools, and, what is more, a special class of workmen, and if orders fall off in the particular class of work for which these are adapted, the engineer must work short time or shut up altogether. The workmen, too, require great care in their selection, and are generally ready to strike upon every opportunity. Starting fresh in business, and especially if his factory be devoted to a class of work not yet widely known, the engineer is bound also to a heavy and constant expenditure in advertising and in agencies. And few men are more exposed to the effects of those periodical vicissitudes in trade, which, reaching so widely, peculiarly affect the speculative and enterprising classes with whom the mechanical engineer has perhaps more than an average dealing.

To gain a name for excellence of workmanship, a name widely recognised in public as well as in the trade, is of immense value; but this oftener takes many years, and, however worthy the ambition of the true mechanic, the prospect is not one inviting the investment of capital with a view to early and extensive profit. There must be a novelty of some kind to start a business successfully, the novelty must be intrinsically good, and the engineer must know how to push it—for the best invention requires pushing—and he must know, too, how to keep it as much as possible in his own hands. Boulton and Watt's steam-engine was such a novelty, and it was well pushed, too. Robert's self-acting mule established the prosperity of the Atlas Works, Manchester, and Giffard's Injector has contributed greatly to maintain it. Bullough's loom patents have returned hundreds of thousands of pounds in profits to the exclusive makers. Nobody had a monopoly of locomotive-making; but had George Stephenson known of, and purchased and defended, Neville's patent (of 1826) for the multitubular boiler—and every English locomotive made from the time of the Rocket down to 1840 was a clear infringement of that patent—the Newcastle works would have become well-nigh a mint to the Stephenson family. Who can analyse the wonderful success of Mr. Penn as a marine engineer, and how it is that he has so long carried the Admiralty in his pocket? Even in his case,

although he was not the first to make either the oscillating or the trunk-engine, he made both his own. And had he not been a big-hearted man, and allowed everybody, on payment of a moderate royalty, to use his wood bearings, he would have had the whole screw steam-ship interest at his feet. In the hands of a selfish engineer, one having Mr. Penn's other advantages and opportunities, this single invention might have paid five millions, since it virtually carried with it a monopoly of all screw-engine building. Look at John Brown, of Sheffield. He, too, took up a novelty before any other ironmaster (with all there was in the papers about La Gloire) had got his eyes open. True, there was no patent for armour-plates, but there was a virtual monopoly in the very magnitude and cost of the plant for making them. What a business has Clayton, Shuttleworth and Co.'s become! Here is a single firm which has built nearly eight thousand steam-engines within the last twenty years. They hit off the favourite familiar locomotive type just at the time when the farmers were beginning to think of using steam. In their particular trade no other firm can ever have another such opportunity, and surely none could have improved it better. And they, too, have a patent, for a simple common-sense thing, viz., placing the cylinders within an upward extension of the smokebox, and so keeping them hot, and this, with the help of a little jockeying, enables their engines to work more expansively than others in the Royal Agricultural Society's trials, and thus, as at Bury, a fortnight ago, to carry off the first prize. But it would be idle to pretend that the extraordinary success of the great Lincoln firm is due to this mechanical expedient, for they have thrived irrespective of agricultural shows, and in virtue of priority, good work, the perfect organisation of their factory, and to the thorough publicity which they have obtained for their productions all over Europe. Gwynne's centrifugal pumps afford another instance of the thorough success of a well-managed specialty. Although the late Mr. Appold is the putative father of all centrifugal pumps, and he took no patents, and large numbers of very successful pumps are still made in his name, Gwynne's pumps are nevertheless believed to have paid their manufacturers nett profits of nearly 100,000*l*.

There are many other successful mechanical engineering businesses, based upon special novelties, still growing up. Look at that of the Tangyes, in Birmingham. Not many years ago the five brothers in this firm were working upon their father's farm in Cornwall. Now they have one of the most unique and prosperous factories in the kingdom, and the Cornwall Works are worth a day's journey to see. Their specialty has been hydraulic jacks and Weston's famous pulley-blocks; in short, the most powerful, concentrated, and simple mechanism whereby men may conquer that eternal and stubborn force, gravity. Tangye's hydraulic jacks at last launched the Great Eastern, and these, almost their first job, also launched them on the tide of prosperity. Now there is not a more rising business in the kingdom, nor are there many works where such thorough commercial management is blended with equally thorough mechanical skill, tact, and ingenuity. How Aveling, too, has cut out the traction-engine trade for himself! He saw, what others refused to see, that traction engines must be strong and simple; and while the great lights of the profession were gravely discussing poor Boydell's and Bray's complicated giants, the price of each of which was nearly that of a railway locomotive, Aveling, with one or two patents for excessively common-sense dodges, was driving all other engines off the road, and now has hundreds of his own working in England and abroad. It is not too much to say that Aveling has done as much for road-traction as Fowler did for steam-ploughing. Chaplin's steam-cranes afford another instance of a successful specialty; but Chaplin had no monopoly of steam-cranes, and although some engineers, with the same opportunity, would have established one, the trade is now divided by a number of eager provincial firms, who would almost make us believe that they were the original and successful makers. Even in boiler-work Adamson has established the best practice, and made his boilers a specialty upon which employers of steam power set a special value. Stiffened flue joints, drilled rivet-holes, and a variety of excellent detail have given the Adamson boiler a name beyond that of perhaps any other maker; but Mr. Adamson has not been content to keep to boiler-making, but has been by turns a Bessemer steel maker, a blast furnace master, and an industrious patentee of various mechanical contrivances. Even railway signals have given rise to a fine business, and there are few lines not now fitted with Saxby and Farmer's ingenious

apparatus, without which it is doubtful whether the in and out traffic of our great metropolitan and junction stations could be worked at all, except with frequent accidents and constant delays. Not merely in mechanical construction, but in collateral branches, the mechanical engineer has the example of many businesses, founded on specialties and managed with excellent tact and success. Chatwood's safes, the first in which real engineering *vous* appears to have been applied to this branch of manufacture, are now, despite their higher price, taking the place of the old sheet-iron and angle-iron boxes, wherever real security is an object. And it is encouraging to our profession to find such a common-sense innovation upon the prejudices of an old crusted trade, and of the jog-trot purchasing class who so commonly go by venerable precedent, to see a "live" safe and lock engineer making his way so well. Even the plumbago crucibles, although not exactly engineering works, are great helps in certain most important branches of mechanical engineering. This branch of manufacture has been made the specialty of a spirited firm, the Patent Plumbago Crucible Company, who have taken pains to make the metallurgical public fully acquainted with the merits of their productions, and there are but few large steel and brass founding establishments which do not now employ plumbago exclusively in preference to clay crucibles.

We might go on enumerating scores of successful businesses, each based upon some specialty, which are now rising into wealth and importance, such as have been long enjoyed by certain older houses who made their name perhaps a generation ago. And yet among the great number in business, how few have the wit to recognise a good thing when they see it! How many believe that we should go on making, buying, and selling exactly what has been made, bought, and sold for years before! Alas! how rare is the faculty of mechanical judgment! How few, among the thousands who can so readily follow are able to lead, or even to discern what, when grasped in right hands, may be able to lead! And is it widely believed that successful engineers thrive by luck alone?—that they merely draw lucky numbers in the lottery of trade and invention? Those who thoroughly know the successful engineers will not believe this, for they will have evidence of such engineering discrimination as must convince them, if their minds are open to reason, that nothing short of the highest human prescience could have schemed and adopted and worked out those inventions which have benefited mankind even a thousandfold more than they can have benefited their most successful proprietors.

THE RODMAN GUN AT SHOE BURY.

WE have at last had a trial of the 15-in. American cast-iron gun against 8 in. solid armour, with the Warrior backing, and we are glad to say that the gun has been thoroughly defeated. The distance, too, was but 70 yards. On Wednesday week it was fired with battering charges of 60 lb. of the coarse-grained American powder, and with cast-iron spherical shot of 453 lb., and on one discharge with a 15 in. ball of steel, weighing 498 lb. The former shot indented the plate about 4 in., and buckled it, in one case 5 in., and in another only 1.6 in., while the steel shot indented the plate 8.2 in., and buckled it 1.4 in. There was no penetration, and in reality had there been men standing directly behind the target, and in the line of fire, or at any point on either side of this line, they would have been unharmed. This is the target, it is to be remembered, which the 9 in. muzzle-loading rifle gun, firing Palliser shell, with 43 lb. of English powder, can just penetrate, the rifle gun weighing but 12½ tons, while the Rodman weighs 19½ tons.

In firing, however, at the 8 in. plate the Rodman has not quite done its best, for the initial velocity was considerably below that attained with the same shot on the former or preliminary trial on the 27th of June. On that occasion the gun was fired with both English and American powder, the latter, large grain, having five-sixths of the force of our own finer-grained powder. On that occasion a charge of 60 lb. of American powder gave the 453 lb. shot an initial velocity of 1210 ft. per second, and a charge of 50 lb. of English powder gave a velocity of 1214 ft. But on the last trial 60 lb. of American powder gave only 1170 ft. per second initial velocity to the same shot, and as the work put into the shot is as the square of the respective velocities, the last trial gave about 6½ per cent. less work, for the same charge, than the first. This difference, obviously, is not a great one, and although it shows a probable deterioration of the powder by keeping, it is evident, from the result of the last trial, that even had

the full former initial velocity been attained, but little more injury would have been done to the target. Indeed, we pointed out more than a year ago, in reply to Captain Ericsson (page 346 of our first volume), that even a 20 in. shot, fired with 100 lb. of powder, could not be expected to go through a good 8 in. plate protected by proper backing.

The 15 in. cast-iron gun was not designed to punch 8 in. plates, if indeed it was designed with reference to armour-clad ships at all; but we have been so often told by believers in the American system of ordnance that this gun would send its shot through anything we could put against it, that it became a matter of real interest that the trial should be made, and we proposed that it should be made against the Royal Sovereign, at the time when the Miantonomoh was in our waters last year. Of course the system of large smooth bores does not necessarily involve the use of cast iron for the gun, and were a wrought-iron 15 in. smooth bore made strong enough to fire a 498 lb. steel ball with, say, 83 lb. of English powder, or one-sixth charge, and taking the value of each pound of powder as but 170,000 foot-pounds, which is hardly up to the average, we should have an initial velocity of 1348 ft. per second, 6300 foot-tons of work (more than twice that of the 9 in. muzzle-loading rifle gun), and nearly 135 foot-tons of work per inch of circumference, or one-half more than that of the 9 in. 250 lb. shot fired with 43 lb. of powder. Still even with this advantage in *vis viva*, the 15 in. sphere might not pierce like the 9 in. punch. But the pressure per square inch upon the chamber of the 15 in. gun, when fired with 83 lb. of powder, would be but slightly more than two-thirds that per square inch in the 9 in. gun fired with 43 lb. of powder. Of course the larger gun would be at least one-half heavier, but the advantage of the lower powder pressure at which large smooth bores can be fired for a given amount of work would seem to constitute a great point in their favour. Thus we now make a 13.3 in. gun which we call a 600-pounder, and we sometimes fire it with 70 lb. of powder, and once or twice it has stood 90 lb. Yet with one-fifth heavier shot than we should propose (in steel) for a 15 in. smooth bore, it has 21½ per cent. less sectional area, and the gun is further weakened by the rifle grooves. On the other hand, the 600 lb. bolt, if of Palliser chilled iron, would go through a target which the 500 lb. steel sphere, impelled by the same charge of powder, would certainly fail to penetrate. But the 600-pounder might, as it has, fail at the fourth or fifth round, while the smooth bore might be good for very destructive work for 200 or 300 rounds.

While we have now little to fear from the 15 in. cast-iron American guns, it is nevertheless evident that with our apparent inability to make *very large* rifle guns, there is much yet to be said in favour of smooth bores.

The notes of firing with the cast-iron gun on Wednesday week are thus given:

AMERICAN 15 IN. GUN; WEIGHT OF GUN, 19½ TONS;
RANGE, 70 YARDS.

First Round.—American cast-iron round shot; weight of shot, 453 lb.; diameter, 14.885 in.; charge, 60 lb. American powder; velocity, 1170 ft. per second; work, 4290 foot-tons; work per inch of circumference, 91.7 foot-tons; indent, 4 in.; buckled, 5 in.; plate not penetrated.

Second Round.—Pontypool No. 6 cast-iron shot; weight of shot, 452.5 lb.; diameter, 14.89 in.; charge, 60 lb. American powder; work about 4290 foot-tons; buckled, 1.6 in.; total effect rather less than in No. 1 round.

Third Round.—Firth's steel round shot; weight, 498 lb.; diameter, 14.945 in.; charge, 60 lb. American powder; velocity, 1134 ft. per second; work, 4440 foot-tons; work per inch of circumference, 94.6 foot-tons; indent, 8.2 in.; buckled, 1.4 in.; shot had seven radial cracks in it, and remained sticking in the plate.

ENGLISH 9 IN. GUN; WEIGHT, 12 TONS.

Chilled iron shell.—Weight, 250 lb.; charge, 43 lb. English L. G. rifle powder; velocity, 1337 ft. per second; work, 3100 foot-tons; work per inch of circumference, 110.9 foot-tons; depth of indent, 19½ in.; diameter of hole, 11 in.

TECHNICAL EDUCATION.

UNDER a well-organised system of English instruction the French and the Germans have acquired, within a few years, perhaps all the knowledge, and certainly a very large proportion of the experience, which had previously been reckoned as the exclusive possessions of our own engineers and manufacturers. Indeed, beyond the mere drudgery of translation into French and German, we have been their most assiduous teachers. We have shown them everything, told them everything, and written out everything it was in our power to write, concerning our arts, in specifications published at an average cost of perhaps a shilling apiece at the Patent Office, in books

like Dr. Ure's, and Brande's, and Bournes', and Truran's, and Fairbairn's, and Edwin Clark's, and D. K. Clark's, and in the published papers of our numerous professional institutions, and by exhibition, by personal explanation, by the instruction of foreign pupils in our offices and workshops, and by the sale of our best examples of machinery with the knowledge that they were to serve abroad as models, we have done our best to place our foreign customers upon an independent footing, and thus to make them rivals of ourselves in many of our best markets. And we have found our pupils (once they were through with their revolutions and Continental wars) apt and studious, and they have certainly done no discredit to their teaching.

From Watt's discovery of the grand principle of separate condensation to the present day, we have had a century of English invention, of which the hundred years of useful and wonderful achievements have lent a lustre to our time, which history will yet place even above that of the classic genius of antiquity. Ours has been the age of the genius of utility and philanthropy as distinguished from the genius of arms and of heathen taste. The astonishing frequency and value of our discoveries, unrivalled, nor indeed ever so remotely approached by foreign inventors and discoveries, has undoubtedly established a faith among ourselves in the invulnerability of English practical genius; and it is but natural that we should still feel assured, in a great measure, of the continued supremacy of English invention and productive skill, although the two are wholly distinct from each other, and the latter, if not the former, may be acquired by the people of other nations, and that with comparative ease. And it is but natural that observing people abroad, wishing to stand in our shoes, should analyse the principles of English invention and discovery more closely than we have possibly done ourselves. Hence it is that we now hear so much of foreign technical education, which has been, and now is, systemised instruction chiefly in the principles of the arts in which we are supposed to excel.

Whether our own appliances for technical instruction are or are not inferior to those now employed upon the Continent, it is certain to practical minds that, with the thousand channels of publicity now available, no invention or improvement of real value can be made, either here or upon the Continent, without its being soon known and adopted by all the industrial nations. If we go on inventing and discovering, we must now expect to see our inventions and discoveries bearing early fruit in France, in Belgium, and in Germany; and if the French, the Belgians, and the Germans should yet, as so far they have never done, show more original genius than ourselves, they will as certainly find us availing ourselves of all, that is really good, that they have achieved. We have no wish to undervalue a knowledge of principles, but we are assured of this fact, that even among comparatively uneducated men, a successful *result* becomes very quickly public, and that the means of attaining it are almost as quickly communicated. There is indeed no keeping such things secret. There is no doubt that the nation which continues to achieve original and great inventions, while retaining the power of working them out in successful practice, will enjoy a valuable *prestige*; but as for the power of commercial competition, as based upon the mere cheapness of production, it would really matter little *who* made the inventions or improvements, so long as England enjoyed advantages in cheaper coal, or iron, or labour, or transport, to work them into goods. The conditions just named are, however, independent of invention, and with respect to them it is not impossible that the Continental nations are already upon an equality with us. As for invention itself, wide-spread technical education will not stimulate it. Our Royal Engineers have a better technical education than any other members of our profession, and yet we believe it does them no injustice to say that they have neither invented nor initiated new and improved practice. None of our professors of engineering in the various colleges or universities have given us inventions, unless it be Professor Rankine, who has provisionally protected a few impracticabilities, the examination of which has provoked wonder that so clever a man could scheme such silly things. We are not aware that any student of our technical schools—and we have several of them, for all that is said in one or two professedly technical publications to the contrary—has yet given us a valuable invention, not but that this may all come by and by. France, too, has long had her school of the Ponts et Chaussées, her Ecole Centrale, her school of mines, and her Conservatoire des Arts et Métiers, and we are really unable to point to a single invention of im-

portance which has proceeded from either of these establishments or from any one taught at them. Nor are we reluctant to say that we believe that all technical instruction is apt rather to chill invention, or possibly prevent it altogether, meaning as we do by technical instruction the imparted teaching of science and practice, in the finite sense which nearly all teaching commonly implies.

But would we deprecate technical instruction on this account? By no means. It is easily provided, often easily received, is always useful to the recipient, nay, invaluable to many who would otherwise remain for their lives well nigh inefficient and valueless members of the industrial community; but we contend that it will never take the place of original genius of the kind which has made England and Scotland so famous for the *great* inventions, those which have revolutionised modern industry, if not society itself. We believe it to be indispensable that the true inventor shall be self-taught, and this country will always afford facilities for self-instruction in nearly every useful art known to man. It is rather to the student, individually, that technical education, so called, will prove valuable by bettering his own condition, while the advantage to the nation, although not infinitesimal, may after all be but slight.

THE SOCIETY OF ENGINEERS.

MR. HUGHES, M.P., has put a notice of motion on the paper, "to ask the vice-president of the Board of Trade whether a petition from the Society of Engineers to her Majesty in Council, for a charter of incorporation, had been referred by the Privy Council to the Board of Trade for a report thereupon; and whether the Board of Trade, on the opposition of the Institution of Civil Engineers, had reported that from the alleged similarity of the name, 'Society of Engineers' and 'Institution of Civil Engineers,' the charter ought not to be granted."

We shall no doubt know, in time for our next impression, what is the report of the Board of Trade to the Privy Council as to granting the prayer of the Society of Engineers for the rights of a corporate body, in so far as these consist of the power of suing and being sued, and holding property of a moderate annual value. With the exception of these rights—and upon an ungracious refusal of a charter, they could of course be taken, at will, under the limited-liability or limited-partnership Acts—the real *status* of the Society would not be altered by the concession. It is now "The Society of Engineers," and probably always will be. The members will never voluntarily change the name under which the Society has grown and prospered, and it is not likely that any other power will be called in aid for the purpose. The Society already enjoys a sufficient publicity, and this, of course, will be greatly increased by the ill-advised opposition of the Institution of Civil Engineers to an obviously reasonable application for moderate pecuniary powers, and for these only—these being, moreover, the sole privileges enjoyed by the Institution of Civil Engineers in virtue of its charter. No mere refusal of these powers will alter the name of the Society of Engineers, which will still be held, as now, as a body wholly distinct from the Institution of Civil Engineers. In the Society of Engineers, as in the Institution of Civil Engineers, no moneys are applied to what, in *trades*, are known as "trade purposes," and yet it is merely because of this misdirection of their funds that trades unions are denied the power of suing and being sued. As no suspicion of such misdirection has been raised with reference to the Society, we feel assured that the prayer for a royal charter will yet be granted.

THE CORLISS ENGINE.

THE discussion upon the Corliss engine, still going on in our pages, has so far led to little practical result. "Observer," although we have our doubts whether he really knows more of the working of the engine than, apparently, he knows of its history, is nevertheless a skilful tactician, and he has led a spirited attack against it, and those who really have the credit of the engine to maintain in this country have done little in the way of giving facts or fitting arguments to save it. It is easy to say that, if it be good, the engine will work its way in spite of opposition; but every man of business knows that plausible and public opposition to a new improvement really has great influence with the timid, who form the majority of the purchasing class. It is for this reason that we wish the engine in question had been more skilfully defended by its friends from the vigorous declamation of its opponents

—declamation which will be quoted and respected, too, by many who might otherwise have adopted these engines, and this notwithstanding that the declamation is easily answered, when competent engineers really address themselves to the facts of the case.

There are a few leading facts bearing upon the whole question. In the first place, whatever a few other engines may do here and there, it is certain that the majority of engines, with ordinary expansion valve gear, do not work their steam at the full boiler pressure upon the piston. And they waste a considerable amount of steam in their ports, and work also under the disadvantage of very considerable slide valve friction, and in many engines there is a considerable loss by compression. Again, they regulate their speed, when working under constantly varying loads, not by altering the expansion, but by throttling the steam, and this is necessarily attended, as we need not explain, with a certain loss.

Now, as compared with this, the Corliss engine opens its valves more quickly than they are opened in ordinary engines, and, as a matter within our own and in some of our correspondents' knowledge, admits steam of very near the boiler pressure upon the piston. The loss of steam in the ports is extremely small. Nearly the whole motion of the valves takes place while there is the same pressure upon both sides of them, and thus they work with exceedingly little friction. The exhaust valves are separate from, and independent of, the induction valves, and are set so as to allow of practically no compression. And the steam or induction valves are liberated at any part of the stroke (up to half stroke) by the governor, according to the speed, so that the speed of the engine under varying work is regulated by the expansion, and not by throttling. This, of course, is not new in itself; but Corliss effects the varying expansion with a nearly imperceptible strain upon the governor, and thus the engine can be kept to an almost absolute uniformity of speed, even under the greatest variations in work. We are speaking, not from any abstract consideration of the principles of the engine, but from an acquaintance of seven years with its action.

Now all these conditions are those of economical working. Not one is opposed to economy in the use of steam. They are worked out, however, by a valve-gear which, to look at it, is certainly complicated; and thousands of engineers, before Mr. Pinchbeck or "Observer" had probably thought of the subject, have counted the joints of this valve-gear, and in many cases concluded that there were altogether too many of them. But a multitude of joints does not necessarily form an objection. There are hundreds of joints in a watch-chain, yet it will work on for years and give but little trouble, and merely because the strain is slight. And so, in the Corliss engine, the work upon each joint of the valve-gear is very little, since each valve, when moving over a partly opened port, is in equilibrium, and it has but very little motion after the port is closed. We can state from our own knowledge, as no friend of the Corliss engine appears able to supply the information, that this valve-gear goes on for years without giving trouble, and that its parts are all cheap of construction, and easy of renewal and adjustment. To call them "rattletraps" is as unproductive of any real conviction in the minds of those who *know* their action, as it would be to apply the term "rattlehead" or "timberhead" to "Observer" himself. It is a term which had better been kept out of the discussion, and which but few, and these of the older school of engineers, now think of using.

This valve-gear, while fulfilling the very first conditions of economy in the distribution of steam, is equally applicable to condensing and non-condensing engines, to high speed and to slow-speed engines, and is wholly independent of steam-jackets, superheated steam, and much else that may go to make up additionally economical results.

"Observer," not, we are sure, from intention, but, more probably, because he has no knowledge of the history of the Corliss engine, treats it as if it were a mere experiment, of which the first public illustration had been made at the Paris Exhibition. So far from this, it has fought its way for the last eighteen years in the United States against much the same class of arguments as "Observer" now brings forward. It was originally introduced by its maker upon the condition only that it should be paid for out of the saving of fuel effected by it over the engines which it displaced. This was the case at several of the largest cotton mills in America; and we happen to know that the particular mills to which we refer are as complete in their construction and machinery as the very best in Lancashire. Against every phase of unbelief the Corliss engine steadily made way, and there are now many more than a thousand

in use in the States, and we know, personally, nearly a hundred users of them who would on no account part with them. Mr. Corliss's factory, at Providence, if not the largest, is one of the most complete in the world, and he and his engineers and agents are often in England to see our latest and best practice. All this forms a history which is not to be overlooked, and we have, besides, seven years' experience of the Corliss engine in this country—at Messrs. Pirie's great paper-mills, at Aberdeen. There are now, also, many at work here, and many more are building, and we never yet heard of one, once started, being taken down and replaced by another type. Those who are really interested in the subject will, we trust, watch the working of these engines, and, as in that case they certainly will, pay correspondingly little heed to mere declamation against it.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Railway Matters.—Legislation on Railway Bills has been especially unfortunate for the Scottish railroads during the present session. The Bill for the Amalgamation of the Glasgow and South Western with the Midland was the first to undergo rejection at the hands of the House of Lords' committee, after it had passed unscathed through the Commons. There is every probability that when brought in again next year it will suffer a better fate. The expense incurred in the contest has been very great. The next and last most important railway project was the pre-preference scheme of the North British Railway Company. It also met with the *coup de grace* in the committee of the House of Lords. The liabilities of the company are 1,875,000*l.*; and this sum it was proposed to raise in the shape of pre-preference stock. Permission was given by the committee to issue 848,000*l.* of debenture stock, and this may tide over the difficulties of this most unfortunate company. But the secretary of the company does not seem to think so; for in his evidence he said if the bill did not pass, there would be an immediate scramble on the part of the creditors to get what they could, and the company might virtually shut up. One wagon contractor had threatened to seize the company's wagons if his claim was not settled. In the case of the Edinburgh, Perth, and Dundee branch, the creditors had at one time actually put up engines to public auction, and they also seized the wire-ropes by which the trains were worked between the Waverley-bridge and Scotland-street station. This state of affairs cannot last long.

Opening of a New Slip Dock on the Clyde.—Whether the Clyde Trustees do or do not proceed with the construction of the graving dock that has been talked of more or less for the last twenty years, docks must be had if the port of Glasgow is not to be left behind by others. One has just been opened by a private shipbuilding firm, Messrs. A. and J. Inglis, at the Point House, where the Kelvin joins the Clyde, a mile or so below the harbour. It has been about eighteen months in construction, and on the day of the opening ceremony the Glasgow and Londonderry Company's steamer *Garland* was taken up for the purpose of being lengthened. The dock is so large that ships of 2000 tons can be repaired with as much facility as at any other port. The following are the dimensions: Total length, 850 ft., and 450 ft. dry at high water; breadth between the wharves, 67 ft.; main carriage, 150 ft. long, and can be lengthened to 275 ft. The hauling power is supplied by an engine of 30 horse power. Mr. Alexander Thomson, civil engineer and architect, has superintended the undertaking, and the principal contractors for the works are Mr. David Mainwell, who did the excavation and piling, Messrs. A. More and Sons, who supplied the hydraulic machinery, and Messrs. Moses Cairns and Company, who supplied the heavy iron castings. By and by the Clyde will be well off in respect of dock accommodation.

New Floating Railway Pier at Burntisland.—An undertaking of no mean magnitude and difficulty has just been completed at Burntisland, for the North British Railway Company, in the shape of a floating pier which has been in course of construction for the last two years. It is to supersede the pier which was erected seventeen years ago for the purpose of enabling the floating railways, as the large goods boats plying across the Forth, to and from Burntisland, really are, to approach the line of railway, and have the wagons transferred on board. The pier commences about 380 yards east of the Burntisland passenger station, and extends for 1000 ft. in a south-westerly direction, thus forming a harbour which is accessible at all states of the tide. Some idea of the extent of the undertaking may be formed when it is stated that 115,000 cubic yards of rock were blasted, and 53,000 cubic yards of earth and rubbish employed in making the embankment. The sea-wall is a substantial piece of work, the facings being composed of massive whinstone blocks, 4 ft. by 3 ft., and the pier itself is built on a rock foundation. The total cost of the works has been about 26,000*l.*, but this is exclusive of the stone employed, which was got on the company's own property, and would, if sought elsewhere, have raised the expense to something like 60,000*l.* Henceforth the trains of wagons will be so expeditiously shipped that the operation will not exceed six minutes. The machinery for conveying the wagons from the railway sidings to the floating railways has all been constructed by Messrs. P. and W. McLellan, Clutha Ironworks, Glasgow; and the cradle or bridge from the line to the ship has been built on the most ingenious principle, rendering it almost impossible for an accident to occur in the transit of the wagons from the shore to the steamers. The works have all been constructed under the superintendence of Mr. John Leslie, C.E.

Greenock: its Shipping, Sugar Trade, and New Harbour.—Some few days since there were no fewer than twenty-two vessels in Greenock with cargoes of sugar, besides others with timber and miscellaneous cargoes; and on one day there were as many as fourteen ships discharging sugar at once. So great has been the demand for harbour accommodation of late that the new or Albert Harbour had to be opened before the Customs authorities were prepared for it. The increase of the Customs re-

venue for the port of Greenock, to the extent of upwards of 200,000*l.* last year, was almost entirely owing to the sugar trade. While Greenock is thus progressing so rapidly, its neighbour, Port Glasgow, is very dull; even its sugar refinery has been turned to some other use. A new sugar refinery is about to be erected in Greenock. It is to be fire-proof, and of a substantial and ornamental character, and is to embrace all the newest improvements in arrangement and machinery for the saving of manual labour. Greenock has a sort of professional interest in the clipper ships that are engaged in the China trade, and therefore the result of the race at present in progress is looked forward to with some anxiety. The *Maitland* was towed out from Foo-Chow-Foo on the 31st of May, and got to sea on the 1st of June. The *Serica* left the next day, and the *Taeping*, *Fiery Cross*, and *White Adder* left on or before the 6th of June, and others were to follow in a few days. The most important shipbuilding contract of the last week or two is one made by Messrs. Caird and Company, who are about to lay down the keel of a screw-steamer of 2800 tons for the Hamburg and American Steam Packet Company, to be employed in the Hamburg and New York trade.

The White Sea Shipping Disasters.—The *Montezuma* transport, one of the ships sent out to Archangel by the British Government on the 1st of July, has just returned home. She landed at Dundee, rather than Aberdeen, on account of the great danger from the heavy sea prevailing at the last mentioned port. Amongst the British vessels lost in the White Sea six hailed from Aberdeen, and the rest belonged to other ports on the east of Scotland and England. Captain McDougall brought home in the *Montezuma* 131 sailors, one woman, and two children.

Agricultural Shows.—The Royal Northern Show of stock, implements, &c., has just been held at Aberdeen, and the Highland Society's Show is at present being held in this city. There is an unusually good display of agricultural machines and implements of various kinds, but the details must be held over till next week.

THE ROYAL CORNWALL POLYTECHNIC SOCIETY.—The thirty-fifth annual exhibition of this society will commence on Friday, the 23rd inst., at Falmouth. Medals and prizes in money will be awarded to the following objects: machinery and models, mechanical and other scientific inventions and improvements, specimens of naval architecture, natural history, scientific papers, specimens of ornamental art, and to all objects of interest connected with mechanics, science, and the fine and industrial arts, which are considered deserving by the judges of the various departments. This exhibition, being the only one of the kind in the west of England, and having been established for upwards of thirty years, affords an excellent opportunity for making known the merits of inventions, &c., throughout the district. Objects intended for exhibition or competition should be forwarded so as to reach Falmouth not later than Monday, August 12th, after which no space can be guaranteed. Mr. J. C. Stephens is the assistant secretary, and his address is the Polytechnic Hall, Falmouth.

THE BRIGHTON NEW STOCK.—With the old shares at 49, the Brighton shareholders last week sanctioned the issue of one-and-a-quarter millions of new shares at 45. This might have been regarded as a depreciation of nearly a quarter of a million upon the 5,400,000*l.* of old shares; but, so far from this, the new shares are actually being sought at 3 premium, or within 1 per cent. of the market price of the old shares. Even this is a crumb of comfort in these dull times. Our home lines get no mercy from Government; but the East Indian Railway Company is just out with a million of guaranteed 4 per cent. debentures, with five years to run.

STERNE'S PNEUMATIC BUFFERS.—It may not be widely known that india rubber, when pressed strongly against brass, adheres to it so tightly that the rubber may be itself torn without detaching it from the brass. Mr. Sterne, a New York engineer, takes advantage of this affinity, and forms a buffer spring, with numerous plates of brass, and intervening and cohering rings of india rubber. When compressed, the air, enclosed by the rings, also offers a certain resistance. Mr. Sterne's buffers, of which we intend shortly to give an illustration and more complete description, have given great satisfaction on the Great Western and the Metropolitan railways. Mr. Armstrong has adopted them for his whole line, and Mr. Burnett is now having them applied to fifty new carriages building for the Metropolitan Railway.

THE ATLANTIC TELEGRAPH.—It cost 11,000*l.* to repair the break of a few weeks ago in the Atlantic (1866) cable in shallow water, 2½ miles from the Newfoundland end. The cost, of course, was in sending out an expedition all the way from England. The last break is 50 miles out, and in at least 100 fathoms. What caused it? An iceberg, a wreck falling across it, surely not an anchor at this depth? It is clear, from the sudden failure of the cable, and from its exact resistance indications, that the injury is mechanical, and not a failure from natural causes of the insulation. The western ends of the two cables will need careful watching, and a repairing steamer should be, and no doubt soon will be, kept constantly stationed in Heart's Content Bay.

PETO, BETTS, AND CRAMPTON.—It is not without a sense of national humiliation that we contemplate the failure of a house which is identified with some of the grandest mechanical achievements of the present century. Perhaps no one, except Mr. Brassey, has filled so high a position among English contractors as Sir Morton Peto. Not only throughout Europe, but in Canada and other parts of the world, he will always be remembered as a leading pioneer of the railway system, and a great master in the art of organising labour. His fall has probably been as severe a shock to public confidence, in its own way, as that of Messrs. Overend and Gurney. It remains to be seen whether the lesson to be derived from it will be equally laid to heart. That lesson is the essential unsoundness of "contractors' lines."—*Times*.

WHAT WILL THEY BUY?—The House of Commons will adopt the report of their select committee, recommending purchases, to the maximum amount of 25,000*l.* of objects of art and science from the Paris Exhibition for the South Kensington Museum.

THE ENGINE TRIALS AT BURY.

THE Royal Agricultural Society has published the following reports of the judges upon the portable and fixed steam-engines tried at Bury:

SINGLE-CYLINDER PORTABLE STEAM-ENGINES.

Names of Exhibitors.	No. of Stand.	No. of Article in Catalogue.	Horse Power of Engine.	Getting up Steam.		Coal Burnt per Hour in lb.	Coal Burnt per Horse-Power.	Price.	Remarks.
				Time taken in getting up Steam.	Fuel Burnt in getting up Steam.				
					Coal. lb.	Wood. lb.			
Holmes and Sons ...	146	3472	8.55	All these engines required about one hour to get up steam.	41	8	50.67	5.92	£ 225
Burrell, C. ...	134	3063	8.10		56	8	68.24	8.42	250
Clayton and Shuttleworth ...	256	4733	8.10		44½	8	28.02	3.45	220
Brown and May ...	257	4747	8.10		36½	8	45.12	5.56	210
Barrow and Carmichael ...	242	4613	7.20		41	8	48.12	6.68	195
Reading Ironworks Company ...	114	2507	10.00		48	8	41.23	4.12	240
Ruston, Proctor, and Co. ...	250	4676	9.50		85	8	61.78	6.50	210
Marshall, Sons, and Co. ...	244	4621	7.80		48	8	47.10	6.03	280
Underhill, W. S. ...	170	4092	6.40		43	8	67.03	10.47	180
Ransomes and Sims ...	150	3555	10.00		44½	8	49.48	4.94	260
Allchin and Son ...	270	4780	8.10		40	8	41.64	5.14	215
Nalder and Nalder ...	272	4787	6.40		33	8	54.82	8.56	195
Tuxford and Sons ...	247	4639	8.10		52½	8	31.57	3.89	220

JOHN GOOCH.
F. J. BRAMWELL.
JAS. EASTON.

DOUBLE-CYLINDER PORTABLE STEAM ENGINES.

Names of Exhibitors.	No. of Stand.	No. of Article in Catalogue.	Horse Power of Engine.	Getting up Steam.		Coal Burnt per Hour in lb.	Coal Burnt per Horse-Power.	Price.	Remarks.
				Time taken in getting up Steam.	Fuel Burnt in getting up Steam.				
					Coal. lb.	Wood. lb.			
Clayton and Shuttleworth ...	256	4732	15.12	All the engines required about one hour to get up steam.	55½	8	55.98	3.70	£ 310
Brown and May ...	257	4746	12.50		67	8	69.07	5.28	260
Ransomes and Sims ...	150	3553	15.12		73	8	63.52	4.20	350
Tuxford and Sons ...	247	4641	14.22		78	8	61.55	4.32	355

JOHN GOOCH.
F. J. BRAMWELL.
JAS. EASTON.

FIXED STEAM ENGINES.

Names of Exhibitors.	No. of Stand.	No. of Article.	Horse Power of Engine.	Coal burnt per hour in lb.	Coal burnt per horse-power in lb.	Price.			Remarks.
						£	s.	d.	
Tuxford and Sons ...	247	4645	10	59.32	5.93	250	0	0	2nd prize, 10L
Reading Ironworks Company ...	114	2505	10	60.34	6.03	230	0	0	Highly commended.
Rawlings, J. J. ...	266	4766	8	62.92	7.66	100	0	0	Commended.
Kinsey, H. ...	261	4758	10	79.09	7.90	107	10	0	Commended.
Deacon and Wood ...	231	4597	8	51.37	6.42	50	0	0	Commended.
Clayton and Shuttleworth ...	256	4731	10	44.44	4.44	240	0	0	1st prize, 20L

JOHN GOOCH.
F. J. BRAMWELL.
JAS. EASTON.

These Tables are published in a form which would mislead nine engineers out of ten; indeed they would mislead every engineer who did not understand the peculiar explanation which applies to them. As far as the portable engines are concerned, the consumption of coal per horse power per hour is derived from both the first and the second series of trials, the first series being that at which the engines were worked only to their nominal horse power, and the second that in which they were worked to one-half more than their nominal power.

But our own Tables, given a fortnight ago, and carefully calculated from the actual results, show a less consumption of coal per horse power per hour than appears in the official Tables. This is explained in a manner which shows merely the uselessness of the Tables prepared by the judges. They base their calculations upon nominal horse power only, even when the engines were worked, in the second series of trials, to one-half more than the nominal horse power. Our own Tables were calculated, as carefully specified in the headings of the columns, to show the consumption of coal for each horse power actually exerted on the brake, or, in other words, for each dynametrical horse power. The judges' Tables give a mean of the consumption per nominal and not per actual horse power on both series of trials. We will venture to assert that but few other engineers would have adopted such an irrelevant and utterly useless standard of comparison, and one which would mislead every engineer who sees their report.

To make the matter clear, we will repeat, that for each nominal horse power, as calculated by the society's rules, 14 lb. of coal were weighed out for the first series of trials, and 10 lb. for the second series, the latter being equal to 6½ lb. per dynametrical horse power, supposing, of course, the engine to run at its nominal speed, or the speed for which the exhibitors entered it. And if, as was generally the case, the engine ran at a higher average speed than that for which it was entered, it was considered to have run as much longer than the actual time as the actual speed was greater than the nominal or intended speed for which

it was entered, and for which the weights had been exactly adjusted on the brake. This augmented time was called the "mechanical time," and it is the time only (in hours) by which the 14 lb. of coal per dynametrical horse power in the first series of trials, and the 6½ lb. in the second

the chimney funnel is too short, the fireplace too large; it would appear that an oil grate should be one-third less in size than the grate required for coal, the heating surfaces remaining the same. The grate is not boiler-maker's work; it should be made

series (10 lb. per nominal horse power divided by 1½ times the nominal power), is to be divided to obtain the actual consumption per dynametrical or effective horse power. The judges have made their averages upon a standard having no real engineering significance, and which is calculated to mislead all who see their Tables. It is a pity that the absurd term "nominal horse power," which has no real definite meaning even to the engineer, and which invariably misleads laymen, has not been blotted out of the English language.

EXPERIMENTS ON COAL AND PETROLEUM FUEL AT WOOLWICH DOCKYARD.

TO THE EDITOR OF ENGINEERING.

SIR,—I enclose you a tabulated statement of the first trials with the common service marine boiler at Woolwich Dockyard, coal and oil being used as fuels. The coal was the best hand-picked Welsh, burning without smoke. The oils, with the exception of 2½ tons of the good crude shale from Scotland, were chiefly country and town made creosotes, the latter filled with salts, oil residuums, Zante surface petroleum, thick like tar, and naphthalene melted. No American petroleum was used, as the supply of oil rested with me. I regret I could not bear the heavy expense which a proper supply of the finer sorts would have occasioned.

The shale oil did exceedingly well; but the others, the residuum, as the refuse from the distiller's vat is called, and the Zante tar, made a great amount of smoke, the latter forming an ash on the surface of the grate 8 or 9 in. thick. They proved fuels of great strength, but required a more delicate construction than the common boiler allowed. With a grate or fire surface 32 ft. superficial contents, all such fuels must be put aside. Either the American petroleum, with or without the spirit, good shale oil, unmixed with water, or the country creosote, should alone be used. The heavy oils required a great expenditure of steam, over 20 per cent. of the whole amount raised having to be decomposed and burnt in the fireplaces. A large amount of air was likewise required; the inability to supply this was the chief fault of the present construction. Rather more alteration than was at first considered necessary is required to adapt the common service boiler to the use of liquid fuel. The distance from the grate to

DATE OF TRIAL.	Number of furnaces.	Pressure of steam or atmosphere.	Water in boiler on lighting up.	Feed-water.	Time occupied in raising steam.	Time occupied in raising steam.	Pounds of coal and oil used in raising steam.	Description of fuel used during trial.	Weight of water evaporated.	Fuel consumed per foot of grate.	Weight of soot.	Description of smoke.	REMARKS.
1867.	2	10	54	52	10	10	200	coal, hand picked	32,096	13.81	20	State of tubes after the trial.	Trial stopped, men not working overtime. Trial lost in consequence. (One furnace only in full flame; the other leaking, superheater destroyed.)
April 17th	..	60	54	52	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
18th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
June 7th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
10th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
11th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
12th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
13th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
14th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
15th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
16th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
17th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	
18th	..	70	144	58	10	10	200	hand picked Welsh shale oil	32,096	13.81	20	State of tubes after the trial.	

as carefully as a lamp or gaselier. The oil, when hot, escapes at every pore as readily as superheated steam would do. During

the last day's trial on the 18th, only one furnace, from this cause, could be kept well in action. No pipes or iron of any kind, in the form of retorts, superheaters for steam, or for the supply of oil, should be exposed to the flame; they are sure to be destroyed, at least in a boiler, where real work, an evaporation of 15 or 20 tons of water every ten hours, is required. In the first small boiler at Woolwich, which made an evaporation of near 20 lb. of water to 1 of oil, highly superheated steam was not used in the grate, nor does it appear necessary, tolerably dry steam of 10 or 12 lb. pressure being sufficient. In this large boiler, with the idea of economising the steam used in the grate, cast-iron superheaters and retorts for mixing the vapour and steam together, each set weighing over 16 cwt., were introduced in the fireplaces. The intense heat destroyed one on the 18th, and prevented, of course, the continuance of the experiments. I wished to take them out, and return to the old construction, which would have supplied the requisite amount of highly heated air, and exposed no iron, unprotected by water space behind it, to the flames; but it would have been necessary to do this at my own expense, and my funds were too weak to bear the large amount this, and the purchase of 20 or 30 tons of good shale and petroleum would have required. The boiler is standing idle; and, for the present, the best hand-picked Welsh coal reigns supreme. Why the latter is called smokeless I cannot tell; it made very little smoke when carefully burnt on the 17th April, but a prodigious deal on the 18th, when the fires were forced.

Truly yours,

C. J. RICHARDSON.

34, Kennington-square, W., July, 1867.

STEEL RAILS IN FRANCE.

TO THE EDITOR OF ENGINEERING.

MONSIEUR.—En parcourant d'anciens numéros de votre estimable journal, auquel je suis abonné depuis peu, je vois dans le numéro du 12 avril, page 337, que les chemins de fer Français emploient, pour essayer les rails d'acier Bessemer, un moulin d'un poids bien inférieur à ceux employés en Angleterre, et l'auteur de l'article en conclut l'infériorité des produits Français. Comme je ne doute pas que vous ne cherchiez avant tout la vérité, je me permets une rectification dont je vous prie d'ailleurs de faire tel usage que vous voudrez, l'important pour moi étant de ne point laisser dans votre esprit une impression erronée. L'appareil que l'on emploie en France est celui qui a servi de tout temps à l'essai des rails en fer, on n'en a pas établi de spécial pour les rails en acier; d'un autre côté, les idées des ingénieurs de chemin de fer Français sont si différentes de celles des vôtres, à tort ou à raison, quant à l'emploi de l'acier, que l'on reproche toujours aux fabricants de métal Bessemer de ne point faire de produit assez dur, et que certaines compagnies seraient toutes disposées à exiger que les rails essayés dans les conditions que vous avez parfaitement décrites cassassent entre deux mètres cinquante et trois mètres. En un mot, tandis qu'en Angleterre on s'efforce de faire du métal qui ne casse jamais, en France on nous demande du métal dur, prenant une trempe telle qu'un burin fabriqué avec un morceau de rail, puisse entamer la fonte blanche. Ceci ne nous empêche pas de produire quand on le demande, pour des tôles par exemple, du métal d'une grande douceur, comme vous pouvez vous en convaincre en examinant nos produits à l'Exposition de Paris.

Excusez-moi, Monsieur, d'avoir abusé de votre précieux temps; j'ai cru que la chose n'était point indigne de vous occuper, et j'ai saisi cette occasion de me dire

Un de vos lecteurs assidus et dévoués,

F. VALTON,

Ingénieur des hauts fourneaux
et aciéries de Terre-Noire.

Terre-Noire (Loire).

THE DRAINAGE DISCUSSION.

TO THE EDITOR OF ENGINEERING.

SIR,—In answer to your correspondent Mr. Gower, I beg to state that I quite agree with him in all he states concerning sewer fluids, but would call his attention to the fact that when faecal matter and remnants of kitchen-stuff are withdrawn from it the remaining liquid cannot be very difficult to deal with. Mr. Gower advises to purify it before discharging it into water-courses, by means of "meadow irrigation." If this be practicable, it would surely be the best that can be done, for then some use, at least, is made of whatever few fertilising ingredients it still may retain. I must confess, however, never to have seen meadows treated with this very thin dilution, and do not know how far the plants are benefited by it, or to what extent they can extract from the fluid that class of impurities.

That the irrigation process with regular sewage (containing faecal matter), as at Croydon, does not succeed in this is now well known. Professor Voelcker's analysis has settled that matter. He has shown that its lucidity, &c., is no proof of its purity, it containing yet so many putrid elements as to make it unfit for any domestic use whatever, and therefore also unfit to be discharged into rivers. This fact explains partly why the grass or hay crops grown with it are, in money value, so far below that of the manure applied. For instance, at Croydon the faecal matter of about 120 inhabitants (worth, as is well known, if it had been properly collected, 10s. per head) is annually given per acre. The town furnishes, thus, the lessee of the meadows actually with 60L worth of manure per acre, and receives from him, according to the reports of Mr. Latham, in return but 5L rent. At Edinburgh the matter is even worse. This is certainly evidence of a horrid waste of fertiliser. That same quantity could, if not diluted with other water than urine, and applied to wheat, give an increased yield of grain worth 120L.

It is quite possible, however, that household water which has been strained, and is not charged with excreta, might give off its few putrifying elements to such an extent that it might with safety be discharged into rivers. But the process is new to me, and Mr. Gower will, no doubt, greatly oblige us by stating where this is done, and what increase in crops is thereby obtained, together with an analysis of the liquid before and after the irrigation process. Without these data it is not possible to judge properly.

Assuming, however, that the treatment is successful, it is evident that the fields must be low enough in respect to the sewer outfall to be reached by gravitation alone, experience having shown that sewage enriched with excreta, &c., cannot even stand the cost of being pumped up for purposes of distribution; which puts this process, for strained household water, entirely out of the question. I suggested the use of Mr. Spencer's filtering preparation on account of the excellent reports given of its performances, even with regular sewage. An instance of that can be found at the military dépôt at Warley, in Essex, where, according to Mr. Digby Wyatt, the engineer, the sewage of a garrison containing 1200 men is successfully reconverted into pure water. Its effects upon mere dirty water have been in a great many places (waterworks, &c.) attested. The Royal Commission of the London Exhibition of 1862, composed of such men as Doctors Neil Arnott, Sir F. Oliff, R. Angus Smith, and F. Sutherland, and the engineers, F. M. Bazalgette and M. Delesse, awarded it, with the médaille, the highest praise. Thus, though I have never seen it, and must confess not to understand its action, nor even fully its composition, still the testimony of so many unquestionable authorities prompted me to recommend its use, and would prefer this course to the irrigation plan so long as I do not know more of the results thereof. I hope then Mr. Gower will oblige us with more information.

To the questions of the irrepressible "O. O." as to what a farmer's lad must do when in manuring the interval fallows, according to my system, the barrel on his cart is empty, I have to answer that he must follow the example of all manure carts distributing their loads over the fields, namely, "go back to the pile and get more." I believe that this plan is generally followed in such cases, firstly, because it is the only thing that can be done, and secondly, perhaps because "O. O." has not yet published his mysterious method of "collecting the manure far out at sea," and so we don't know any better. How is it to come back ashore by that process, washed or unwashed, by tube, per ship, or per balloon? His valuable letter of July 19th does not state this, unfortunately, but mentions the brilliant plan of "scurrying the air with chloride of lime vapour puffed all up chimneys or shafts to distribute such." I dare say Mr. Bazalgette, for whose benefit this is stated, apparently, is very grateful for hearing in time of this engineering dodge. But how about "the full-plumed eagles, or I may say hawk, soaring into the 'secondary means of purifying all such vapours, in fact where they must be before they can win their bread and cheese," as he touchingly describes them in his letter of May 17th? I sadly fear that these full-plumed birds would not like it, and still less the arrangement "O. O." proposes in his letter of June 14, where he asks, "Where, air, is there a shaft like the 'one in our mind's eye, soaring amongst the eagles, for dis-tributing the foul miasma, that your 'correspondent' allows 'salutes his olfactory organs?'"

It must be a very unpleasant business for eagles to soar in air where chimneys fly about distributing foul miasma, and if one of them during its gyrations should salute "O. O." on his "olfactory organ," the shock might convince him that also this plan has its objections.

To return to terrestrial matters, I beg to inform "O. O." that my manure carts must go forwards and backwards from the pile where the barrels are deposited every time a barrel is empty, just as if the stuff was not in a barrel, and that the whole difference between the old method and mine lies in this, that by the former one the manure is shovelled out in heaps and spread out afterwards, while in the latter "it runs out" at once where it ought to be. But the riding about remains the same. "O. O." has misgivings that the driver would not be able to find the place back where he left off. Most men would ascertain that by the mark on the ground made by the scraper, which closes the furrow; but "O. O." would, perhaps, prefer far more security, "a chimney or a full-plumed hawk to indicate such." Let him have his way.

When the soil is so light as to allow the manure cart to make at once the manure furrow by means of a little tool or ploughshare fastened to it (which will be in most cases possible, if Mr. T. B. Lowe's advice is followed, of making the furrows but 4 in. to 5 in. deep), the tool and the closing scraper must, of course, be lifted up "out the way" while going back and forwards. When the soil is so heavy as to make it too much for one horse to pull the cart and to make this light furrow at the same time, then, of course, another plough must go ahead and prepare the ground. In that case the ploughing may be done the day before, and in either case need not wait for the manuring process. There is no loss of labour in this, for the fertiliser must be ploughed in, no matter which system is followed.

The difficulties "O. O." raises about such an obviously simple business as pouring fluid manure on the soil remind me of those I find in a pamphlet, printed some fifty years ago, on "the impracticability of lighting towns with coal gas." The author is quite enthusiastic about it. He says: "It is evident that, in a moderate-sized town, there would be at least a million burners, in streets and houses, each one provided with a cock. Now it is known that, practically, these cannot be made tight, and, under the pressure of the gas, must be constantly leaking, more or less; also, in such a large number, must be always more left open by carelessness. There is thus a certainty that a large volume of this gas will be constantly escaping—a gas which is known to be poisonous when inhaled, and inflammable when concentrated—thus actually endangering the life and property of every one in town. Let the Government look to it that these newfangled projects are not allowed to bring destruction on all, and let us content ourselves with such means to light up the night as the Lord has provided, namely, the moon and the stars. Those for whom this is not good enough should go to bed and rise early, and do their work in 'daytime.'" The sapient absurdities of this individual are somewhat like those of "O. O." with the difference that the former's grammar is better, and his language clear.

"O. O." says he is "forced to apply the searing-iron in my flesh, and would be no true knight if he raised his visor, while 'unravelling my dirty schemes,' meaning the use of air instead of water in privy closets. I really am at a loss what to say to this, except that he is perfectly right in keeping his visor tight down, so as, at any rate, to keep the exact length of his "acoustic organs" from being seen; and in regard to "searing my flesh,"

I beg to be fairly warned beforehand of the time when he is going to do it.

"O. O." quotes Hamburg as an instance of bad closet arrangements, &c. Well, he is also right in that—having been there not long since, I can testify to that fact. The truth is, it stinks there most abominably both in streets and houses. But "O. O." errs in ascribing it to dry closets, &c. That town has been provided with perhaps the most complete sewerage by water-carriage system extant, water-closets and all, by a very capable drainage engineer, namely, Mr. W. Lindley, and the whole arrangement with the new waterworks in connexion with it are executed in a masterly manner. But all this does not keep the gases which are formed in the sewers from escaping, and making people sick; nor the water-closets from getting very dirty when the pan is soiled higher than the stream of water can rinse, or when somebody has forgotten to work the handle; nor the harbour from getting fearfully polluted. These are evils inherent in the system, which no splendid masonry and cunningly laid gradients can cure.

The fact is, I doubt whether a better and more permanently clean arrangement can be made than a straight tube without bottom valve, and so shaped that with ordinary usage the sides cannot be soiled. Of course there are people who will soil anything, even the seat—there is no help for that. But my rather long experience in forts, arsenals, garrisons, and similar places occupied by many individuals has shown me that water-closets will not answer unless a guard is constantly in attendance to see that the valve has been properly opened, &c.

The assertion of "O. O." "that I want farmers to throw 'their stable manure into the sea, and use human excreta instead,' is only another effect of his lively imagination. I never said anything of the kind, and have insisted constantly on using all excreta, both animal and human, on the land in preference to sending for fertilisers to the Pacific Ocean. The ashes of the food of men and beasts have been obtained from the soil, and must be returned to it, if we wish to prevent exhaustion. There is no fear of getting too much manure; if we give back just what was taken away, we will never have more nor too much.

"O. O.'s difficulty of the 'hydrostatic head,' in Mr. Menzies's pipes is not worth while refuting.

I am, Sir, respectfully yours,

CHARLES T. LIERNUR.

2, Royal Exchange-buildings, E.C.
July 29, 1867.

THE CORLISS ENGINE.

TO THE EDITOR OF ENGINEERING.

SIR,—I had no expectation that any of your correspondents would be able to show that the Corliss engine presented any feature of solid advantage over other engines of more ancient type, or that its rattletrap valve-gear was not merely futile but objectionable; and so far I think I am justified in saying that my anticipation has been confirmed by the event. You have published a number of letters in favour of the Corliss system, which have been more or less lavish in assertions of superiority. Yet neither by argument nor by evidence has any one point of superiority been proved; and the result of the controversy has been to show that the Corliss gear involves greater cost and complexity without visible compensation. I am old enough to remember many vaunted improvements in the steam-engine which have died the same natural death that this one will do, which have had partisans quite as zealous and quite as extended an introduction. But the inexorable authority of physical fact has finally prevailed, and those may try their teeth on steel who imagine that the decrees of such authority can be either evaded or resisted. For my own part, I can say with truth, that if I had seen anything eligible in the Corliss system of valve gear, I should surely have been glad to recognise it. But I will not at the bidding of partisans, whether ignorant or interested, profess to discern merits which have no existence. The advocates of the Corliss gear have been challenged to show that the engines fitted with it worked with greater equability than ordinary engines, with greater smoothness and durability, or with a smaller consumption of fuel. No such evidence has been produced. But, on the contrary, it has been shown that some engines of the old type work with greater economy than is even claimed for engines on the Corliss plan. Then none of your correspondents has ventured to state the cost of the Corliss gear as compared with the cost of the gear of common engines working with equal economy. Mr. Pinchbeck has counted up the number of joints in the Corliss gear, all of which are subject to wear, and from which some idea may be formed of its complexity and liability to derangement. But although any one may form an estimate of the cost of this gear, it is only the makers of it who can state the actual cost, and no such statement has been given. Here we have a more costly, more complicated, and more precarious gear, which after all, it seems, is unable to attain any result which is not attained with equal efficiency in common engines. Can such an innovation be characterised otherwise than as a "retrograde improvement" tending not to make things better, but worse? The aspiration to control the action of the expansion valve by the governor is not new, is not judicious, and, even if it were, is capable of more eligible realisation than by the adoption of the Corliss rattletraps. There is no chance whatever of the Corliss system coming into extended use in England, simply because no intelligible inducement for its adoption is or can be presented, and I believe I am warranted in predicting that, spite of any spasmodic efforts in its behalf which its partisans may make, it must soon be consigned to "the tomb of all the Capulets." Those who stick to it too long only incur the risk of sharing its fate.

I am, &c.,

OBSERVER.

THE CORLISS VALVE GEAR.

TO THE EDITOR OF ENGINEERING.

SIR,—It is much to be regretted that so much has been said by various of your correspondents in favour of the Corliss gear, when, after all, so little has been said to the point.

Mr. Gill may think it an object of importance that an arrangement has been introduced whereby the steam adjusts itself to

the working requirements of causing the governor to determine the amount of expansion. It is, nevertheless, well known that this has been accomplished, for more than half a century, by means less complicated than those of the Corliss system. The benefit has not, however, been such as to induce the general adoption of that mode of working the steam. Certainly no one has yet shown that engines with the Corliss gear are less expensive, less complicated, or more durable than ordinary engines. Nor has it been proved that the Corliss gear enables engines to work with more regularity, higher speeds, or less fuel than engines otherwise fitted.

What motive is there, therefore, for its adoption, beyond that presented by advertising tradesmen, who praise the thing they have to sell, but without being able to establish any valid title to an unbiased preference?

I am, Sir,
July 27, 1867. W. H. N.

THE WATER-JET PROPELLER.

TO THE EDITOR OF ENGINEERING.

SIR,—So much has appeared in your columns relative to water-jet propulsion, that it is not without hesitation that we venture to request space in your journal for this letter. Perhaps, however, our views on this subject may have some little extra weight from the fact that we are laying out a considerable amount of money in building a vessel for commercial purposes on this system of propulsion. We hope to sell this steamer on her completion in the regular course of business, or to run her on our own account, unless we find the disadvantages too great to allow of her profitable employment; and, with your permission, we will state what has led us to form so favourable an opinion of this principle.

Some time back *La Société Cockerill*, of Belgium, built a steamer to run on the Meuse on this system, and they tried it against a paddle-vessel on that river. Although the arrangements for pumping or forcing the water were in many respects capable of considerable improvement, we ascertained from private and reliable sources that the loss, as compared with the paddle, did not exceed 12 per cent. This result immediately attracted our careful attention, for we have always considered that perfect adaptability of mechanical power is of greater importance than even 12 per cent. apparent loss of fuel, and will in the long run prove itself more economical. Allow us to cite again some of the advantages which will strike all practical men; and putting aside war vessels, with which, as a "Quaker" firm, we never meddle, first, take the arrangement of the driving power. Could any one indicate any modification of the existing types of marine engines which would tend more to simplify them than the doing away with all reversing gear, and with all necessity for suddenly stopping or starting them? A single horizontal cylinder, with any valve gear such as would suit a land engine, is evidently fully adequate for every purpose. Then you have the invaluable property of being able to work up your engines to their full speed, or nearly so, while the vessel is standing still; what a gain this would be in towing! The engines are always under the sole control of the engineer, but the captain has always perfect command over the *direction* in which the power is applied. In less time than it would take to convey an order to the engineer, the ship may be slowed, stopped, or backed astern, the engines at the same time working at their regular speed. The racing of screw engines, when the propeller, by the pitching of the vessel, is brought out of the water, can never happen to the engines of the hydraulic propeller, since the immersion of the jet alters but slightly the pressure at the orifice. In shallow water navigation, where the screw is inapplicable and the paddle unsatisfactory, this propeller would remove difficulties which we, as well as every other firm which has paid particular attention to this subject, have found almost insuperable. There is another peculiarity connected with the water-jet at present not fully explained, viz., the rapidity with which a steamer can be brought up when it is wished to stop her; this, as tried in the *Nautilus*, was apparently more powerful even than the paddle. Taking all these things into account, it seemed to us that all and more than the advantages of the paddle and screw combined, as far as the application of them is concerned, would be found in this novel mode of propulsion.

The next step which we took in the matter was attending the trials of the *Nautilus*, after an introduction to Mr. Ruthven by a mutual friend.

The trials of this steamer have been sufficiently published, but we may subjoin the leading data.

Length. Beam. Draught of water. Ind. H.P.
Nautilus (hydraulic) 115 ft. 15 ft. 2 ft. 91½
Volunteer (paddle) 110 ft. 13½ ft. 2½ ft. 105

Note.—The indicated horse power of the paddle was not obtained with strict accuracy.

As regards the above trial, the midship section of the hydraulic was less than the paddle; but the model was much inferior in every way, and we question if there was much difference in the displacement. The wetted surface, was, we believe, greater in the hydraulic, and the indicated horse power was in favour of the paddle, while the advantage in point of speed lay slightly with the hydraulic, and the perfect way in which she could be handled was a pleasure to witness.

Next came the trials of the *Waterwitch*, about which some of your correspondents have made such astounding calculations. We inspected her on the stocks, and found her model to be one eminently unsuited for speed; a flat bottom, a sharp bilge, both ends alike, all these are against fast going, and would lead a practical shipbuilder, who knows how often a full knot has been lost through bad lines, to expect a low coefficient. No coefficient can ever have much practical value which does not take into account the model or lines of the hull. Or, in other words, where the propeller is the same in two steamers, the coefficient will indicate which is the best model; or where the lines are the same, the coefficient will be a guide as to the efficiency of the propeller. Unfortunately there is no vessel existing with the same lines as the *Waterwitch*, although the *Viper* and *Vixen* are sufficiently near to give some idea, especially as the advantage, if either way, lies with them.

It is generally considered that at any rate for speeds of about 9 knots the power must vary as the cubes of the speeds, and in

the direct ratio of the displacement when the vessels are of the same size; or according to the cube root of the square of the displacement ($D^{\frac{2}{3}}$) when the vessels differ in size. For our present purpose the first formula,

$$(\text{Speed})^3 \times \text{Displacement} = \text{coefficient,}$$

will probably be sufficiently approximate. You have given us in *ENGINEERING*, vol. iii., page 815, a list of screw-steamers of about the size of the *Waterwitch*, and of about a 9-knot speed. We subjoin a part of this table, taking every other one at random as they stand, with coefficients calculated according to the above formula. We have no authority for correctness but your own.

	Coefficient.	Displacement.	Speed.	Indicated H.P.
Rapid	124	894	8.888	505
Fawn	170	1004	8.578	374
Columbine	127	889	9.504	598
Shearwater	120	885	8.957	532
<i>Waterwitch</i> (see below)	103	1062	9	750

Here, as might be expected from her wretched model and high power, the *Waterwitch* stands lowest, though lower than what the official trials show, while the *Fawn*, with the least power, shows the highest result; but the difference between the hydraulic and the usual run of the screws is not nearly so great as between the best of the screws and the worst.

We now add the comparison with two vessels designedly built so as to be tried against the water-jet; the particulars are official:

	Coefficient.	Displacement.	Speed.	Ind. H.P.	Date of Trial.
<i>Waterwitch</i>	119	1030	9.909	834	1 January, 1867.
Ditto	109	1219	9.255	828	17 "
<i>Viper</i> , twin-screw	109	1072	8.958	690	4 June, 1866."
<i>Vixen</i>	112	1121	9.216	751	31 May "

We believe Mr. Ruthven considers that the indicated horse power of the *Waterwitch* is overstated in the above table, and that the card taken at the beginning of the mile was not maintained throughout, but probably there was an equal amount of jockeying with the sister ships, and the result shows the performance of the hydraulic to be fully better than that of the twin-screws.

With these facts before us, and making, in our own minds, all due allowance for the difficulties connected with the perfecting of a new invention, it was with no small surprise that we read letters or articles in *ENGINEERING* proving the enormous loss connected with water-propulsion. We would respectfully suggest to those of your correspondents who rushed so hurriedly into print, to look back to twenty years ago, and read the letters of a similar character written to prove the fallacy of the screw propeller—with all the ingenious comparisons of and deductions from the *oblique* action of the screw, and the *direct* action of the paddle, and in the presence of such steamers as the *China* and *Cuba* on the one hand, and of the *Scotia* and *Persia* on the other, ask themselves if they are quite sure that they have mastered all the secrets in the arcanes of science; if they are entirely certain that their problems contain all the elements affecting the result; if their premises are strictly accurate and germane to the subject; and if, when they find their calculations so wide of the realised facts, they may not suspect that a *reductio ad absurdum* lies in their formulas and not in the propeller, however difficult it may be to explain the anomaly. As regards accuracy, a correspondent of yours, Mr. George H. Phipps, writing under date October 24, 1866, gives the displacement of the *Waterwitch* and *Viper* as 778, instead of 1030 and 1219! What notice can be taken of a letter founded on such an inaccuracy? In another part of the same number, page 314, we find these words: "It is indeed probable and nearly demonstrable, that of the 750 horse power indicated on Friday, less than one-fourth was actually utilised in 'propelling the ship,' or in other words, that friction and slip amounted to over 75 per cent. In the face of the trials noted above, one would have expected the writer to pause before making such an assertion. Nor is our astonishment at the confident tone of the writer lessened, when lower down we find that he positively takes for granted that all excess in speed of the effluent jets over the speed of the vessel is so much loss, or as he puts it: 'Resting for a moment on the quantities already obtained, the whole power would be utilised only when the vessel moved forward at the same rate as the effluent velocity of the jets.' . . . 'Now, the *Waterwitch*, so far from moving at the rate of 24 knots an hour, or 40½ ft. per second, went at 9 knots an hour, or 15.19 ft. per second, and hence 'in any case nearly two-thirds of the power would appear to have been wasted.'"

A little reflexion should have shown the writer that such an assertion as this is wholly unfounded. Supposing that the nozzles of the *Waterwitch* were contracted to, say, one-half of their area, the velocity of the stream of water would then be about doubled, while the propelling power, it is found, would be nearly the same; or, to state the argument conversely, the efficiency of the jet-propeller has been shown to be great in towing; suppose now the *Waterwitch* were to take in tow another vessel of the same size, model, and displacement, then, allowing the formula above to be approximately correct, the speed of the ship would be reduced just one-half, or from 15.19 ft. per second to 7.6 ft. per second. Would the writer of the article in question be prepared logically to carry out his pseudo-proof, and assert that *five-sixths* of the power in this instance would be wasted? We fancy he has been misled by the word "reaction," whatever may be the case in a Barker's water-mill, where the weight of the machine is very small, or in a rocket, with an expanding elastic fluid, we feel sure that it would be a clearer basis on which to found theoretical deductions, if the action were regarded from the point of view which would consider the forward side of the nozzle to be a surface on which a large body of

water to which the pump-wheel has imparted a considerable velocity, impinges with a steady force, so that the action is, in a modified form, much the same, only infinitely more effective, as if an enormous fire-engine were placed on shore, and a jet of water set to play on the stern of the vessel, so as to shove her forward. Of course, all propellers work on the reaction principle, using the term in its widest sense; but even in so familiar a form of application as the screw-propeller we find that some of the phenomena exhibited are so difficult of explanation that even those who have most studied the subject are very shy of expressing a decided opinion.

Experiments and practice are still too limited to allow us to say what are the right proportions to adopt in the size of the wheel-pump and of the jet-nozzles, but good results have been obtained with widely differing dimensions. Experience, however, points to large orifices, which agree with theory; but this subject will no doubt ultimately be as vexed a question as that of the diameter and pitches of screws now is.

And now, Sir, we must apologise for the length of this letter. As soon as we get our steamer completed, we intend to make some very careful trials for our own instruction and satisfaction, and in order to place us in a position to tell steam-ship owners exactly what we can and what we cannot do. We will send you notice of these trials, and shall be only too happy to see you or any of your friends, and in the mean time we hope you or some of your staff may consider the subject of sufficient importance to merit your investigation.

Yours respectfully,
J. WIGHAM, RICHARDSON AND CO.
Iron Shipbuilding Yard, Newcastle-on-Tyne, July 29, 1867.

THE RUTHVEN HYDRAULIC PROPELLER.

TO THE EDITOR OF ENGINEERING.

SIR,—When retired vice-admirals and gallant captains dabble in machinery, they are apt to come to queer conclusions. Would any of them now-a-days recommend a fast paddle-ship, one that would run round and round the average of our screw ships of war, as a good arm for our navy? I should think not. Neither would I the "hydraulic propeller," for various reasons. And, firstly, it has not passed through that ordeal which all other propellers have, namely, the mercantile marine, not that it is necessary that a good invention should undergo that severe test, but about twenty years of experience with the "hydraulic." Have twenty ships been so fitted—I mean good-going merchantmen of an average burden? And I dare say most will recognise that the "hydraulic" is most suited for that class of vessel. The best location for the "hydraulic" is where the turbine is placed at or near the water-line, consequently the engines must likewise be placed there or thereabouts. Now, with our top-heavy broadsides, would this distribution of the weights improve the rolling propensities? The "Red Indian," as likewise I may say our amateur naval architects, those that paddle their own canoes on the *Serpentine*, ballast their tiny yachts with a good heavy leaden keel, and the instinct of the former with stones, to keep their craft in proper trim. Our ironclads are in the same unhappy condition, and the designer generally keeps the machinery low down in the ship to counteract the top weights. Of course the inventor of the "hydraulic" may have made similar arrangements, but I think we have not seen them as yet, and, until I do, I have no faith that for a vessel of 22 ft. draught a good arrangement can be so placed. The nozzles are placed above the water-line, and by the white foamy water that issues from the side it is a conspicuous mark for an enemy. Shields will prove of no avail against the ordnance of the present day, as concentrated fire would hammer the propelling agent to pieces, and after that a lumbering ironclad would soon share the same fate. If placed below the water-line, the huge bulging pipes would offer a great resistance, both under steam and under sail, and we have not seen any mode as yet of unshipping them. As regards the means of reversing from the engine-room alone, as certainly the engineer is the most competent hand to do so I do not consider the "hydraulic" offers any better means for manoeuvring a vessel under all circumstances over that of the twin-screw system. The engines can be reversed with certain appliances in a second of time, and, of course, immediately the propellers come into action. Although I have seen various improvements in the method of reversing the current of the water since the "hydraulic" was first introduced, I consider none of them can be done so quickly as in the twin-screw system. Hoping these few remarks may find space in your columns,

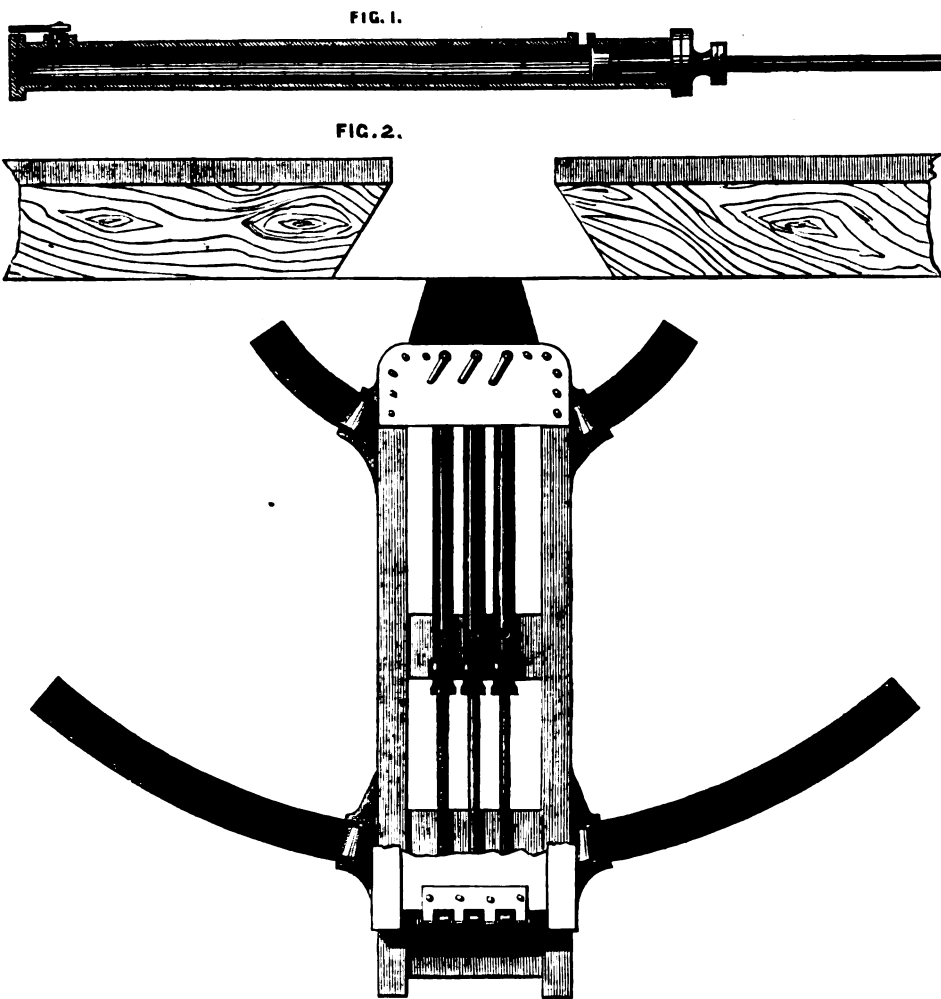
I remain yours respectfully,
London. TWIN SCREW.

THE MIDDLE-CLASS SCHOOLS.—The middle-class schools, for which such handsome subscriptions were collected last year, have now 700 scholars at the schools in Bath-street, City-road. A distribution of prizes to the scholars took place last week. The new schools to be built on property purchased of the Ecclesiastical Commissioners, on the Finsbury estate, are to accommodate 1700 pupils. They will be models for space, light, and ventilation. The course of instruction is just what is now wanted for boys intended for business. It is not classical, but chiefly practical, graded, however, by a course of the higher English literature.

WOOD-WORKING MACHINERY.—We some time ago drew attention to the especial excellence of finish of the wood-working machinery sent by Messrs. Samuel Worsam and Co. to the Paris Exhibition. It was awarded a silver medal, the highest award made in this class. The improvements made in wood-working machinery, and especially by this firm, within the last few years might have been held to deserve even a gold medal. No other branch of machine construction has shown such progress. The bronze medallists at the Exhibition are making a lively stir in such of the mechanical journals as will insert their lamentations, to prove that they were really first in merit, but were somehow overlooked by the jury.

NEW STEAMSHIP LINE.—A new line of steamers is announced by Messrs. Howden to commence running from London to Rio Janeiro, Montevideo, and Buenos Ayres on the 21st of next month. The charge for passengers is to be 30*l.* to Rio, and 35*l.* to the River Plate.

CUNNINGHAM'S METHOD OF CHECKING THE RECOIL OF HEAVY GUNS



MR. CUNNINGHAM'S arrangement for stopping the recoil of guns by atmospheric pressure, of which we give engravings above, consists in placing between the slides, in the same position as the present friction-plate compressors, tubes furnished with pistons and rods, the ends of the latter being connected with the rear end of the carriage. The tubes are capable of being shut or opened at their outer ends by valves. The inner ends are closed, but at about a foot distance from their ends are air-ports to admit air to the inner side of the piston, and also to perform a function which will be presently described.

The accompanying diagrams represent the slide of a 12-ton gun fitted with the controlling tubes. It will be seen that three tubes are here used, each having its respective valve-handle, or these may be all arranged to work by one movement. The action of these tubes is this: When the gun is fired, and is driven back, it carries the pistons with it, and immediately these commence to travel down the tubes (the outer valves being closed) a vacuum is created on the outer sides, and atmospheric pressure on the inner, the pressure increasing in intensity the further the gun runs back. When the pistons pass the air-ports, clearly distinguishable in the tube in Fig. 1, the vacuum in each tube is destroyed, and the air filling the tubes prevents the return of the pistons, and consequent reactionary running out of the gun until it is loaded, when on opening the outer valves the gun is free, and is run out without impediment. When the pistons pass the air-ports they enter the parts of the tubes already filled with air without free means of escape, which air forms a cushion in each tube to complete the final arrest of the pistons and stoppage of the gun. The amount of stopping power to the gun can be regulated by the number of tubes used. In the event of the gun running out too violently, one or more of the valves can be closed, which will at once create cushions of air upon which to receive the piston, and so bring the gun up.

In the Transactions of the Institute of Naval Architects, of 1863, is a description of a method proposed by Mr. Cunningham for using steam for working guns and also checking recoil; and it would seem by recent reports that the American Government has already adopted similar means in the Winnebago, Milwaukee, and Rickassoo, light-draught ironclads, these having had their 11 in. guns worked by steam tubes between the slides, in the same manner as proposed by Mr. Cunningham, for the last three years, and it is said with entire success. The elastic nature of both air and steam certainly recommend themselves as admirably adapted for controlling heavy guns, and lessening that violent shock to the ship which is produced by the present action of compressing or rather stopping the recoil of guns. By the present arrangement, before firing, the gun is fastened to the slide, and the force of recoil simply tears away that fastening, resulting in a violent shock upon the fastening of the slide and parts to which those fastenings are connected. The American Government have evidently considered the use of more elastic

means for stopping guns as important by their adoption of steam for the purpose.

Fig. 1 is an enlarged view of the interior of one of the air-tubes, and showing the piston just passed the air-port, and entering on the final stopper of the air-spash.

ROCK-TUNNELLING MACHINES.

THE difficulties experienced in connexion with the works at the Mont Cenis Tunnel have led to the introduction of machinery to take the place of manual labour where tunnelling through hard rock is necessary; and considering the economy that must result from the employment of such tools, not only in the saving of labour, but also in the time required for the completion of such works, it is not unlikely that they may come into very general use wherever the nature of the stratum met with in tunnelling works may render their employment practicable. In soft soils they are neither necessary nor can they be profitably employed; but wherever hard quartz, limestone, or sandstone is met with, great advantages may be obtained from the use of them.

Tunnelling machines may generally be divided into two classes—those which propose to substitute mechanical for hand labour in boring the shot-holes only, and those which propose to make the whole tunnel by machinery. Of the first class there are four in the Exhibition—the diamond boring-machine in the French department, M. Doering's machine in the Prussian section, a Swedish and an American machine, by General Haupt. Of the second class there are two—one designed by Captain Beaumont, R.E., which is now at work in the machinery department of the English section of the Exhibition, and the other, not yet in working order, by M. Berrens, of Faibes, in the Hautes Pyrénées, which is in the open park.

As the first class of machines only do a portion of the work, it would appear likely that machines going further than this, and effecting the whole operation, will in some cases supersede them. The principle upon which both Capt. Beaumont and M. Berrens propose to act is identical, viz., by making the machine cut an annular chase or groove, and at the same time a central hole destined to receive a charge of powder to break up the core of rock thus isolated. It will be understood that, though by this system the machine is cutting the whole tunnel, it is doing it with a minimum amount of exertion, since it is acting only on an external rim of rock. Even then the work thrown on the machine must be very heavy, though nothing beyond what, with a proper choice and disposition of material, it can be made to support.

M. Berrens's patent is subsequent to that of Captain Beaumont. The work done on the rock by this system—that is to say, the cubical amount of rock pulverised, resulting from the chased central hole—is no doubt greater for a given advance of galley than in the single-action machines; hence a certain hard-

ness of rock might eventually be reached which would render this system uneconomical; but, from the rates of cut which Captain Beaumont states he has actually effected, this limit is certainly not reached by any stone short of actual quartz, and rocks as hard, of which there are some; but by far the greater quantity of tunnelling has to be done in stuff of a medium quality, like granite and hard limestone. A machine on Capt. Beaumont's principle has been in operation on the Vartrey Waterworks tunnel and at Bolton. The machine was taken to the former place before it had assumed its present form, and the results obtained, so far as that machine was concerned, were not satisfactory. The rock was the very hardest greenstone and quartz, and the speed of cutting varied from 1½ in. to 2 in. per hour only. At Bolton, where the nature of the stuff was soft, the machine cut at the rate of 2 ft. 3 in. per hour; but the proper depth of chase could not be obtained, owing to the rock falling away and clogging the groove completely up. Captain Beaumont looks for a satisfactory result from all those rocks which lie between these two extremes. In sandstone 2 ft. has been actually cut in 1 hour 32 minutes, and the rate in granite is about 10 in. per hour. If these speeds can be maintained, there would appear to be no reason why excellent results may not be got, and an increase of four or five times the rate of driving by hand obtained.

Captain Beaumont anticipates being eventually able to cut and clear away 2 ft. lineal of galley in granite in every eight hours, giving an advance of two yards per day.

The illustrations on page 100 are taken from drawings kindly furnished to us by Captain Beaumont, and these engravings, together with the following description, will render the whole plan perfectly intelligible.

The machine itself is driven by compressed air, supplied, at about 25 lb. per square inch pressure, direct from a receiver into which it is forced by a direct-acting horizontal engine of about 25 horse power. The compressing apparatus is outside the tunnel, the air being conveyed to the rock-borer in pipes. The machine itself rests upon the planed bed of a cast-iron carriage, upon which it can traverse either forwards or backwards. This carriage is supported on four wheels placed radially, as shown in the illustration, and turning upon fixed axles made eccentric to their bearings, this plan bearing a slight adjustment to be given to the whole machine, so as to compensate for irregularities which cannot be avoided in the surface of the rock over which the wheels pass. This is effected from the back end of the machine by means of shafts with worms cut on them working into worm wheels on the wheel shafts. The machine itself consists of a cylinder 20 in. in diameter, and with a stroke of four inches; but in practice it has been found that the proper stroke is about 2½ in., and in very hard rock even less than that. To this piston is connected a very large hollow piston-rod, at the forward end of which is screwed on, by means of a heavy nut, a strong cast-iron circular head-piece, into which are keyed, in recesses formed for the purpose, fifty holders for the purpose of receiving a similar number of steel cutters, each 2 ft. 6 in. in length, having cutting faces set radially from 1½ to 2 in. broad. From the centre projects a single cutter, with its cutting face in the form of a cross, 2½ in. in width. This central cutter is hollow, and through it passes a stream of water, which is obtained under a head pressure from the other end of the shaft, and, passing right through it, is emitted at a small hole near the edge of the cutter. Water is also similarly conveyed from the central bore in the piston-shaft, through pipes up the radial arms of the cutter head, to six small jet-holes in the side of its rim, in a line with the cutters, through which it is ejected into the chase to keep the cutters cool, and wash out the pulverised stone. In the event of the water supply being found too great, means are provided for shutting off any number of the jets. The piston, when working against ordinarily soft stone, would make from 250 to 300 strokes per minute (in the Exhibition 180 strokes are obtained; as there is no rock to shorten the stroke, it makes a reduced number of longer strokes); but Captain Beaumont proposes that on meeting with any excessively hard substance the length of stroke should be reduced and the speed increased to 400 strokes per minute, thinking that the best result is obtained from a larger number of strokes than a less number of heavy blows. As the piston moves backwards and forwards, a slow rotative motion is given to it by means of a friction ratchet-wheel, upon the shaft of which is a worm working into a worm-wheel set loose on the shaft, but made to revolve with it by means of a fixed key on the shaft passing through a slot in the boss of the worm-wheel. On expressing our surprise at the use of a friction-ratchet in a machine liable to such severe jerking, Captain Beaumont informed us that he had found it very disadvantageous in practice, and that, although this machine was so fitted, he had found it necessary to use a tooth-ratchet in practice. At the same time that the bore-head revolves, another system of ratchets, worm, and screw gives the upper bed-plate a forward motion along the bed of the carriage with each stroke, this motion being capable of being regulated according to the hardness of the material operated upon, so as to make the advance equal the rate of cut. The slide-valve is worked by a bell-crank rocking on a shaft working in fixed bearings, and which is actuated by means of a pin, sliding in an irregularly curved slot in an armature bolted on to the piston-shaft, and consequently moving with it. The action of the slide-valve is very sudden, and it takes place at about the middle of the stroke by means of a screw fitting in the valve-rod. The position of the valves can be altered at pleasure, an irregularity in the force of the forward and backward strokes can also be obtained, making either stronger than the other, as may be desired; at the same time, by the adjustment of double cutters on either side of the pin in the valve-rod head, further alterations in the length of stroke of the slide-valve are practicable. The piston-shaft ends at the backward extremity in a small tube which, working through a stuffing-box in a small brass pipe, receives the supply of water through a flexible tube from a suitable head. The carriage itself is firmly held in position by a set of screw-jacks, as shown in the illustrations.

In practice Captain Beaumont has found that, after having cut a chase to the depth of about 2 ft., a suitable charge of gun-cotton fired in the central hole never fails to bring the whole

mass of rock completely away to the entire depth of the cut. The cut made by the machine is a circular chise 5 ft. 6 in. in diameter, and the clearance allowed at the end of the tools where they fit into the head-stock is but $\frac{1}{4}$ in., so that very accurate adjustment of the machine is absolutely necessary, and for this purpose the eccentric arrangement of the carriage-wheels has been adopted, which renders the unevenness of the floor a matter of little importance; the machine, however, leaves generally a very smooth and even surface, which the wheels run readily over. Whilst working in the Exhibition, we noticed a very considerable vertical and lateral movement in the head-stock of the machine, which was, no doubt, due, in a great measure, to the total want of any proper foundations; and this might also be the case where rock was found of an insufficient hardness, causing the wheels to bed themselves irregularly from the shock of the machine working. A sinking of less than $\frac{1}{4}$ in. on any wheel would bring the whole machine up, but this might be obviated by placing bars of iron for the wheels to run on. The machine is jammed in the tunnel by means of blocks to the roof and brakes on the wheels. Captain Beaumont confidently expects to be able to tunnel at the rate of 6 ft. per day in granite, and at the rate of 7 ft. or 8 ft. per day in sandstone.

M. Berrens's perforator consists of a sheet-iron cylinder $\frac{1}{2}$ in. in thickness, a little over 4 ft. in diameter, and 5 ft. long. To the end of this are bolted eight sets of cutters, each set consisting of four cutters placed side by side, but with their cutting faces set at different angles to one another. At the other end this cylinder is fastened to four iron arms radiating from a central boss which is keyed on to the driving-shaft. This shaft is carried on cast-iron rollers with grooved surfaces, running on shafts supported by uprights bolted on to a framework of wood which fits the bottom of the perforation made by the tool, and along the central channel of which it is proposed that the water used for keeping the cutters cool should flow off. Near the end of this shaft a worm-wheel is keyed on, 3 ft. in diameter, beneath which runs a short shaft with a worm on its centre, which works into the worm-wheel and ratchet-wheels near each end, these latter being worked by ratchets attached to levers working on the extreme ends of the worm-shaft. The end of the main shaft is attached to another shaft, which is hollow, and in shape like the letter U, by a joint which nevertheless permits of the one revolving without the other. This U shaft runs also on grooved wheels, and connecting-rods, attached to it some few feet from where the two shafts join, are connected with the upper ends of the ratchet-levers. On either side of this shaft iron pins about 15 in. long, set at about 3 ft. 4 in. apart, project horizontally at right angles to the shaft, seven pins being on the one side and eight pins on the other, those on the one side being placed opposite to the centre of the space between two pins on the other side. Corresponding to these pins are seats formed on a ledge on the wooden trough already referred to, for the accommodation of the motive power which M. Berrens proposes to employ.

This machine, M. Berrens informed us, was admirably adapted for making a tunnel between England and France for the long talked-of railway. The action of working it will be readily understood, for as the machine is thrown forward by an action similar to rowing by the fifteen stalwart operators, the cutters are forced into the rock, and at the same time, by means of the ratchet and worm wheel arrangement, a slight rotatory motion is given to the tool with each stroke. By the by, we must not omit to state that M. Berrens intends to employ women for this work; for, as he says, they are broader in the hips, and therefore better qualified, physically, than men for that style of work, besides which, as he judiciously remarked, they require less wages than men do, and consequently their employment would be economical! Comment on M. Berrens's perforator and mode of working is unnecessary.

THE CINCINNATI SUSPENSION BRIDGE.

(Continued from p. 76.)

Floor, Girders, and Trusses.

THE total width of the floor is 36 ft. between the outside railings. The cables are suspended between the roadway and side-walks, and they form, therefore, together with the suspenders and stays, division lines. Inside of the suspenders two lines of iron trusses, 10 ft. high, extend over the whole length of the bridge from abutment to abutment.

It was resolved by the Board at an early day to employ wrought iron in place of wood for the framing of the floor. Accordingly all the bearing parts are made of iron. In its general features, the iron framework of this bridge is similar to that of the Alleghany bridge at Pittsburgh. Every 5 ft., corresponding to the suspenders, iron beams, 39 ft. long, are attached to the latter. These beams are made of two pieces, spliced in the centre; their section is of the usual beam pattern, 7 in. deep, weighing 20 lb. per foot lineal. At the points of suspension, each beam is further strengthened by additional flat bars 7 ft. long, 6 x $\frac{1}{2}$ in. section placed on each side of the stem. As no outside cables are employed for the support of the side-walks, this additional strength became necessary. Under the roadway, each beam is further strengthened by truss rods, which pass under the centre girders.

Underneath the floor beams iron girders of 12 in. depth, weighing 40 lb. per foot lineal, and rolled in length of 80 ft., are suspended in the centre of the floor, running lengthways. Another line of 9 in. girders, weighing 30 lb. per foot lineal, rests on top, and corresponds to the lower line. The upper and lower girders thus embrace the floor beams, and are bolted together in such a manner, that in point of stiffness they are more than equivalent to a continuous plate girder of the same depth. As soon as this composite girder was put in place and the bolts tightened, the stiffness of the floor was sufficiently increased to admit of the passage of heavy loads. Its principal object is to distribute the effects of heavy transitory weights over a greater length of floor, and also to assist in meeting the impressions made by heavy gales.

In order to allow for the contraction and expansion to which an iron girder of 1630 ft. length is exposed, in consequence of the variations of temperature, *slip joints* are employed in the

splices. Rivetting was of course out of question. Although provisions might have been made on the towers to allow the whole girder to expand and contract, its effect upon the planking, as well as upon the whole framework, would have been fatal. The Alleghany bridge at Pittsburgh is, I believe, the first work, so far as I know, where this task has been successfully accomplished. It proves equally successful in the Ohio bridge. One of the worst results of a continuous solid girder would have been lateral bulging and buckling. This tendency was plainly exhibited, and caused some trouble during the construction of the floor. As soon as sufficient inherent stiffness was obtained by the framing to resist this action, and to confine its forces within a straight line, then all worked right. One good result of this slip-joint arrangement is that the straight line of the floor is maintained during all variations of temperature, and that the fastenings of the planking are never effected.

The same principle is observed in the combination of the trusses which separate the roadway from the side-walks. These are also 1630 ft. long, and their efficiency, of course, depends in a great measure upon their true alignment. As their sole object is to increase the vertical rigidity of the floor, the strength and arrangement of the different parts is, of course, the same throughout. Iron posts, 10 ft. long, 7 in. deep, and of the same section of the floor beams, are set up in a vertical position upon each beam. The upper and lower chords are formed by four lines of trough bars, 9 in. deep in section, with 2 $\frac{1}{2}$ in. flanges. Tension bars 8 in. wide by $\frac{3}{4}$ in. thick, their upper ends welded to $\frac{1}{2}$ in. diameter screw bolts, are placed in position diagonally, so that each of them extends to the third post, passing through the centre of the second one by a slot cut out of its stem. Thus the bars form a diagonal network, crossing each other nearly at right angles. The lower ends form eyes, held by pins, which connect the lower chords, the two pins next to a post being again connected by two stirrups, which pass under the beams, and are tightened by wedges. The upper screw bolts are passed through cast-iron triangular blocks, which rest on top of the posts, and receive the pressure when tightened up. The small additional weight which these trusses have added to the floor is well compensated for by its increased stiffness. The floor of this bridge possesses more inherent stiffness than is ordinarily exhibited in timber railway bridges of large spans. I mean to say, that a railway train passed over the Ohio bridge will cause less vibration than is produced, for instance, on the timber bridge over Mill Creek, on the O. and M. R. R. below the city of Cincinnati.

As an additional means of preserving the alignment of the trusses, strong braces, made of $\frac{1}{2}$ in. square iron, connect the posts and floor beams.

The roadway for vehicles is divided into two tracks, which compels wagons to keep to the right, and to follow each other in succession. By this arrangement all confusion and turning out is avoided, and more teams can be passed than would otherwise be possible. The tracks are formed by four lines of iron tramways, each 14 in. wide; thus all the different gauges of vehicles are accommodated, street cars included. The economy of such iron trams has been fully proved on the Alleghany bridge at Pittsburgh, where I have applied them for the first time.

The flooring of the roadway is composed of three thicknesses of plank, making a total average thickness of 8 in. Most of this plank is oak. All the lumber has been thoroughly seasoned in a drying house, and has been planed down to an even thickness, except the track plank, which are left rough. To keep the water out from between the courses, a mixture of coal tar and rosin has been copiously applied in a hot state to every layer. The lowest course of plank is fastened to the iron beams by small bolts; the upper courses are secured by wood screws. The two lower courses are laid lengthways, the third course on the horse tracks is laid crossways. This last one is, of course, subject to wear, but can be easily replaced.

The side-walks are composed of two courses of plank, $2\frac{1}{2}$ in. thick each, the lower one of white pine, the upper one of oak principally.

Neat iron lattice railings, 4 ft. high, protect the side-walks, and add to the appearance as well as to the stiffness of the bridge.

By our charters, the bridge floor in the centre of the main span is required to be 100 ft. in the clear above low water. This elevation now is actually 103 ft. at a medium temperature, and is, of course, subject to imperceptible variations. The extreme rise will be about 1 ft. in the coldest, and the extreme fall 1 ft. below the medium in the warmest weather.

By the reduction of elevation from 122 ft. to 103 ft., the ascent of the approaches has been considerably improved. The elevation of Front-street on the Cincinnati side is 60 ft. above low water. The height of floor in the centre of the tower is 91 ft., and this ascent of 31 ft. is overcome within a distance of 654 ft., which is at the rate of 4.77 ft. in 100 ft. As far as the solid pavement extends from Front to Water-street, the grade has been a little steeper, and correspondingly reduced beyond.

On the Covington side, the approach begins at Second-street, at an elevation of 71 ft. above low-water mark, and this makes the grade to the anchor walls very easy. When the immense traffic is considered which is daily passing over this great thoroughfare, the reduction of its elevation to the present level will not be regretted, even by those who have consistently opposed it.

All the wrought-iron beams, girders, and channel bars which have been used for the construction of the floor were manufactured by the Buffalo Union Ironworks, in Buffalo, N. Y. I consider it but just to state here that the quality of these irons has fully come up to my expectations, and that the rolling cannot be surpassed in smoothness and finish.

By the firm of Charles A. Wolf, the greatest portion of the bar iron consumed in the floor was manufactured; another portion was delivered by the Globe Works; and Messrs. Phillips and Son supplied the plates for the girders over Water-street.

Strength and Stability of Work.

Among the various branches of modern industry, perhaps none has produced riper and better fruits than the art of making and improving iron and steel. Before the manufacture of iron had attained to a high degree of perfection, no such work as the

Ohio Bridge could be erected. Stone and timber being the only materials at the service of the engineer, his efforts at crossing rivers were limited to small spans. This scope was considerably enlarged by the employment of wrought and cast iron. The erection of cast-iron arches of 100 ft. span and over, at the beginning of this century, was a great triumph in civil engineering. Telford's successful accomplishment of the old Menai suspension bridge, however, was the great feat of those days. But by the modern railway traffic greater strength and stability were demanded, and Telford's great achievement was then mistakenly left unappreciated and greatly undervalued. When this same famous strait was to be crossed by the railway, something original and new had to be substituted. To the genius of the late Robert Stephenson we owe the tubular bridge, while it was reserved for the ingenuity of Brunel, jun., to illustrate an apparent perfection by the construction of the Saltash bridge. But all these have now ceased to serve as models; they have yielded to better systems, as exemplified by the various combinations of the triangular truss, and by the lattice bridge, of which so many fine specimens have of late years been erected in Europe.

It is a curious fact, that the various systems of arching, trussing, and tubing, when they are analytically examined, and each system is considered as complete within itself, and not exerting any forces upon the abutments, except by the simple weight of the structure, have no advantage over each other, neither in point of strength nor economy, providing the vertical supporting power is alone considered, without any reference to buckling or other lateral deficiencies. I have made these comparisons, and I mention this fact as a statistical curiosity. This, however, will only hold out and show equal results in such combinations as are free from statical blunders. Where this is not the case, of course there is waste of materials, or material misapplied.

For small spans the principle of suspension in a scientific point has no advantage over arching, trussing, or tubing. By the application of a superior material, however, as for instance wire, a decided economy may be effected.

It is in large spans, where the principle of suspension asserts its full claims, and where it will for ever stand without a rival, no matter what novelties may turn up in the future. Within the whole range of engineering, no system of construction presents such favourable conditions as is offered by the suspension system. Fully aware that opposite opinions are taught in textbooks on engineering, I know that I am exposing myself to criticism, but I also know that the future history of engineering will do me full justice.

Spans of 450 ft. may be safely attempted on the tubular plan, but it can only be done at an enormous waste of materials. Each single tube of the Britannia bridge weighs 1550 tons gross, and is 460 ft. long. The main span of the Ohio bridge weighs not quite 1500 tons neat, and is 1057 ft. long. The latter will safely support over 3000 tons, while one-half this weight will overtax the strength of a Britannia tube. A comparison with well built lattice bridges is not quite so favourable, but leaves still a great margin in favour of the suspension plan. But while the great economy of the suspension plan has always been granted, the old stereotyped objection of the want of stiffness remains. Just as soon as "suspension" is uttered, a picture is conjured up in imagination full of violent agitation. But while engineers and others shake their heads at "suspension," they do not reflect that every system is suspended, and that the differences grow out of the different modes of suspension, and are not due to suspension in itself.

In all tubular and lattice bridges, an enormous waste of material is necessarily incurred in order to prevent buckling, and to provide for that lateral stiffness, which is quite as important as vertical strength. The railway bridge over the Rhine at Cologne, in Germany, is probably one of the best specimens of lattice erected of late years. This bridge is as strong, if not stronger, comparatively, than the Britannia tubular bridge, and it will certainly last much longer. The Britannia tubes are 460 ft. long; the reaches of the Cologne bridge are 330 ft. But, like all large spans of truss-work, the Cologne bridge is subject to injurious oscillations; but no such motions can be noticed in a well built suspension bridge. The Ohio, the Niagara, and the Alleghany bridges are entirely free from such oscillations. By the movement of a dense crowd of people over the Ohio bridge, a slight lateral motion may be noticed in the cables, and, to some extent, in the floor, between the centre of the main span and the towers, but not in the centre itself. This motion is so slight that few persons will notice it; it is owing to the want of outside cables for the support of the side-walks. And since this movement occurs only in extreme cases, and is scarcely perceptible, I am not disposed to make further provisions for its counteraction. In a bridge with side-walks of 10 ft. wide, or more, such as the Alleghany bridge, outside cables are necessary.

If a special railway track was laid down in the centre of the floor, I feel satisfied that full trains might be run over at a speed of 20 miles per hour, without producing any more vibrations than are usually noticed in our best constructed iron truss bridges of ordinary spans.

A simple cable or chain, freely suspended, is of course susceptible to forces which have a tendency to disturb its equilibrium. As the laws of the catenary are well understood, it is easy to calculate the deflections which may be produced by any stationary or transient load, that may tax a certain part of the system. To no combination can mathematics be applied so surely and successfully as to the suspension system. The importance of this fact is not to be underrated. No engineer is as safe in his work as he who is competent to plan and execute a suspension bridge. There is no guesswork, no blind judging, but absolute certainty for him, provided he understands what he is about.

The comparative extent of disturbance to which a cable may be subjected depends upon its span, deflection, and weight. The greater its weight, the less its disturbance. And since this weight is increased by the permanent weight of the suspended floor, it follows that the larger the span, the greater is the weight, and the greater will be the stability of the structure. Although this law is well understood by mathematicians, it has, in all late engineering discussions on the merits and demerits of suspension bridges for railway purposes, been kept studiously out of sight.

A suspension bridge should be considered in the light of a *suspended girder or truss*. The floor of the Ohio bridge, in connexion with its girders, trusses and stays, is a *trussed* bridge, but of so large a span that the truss will not supply the requisite power; other elements of support must be added to the system, and these are supplied by the *cables*. And just in proportion to the weight and inherent stiffness of these cables will the rigidity and strength of the whole structure be increased. Treating this problem in this light, its whole aspect becomes changed. We are no longer dealing with a system that is liable to be disturbed by a "dog's trot," but we are considering a huge truss and girder suspended over a span exceeding 1000 ft. in the clear, and moreover we are treating a problem which cannot be solved in any other way.

Since the interruption of travel across the East river, between New York and Brooklyn, caused by the ice last winter, the old project of bridging this tidal arm of the sea has been revived, and various charters are now being enacted to realise this conception. This great tidal flow not only preserves the normal condition of the harbour of New York, but it also serves as one of the principal highways of its commerce. With a depth of water of 20 to 50 ft., its whole width is navigable. Reflecting now what an immense commerce will be crowded through this channel, say in 100 years hence, can the question of a permanent obstruction by *piers* or otherwise ever be entertained? The planting of such obstacles to navigation would be a great national offence; it would be a thrust at the commerce of this continent. Except *tunneling*, all other projects which design obstructions in this river are out of question. Consequently the East river will have to be crossed by a single span, which may vary from 1400 ft. to 2000 ft., or more in the clear, according to location, and at an elevation in the centre of no less than 130 ft. above high tide. But, the larger the span, the more rigid it can be made, and since the above dimensions are far within the limits of practicability, their erection is simply a question of cost.

(To be continued.)

ENGINEERING IN AMERICA.

A CIVIL engineer in London sends us the following extract from a letter from a young English engineer now in Saint Louis, Missouri, U.S.:

"On my arrival here I called on your friend, and he procured me introductions to several engineers. I have been to see them all, and I have also called at the various railway offices, but cannot get anything to do. *This looks very much like the old country.* I have now been two months on the look out, but without success; however, I do not mean to be down yet, but I must say that, so far as I can see, this does not appear to be a good country for civil engineers. Every one tells me that an engineer should carry more than one string to his bow. They are a very practical people here, and they only stick to engineering so long as it 'pays.' When things get slack, they drop the 'C. E.' and turn to something else.

"I am told that it is not an unusual thing to see a man combining the professions of engineer, land-surveyor, lawyer, house-agent, and schoolmaster, and on a pinch they have been known to take to *preaching*! I have taken a house with four rooms and a cellar, for which I pay 65*l.* per year: such a 'crib' in Liverpool would bring a rent of about 18*l.*

"Engineers or surveyors are paid at rates varying from 12*l.* to 38*l.* per month, but the latter appointments are like angels' visits.

"This is a great city for commerce; it certainly is the most busy place I have ever seen. It has a population of over 200,000, chiefly composed of French, Germans, Dutch, and Irish. I see every one living well here, but how to get *into* the way of doing so is the grand secret. I have already come to the conclusion that civil engineering is not the right *track*, so I mean to run off into some other direction.

"I annex a list of wages paid here, from which you will see that this is a perfect Eden for working-men: Mechanics, 6 to 8 dollars; masons, 4 to 5 dollars; bricklayers, 5 to 6*½* dollars; carpenters, 4 to 5 dollars; labourers, 2 to 2*½* dollars. Farm servants get 28 to 35 dollars per month, and are found in board and lodging. The dollar is now worth about 3*s.*

"A new addition to the St. Louis waterworks is about to be made, and I annex a list of the prices agreed on:

	s.	d.
Earthwork in embankment	1	6 per cubic yard.
Puddle	4	6 "
Rough paving	12	0 "
Concrete	24	0 "
Rubble masonry	18	0 "

"The rubble masonry which I have seen built here would not be allowed for temporary work in England."

MINERALS IN FRANCE.—The quantity of iron minerals imported into France in the first five months of this year was 195,800 tons, as compared with 169,700 tons in the corresponding period of 1866. The increase of 15 per cent. here indicated was attributable to the larger deliveries made from Spain and Algeria.

AN IRON-CLAD FOR MELBOURNE.—Some of the leading shipbuilding firms have submitted tenders for the construction of an armour-clad monitor for Melbourne. She is to be 2107 tons burthen, with twin screws, and she is intended solely for coast defence. She will not have any mast, and will lie very low in the water.

THE PARIS EXHIBITION.

In continuing our attempts to generalise the great facts brought before the eyes of the public at the Paris Exhibition, and to draw our conclusions from them with regard to the direction of progress in our profession all over the world, we now turn to the second element of engineering work, viz., the manufacture of iron. In this branch, above all, progress is rapid, the changes important and characteristic, and the results striking and effective. We have seen in the space of ten years the whole method of working iron revolutionised by scientific discoveries and important inventions, we have seen the basis of iron manufacture changed, and the great centres of industry shifted from one locality to another, in consequence of the difference of conditions afforded by the different places for the improved methods of working. All this is—although not exclusively, yet principally—due to Mr. Bessemer's great invention. We find the products of the Bessemer process exhibited in the departments of all countries, and wherever iron is made, or iron ore found, we can trace some important effect, some vital change which has taken place, and which is due to that one invention. Wherever a mine of pure iron ore is worked, the production has risen and trade improved; wherever the pressure of competition kept down the quality of some average mark of pig iron below mediocrity, improved modes of working, increased care and attention, and improved scientific appliances have been resorted to, and the quality of iron has been raised. The quality of iron ore, formerly a question of secondary importance, has now become prominent above all, and of the two mining products, coal and ironstone, the former has ceded its primary position to the latter. How does this great and complete change affect the iron manufacture of this country, and its relative position to other manufacturing places all over the world? At first sight it would appear that we must be the losers by this change. Our iron ores are decidedly inferior to those of Sweden, Austria, Germany, and Italy, while our coals are vastly superior to those of all these localities. To make the quality of the staple article dependent upon the ore in which we are behind our neighbours, instead of basing our industry upon the coal, in which we have a decided advantage, would appear to be equivalent to a suicidal act on the part of our iron industry. The thought that the Bessemer process will make this country lose its manufacturing superiority, for which it is principally indebted to the invention of puddling, has been more than once expressed in foreign countries as well as in our own. Yet all facts prove the reverse. The more carefully we look at the products of iron manufactures throughout this great Exhibition, the more convinced we must be that in this branch most particularly England has maintained her old position, and is likely to do so for a future period of time, the length of which no human eye can at present overreach. Looking at the specimens of pig iron, we have as yet failed to discover a single specimen which will beat the Cleveland iron in price, or the Scotch foundry pigs in quality, or the British hematite in all those qualities which are essential for the Bessemer process. There is cheap iron made in the Saar district, and there are excellent specimens of it and of the products made from it in the Prussian department, but if Mr. Dixon can come up to his statement, and there is no reason why he should not be able to do so by a little exertion, no iron manufacturer in the Saar district will compete with his Cleveland rails at 6*l.* per ton, nor with his ship plates, which are guaranteed to come up to a breaking strain of 22 tons. There is also finer foundry iron made at Ilsenburg and Silesia, and in Sweden, than the most celebrated furnaces in Scotland can produce; but what are the prices of these marks, and what the quantities which can be made under the most favourable circumstances? Made with charcoal in small furnaces, and in localities so far removed from all suitable means of communication with the markets of the world, that the cost of transport doubles the prime cost of the article before it can reach the nearest seaport, such products have no chance in the actual struggle of international commercial competition. They are very beautiful for making trophies of, but in the great open market in the real race of competition they are nowhere. If we turn to the iron manufacturer of France, we find the natural gift of the rich layers of ore existing in that country marred by the great impurity of these minerals. With the exception of a few unimportant mines in Alsace and in one or two other places, all French mines yield very inferior qualities of ore, which, when smelted by themselves, produce a material scarcely fit for any purpose. We find, there-

fore, all the great ironmasters of France in the possession of mines in foreign countries wherefrom they draw a large supply of purer ores to mix with their own, and to bring up the quality of their iron to a proper standard. We find the Creusot works dependent upon ore from the Isle of Elba and from Algeria; we notice the products of Messrs. Petin and Gaudet's furnaces in the Italian islands, and almost without an exception throughout the iron manufacture of France the transport of ore from enormous distances is a characteristic feature of the present method of working. How is that to compete with the Furness district, where the iron ore comes up from the mines to the side of the furnaces ready for use in its raw state, unmixed, unprepared, all of first quality; where the pig iron may be tapped from the blast furnace and run into the Bessemer converter, and from that without cooling pass under the hammers and rolls; where the wagons, which are sent for the coal, take iron ore to the collieries, as their cargo, and the finished articles come out of the works at the side of the sea; where the very slags from the furnaces are rolled into the sea to form fresh ground for further extension? If we come to Bessemer steel as a specialty, we must admit that both the Swedish and the Austrian specimens of that article are superior in quality to the average made in England. In these countries steel-making undoubtedly has a great future, and, particularly in Austria, the steel manufacture may at one time reach an importance and prosperity through the Bessemer process, which as yet can scarcely be fully appreciated. Still this is a question of a distant future, and at this moment it shows us only an excellent opening for British capital and enterprise to avail itself of this much-promising opportunity, and draw an immediate gain in every respect from the development of the natural resources of Austria. Cast steel—once the pride and monopoly of Sheffield—cast steel is the only material where the progress of this country has been overtaken by that of a still more rapidly advancing manufacturing district. There are two great works in Rhenish Prussia to which we must grant precedence before any steel-maker in this country. The question is beyond dispute. The quality of Krupp's steel, the unequalled facility of the Essen works for producing large masses and great quantities, the fact of an enormous import trade carried on by the firm of Krupp in our own country, all this speaks for itself. Equally so do the steel castings shown at Paris by the Bochum Company defy all competition on the part of steel-makers all over the world. While admitting and naming these important facts with all the prominence which is due to them, we cannot overlook the circumstance that the superiority of Prussian steel manufacture is not due to any unusual natural facilities. The coal of the Ruhr district is good, but not better than the average of British coals. The iron ores found in the vicinity of coal are unfit for steel-manufacture, and better ores must be drawn from Nassau and from Siegen for the best marks of pigs. Indeed, a very large quantity of British hematite iron is purchased every year by the Prussian steel-makers, and used by them in admixture with our own and the Siegen iron, which also forms a part of British steel. The success of the Prussian steel-makers is, therefore, due only to their own exertions, to the discovery and application of scientific principles to improved practice and great enterprise. We, therefore, see nothing discouraging to the profession in this country in the brilliant results obtained by our neighbours. The qualities and elements to which they thank their progress are not in any way missing or scarce among us. Let them go ahead with all speed and power, and let them be assured that we will follow them in that great race so closely and as quickly that they themselves will find it difficult to know for certain who is the first.

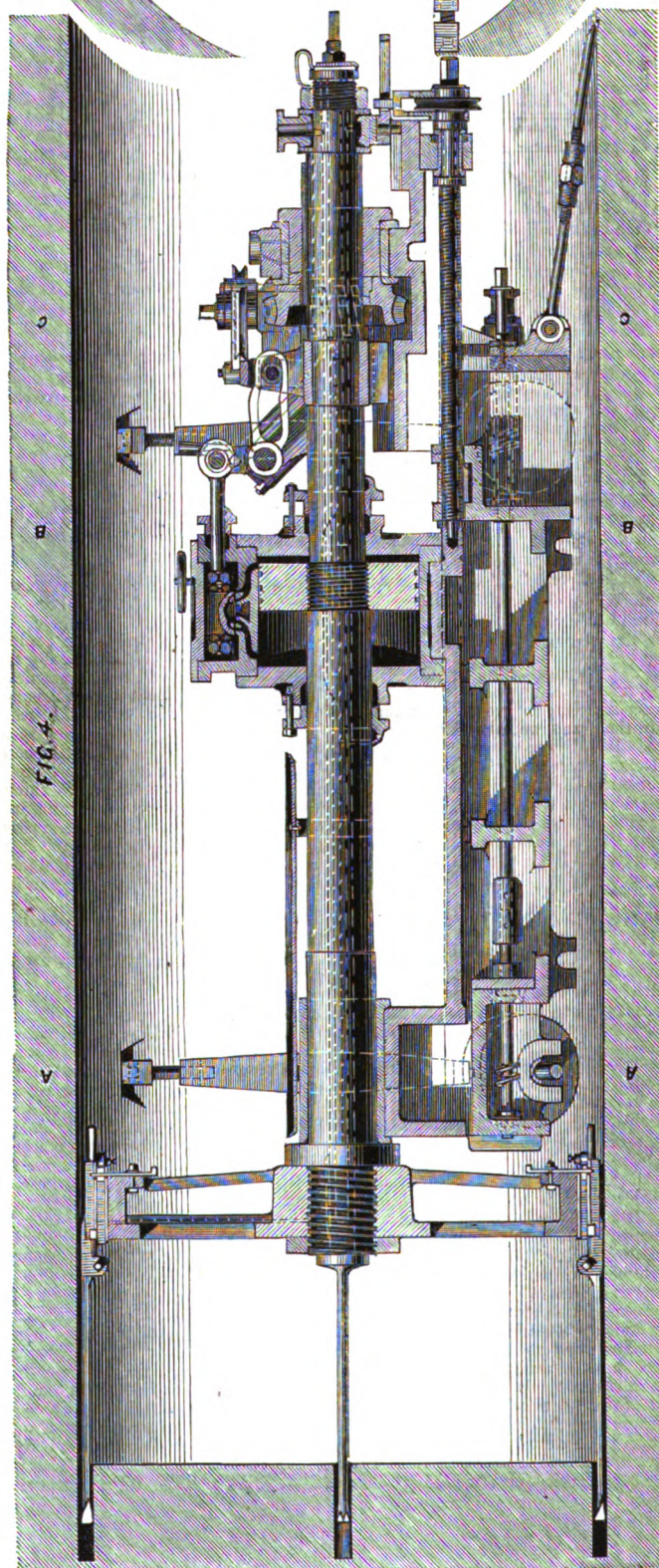
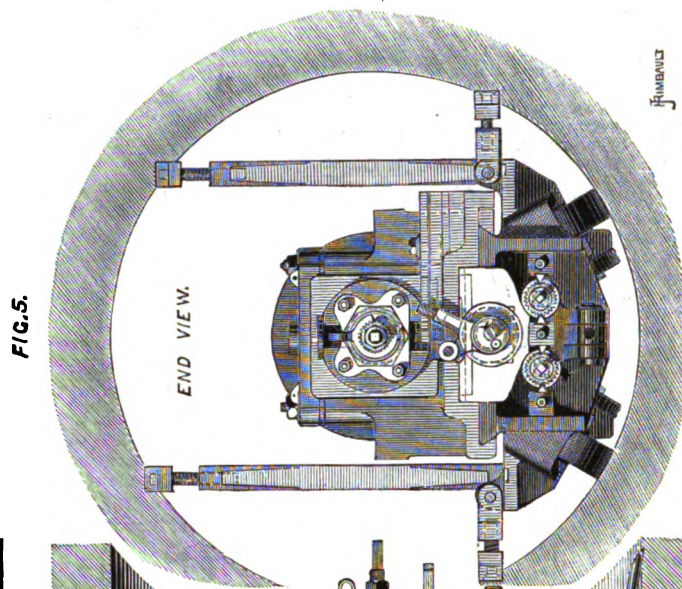
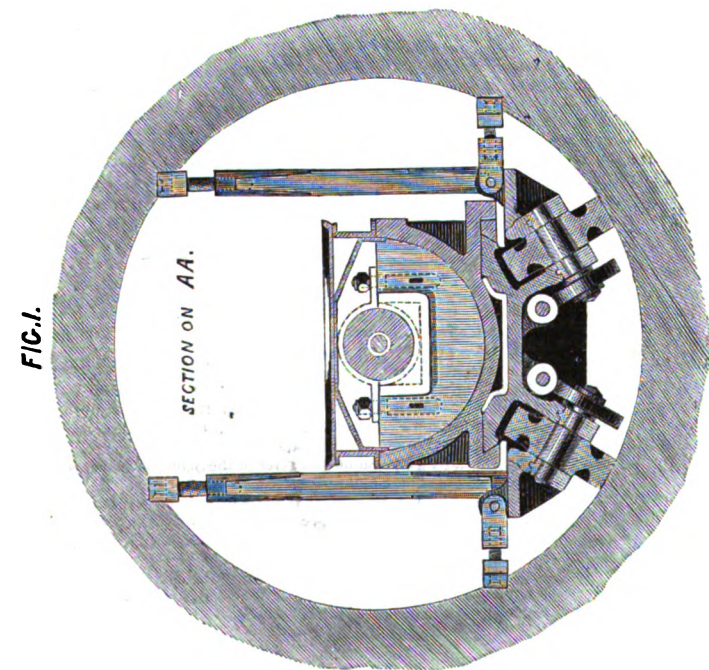
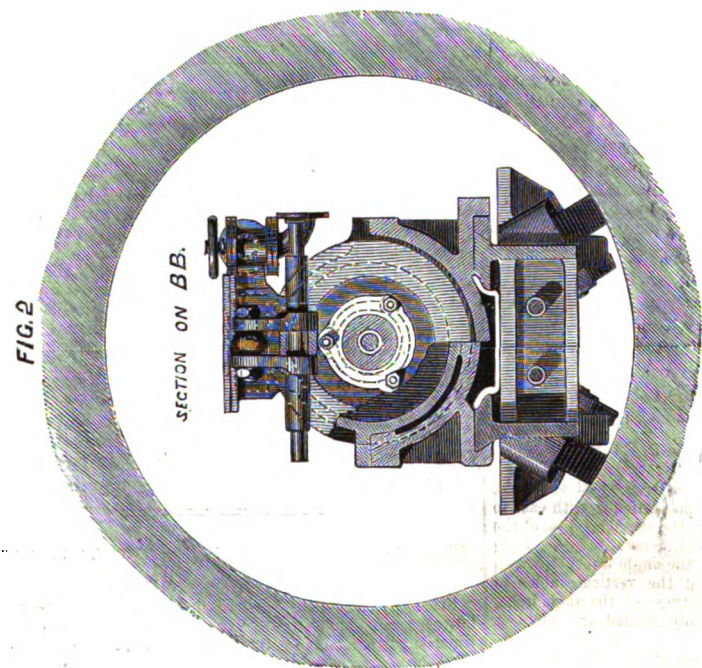
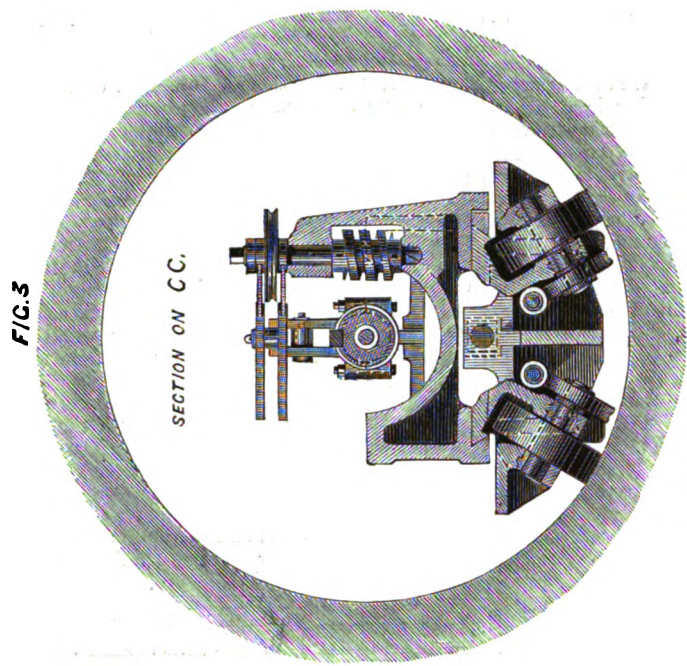
RAILS FOR RUSSIA.—The screw steamer Norfolk has left the Tyne with 1851 tons of rails for Russia. These rails form part of a Russian contract in course of execution by the Consell Iron Company.

MR. JAMES ASHBURY.—Her Majesty the Queen of Spain has been graciously pleased to confer on Mr. James Ashbury the order of Commander of Charles III. This high order carries with it the rank of Excellency, and is not often given to foreigners.

IRON-CLAD RAM FOR JAPAN.—The Tycoon of Japan has bought the former Confederate ram Stonewall for 80,000*l.*, and we believe it is now on its way to Nagasaki. It has two case-mated towers, which have been called turrets, and could easily destroy any wooden fleet not armed with heavy rifled guns firing steel or chilled iron shot.

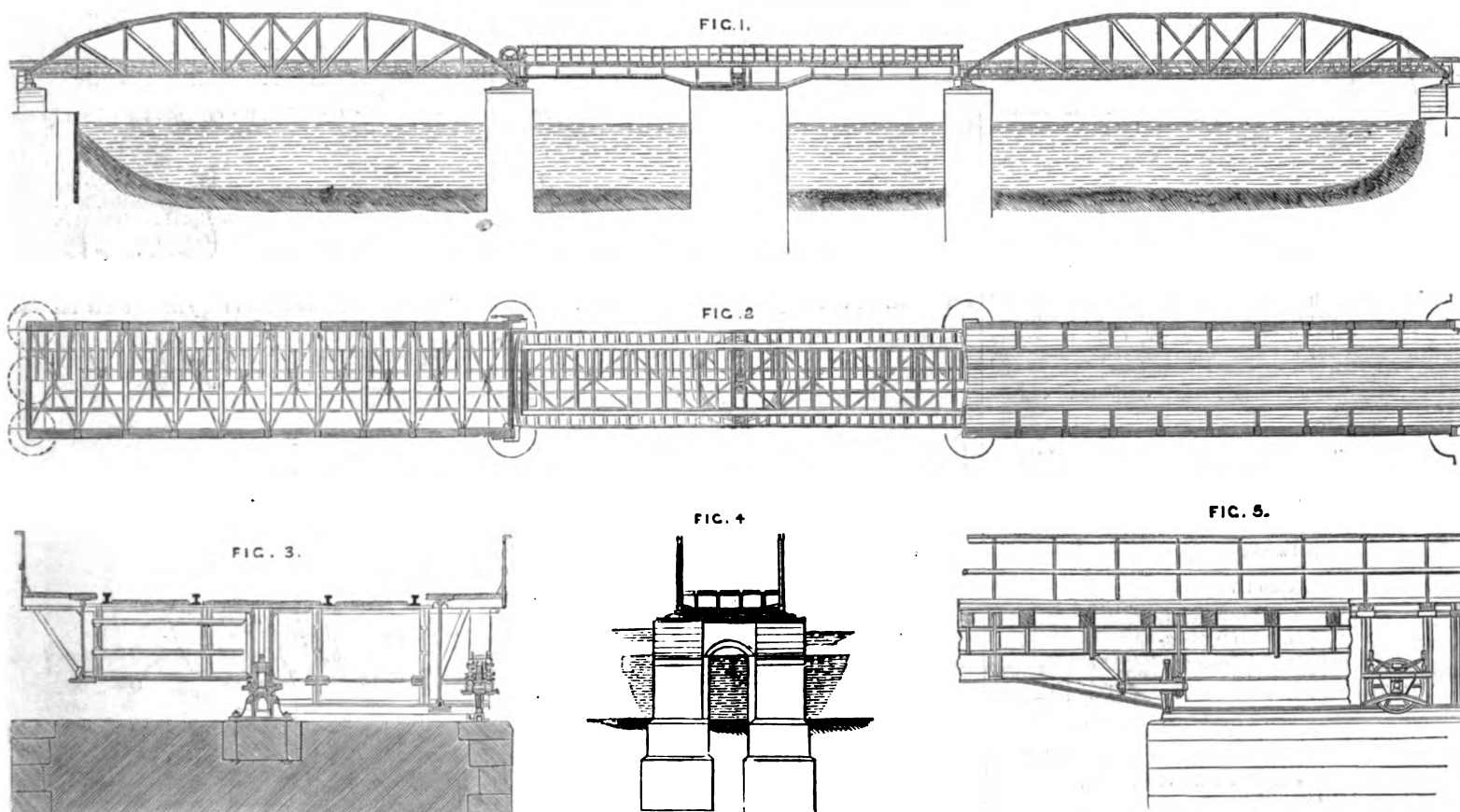
THE MIANTONOMO.—This vessel, lately the only United States ironclad in commission, is now laid up in ordinary, at League Island, near Philadelphia.

ROCK-TUNNELLING MACHINE, AT THE PARIS EXHIBITION.
 DESIGNED BY CAPTAIN FREDERICK BEAUMONT, R.E., AND CONSTRUCTED BY MESSRS. BRYAN DONKIN AND CO., ENGINEERS, LONDON.
 (For Description, see Page 97.)



THE PARNITZ BRIDGE, BERLIN AND STETTIN RAILWAY.

CONSTRUCTED ON MR. J. W. SCHWEDLER'S SYSTEM.



THE system of bridge construction suggested and adopted by Mr. J. W. Schwedler has already been briefly noticed in our columns. In a short criticism of the civil engineering models exhibited at Paris, we analysed the system as illustrated by the model of the Parnitz bridge with the view of detecting some trace of reason for the adoption of a form which we then stigmatised as "an ugly mean between a parallel trussed girder and a bowstring." The details of the system we are now possessed of do not invalidate our former conclusions. We think an inspection of the engraving of the Parnitz bridge on the present page will justify our condemnation of the system as far as appearance is concerned; indeed, M. Schwedler himself, in the "Wochenblatt des Architekten-Vereins," admits that his formula gives an unpleasant outline to the top member of the girder, but, on the other hand, he claims peculiar economical advantage as the result of that form—a conclusion we are bound to say we think is not proven. Undoubtedly the form and details of the system are such that the sectional area of each or any portion of a member may be proportioned with great accuracy and simplicity to the maximum strain occurring on it at any time, and we take this to be the chief merit of the design. It is, however, one which it shares in common with all "skeleton" structures when the conditions of uniform stress may be complied with.

An engineer is prone to take too exclusively a contractor's, at the sacrifice of a proper proportion of an architect's view of the structure he is designing. A strong reaction has, however, recently set in in this country, and notwithstanding that some eyes, such as the Ludgate-hill bridge, may be due to this, we have reason, on the whole, to congratulate ourselves on the innovation. If it be meritorious to design a bridge which shall be 5 per cent. cheaper and 50 per cent. uglier than some other bridge of similar strength and size, it will be equally so concerning other structures. Station buildings, therefore, should consist of plain walls pierced with holes for light; but lacking cornices, pilasters, panels, or indeed anything which might afford relief to the eye or redeem the design from hideousness.

It will be seen from our illustration of the Parnitz bridge that the Schwedler truss is made up of one or more parallelograms at the centre, with a pair of diagonals in each; of a series of trapezoids, with one diagonal in each bay; and of a couple of triangles at the ends, formed of the top and bottom members. The form of each trapezoid is such that the strain on its diagonal ranges between $\frac{1}{2}$ and the maximum tension to which it is liable under the most unfavourable position of the rolling load. It is obvious, if double diagonals were not introduced at the centre of the bridge, the form of the bays at that point would also be trapezoidal, but with the shorter vertical towards the centre of the bridge additional horizontal strain would of course result from this depression of the top member, and on that account Mr. Schwedler has adhered to the double diagonals of the ordinary bowstring construction at that point. The proportional length of the span so treated will be governed by the ratio of gross to rolling load. Mr. Schwedler urges that, in comparison with the lattice girder of uniform depth, his system has an advantage, since the verticals and diagonals are shorter and lighter, and that in comparison with the bowstring it also maintains its superiority, as the top and bottom members are of reduced instead of increased section towards the bearings. With the refinement of economising evidenced by these argu-

ments, we are surprised that the diagonals were not designed to resist compression as well as tension, and the outline of the truss assimilated more closely to the parabola, since a few pounds of iron would then have been saved by allowing the strains on the diagonals to range between — and +, instead of between 0 and — only, as at present.

The formula for the depth of truss, conforming to the conditions of 0 and — strains alone on the diagonals, is given by Mr. Schwedler as follows:

$$y = \frac{4Fx}{l^2} (l - x) \cdot \frac{p + \frac{\pi}{2}}{p + \frac{\pi}{2} + \frac{\pi}{l}}$$

where p is the dead load, π the rolling load, F the depth, l the span, and x and y the co-ordinates.

The chief practical advantage claimed for the system is that the sectional areas may in all cases be proportioned with ease to the strain. The required variations in the sectional area of the top and bottom members are obtained, generally, by reducing the width of the horizontal tables of the angle irons, of which those members are built up, keeping the vertical tables of uniform depth throughout. The jointings of the angle irons, verticals, and diagonals are very simply effected, one plate at each intersection covering the whole.

The platform of the bridge consists of deep cross girders rigidly connected to each vertical, in such a manner as to maintain the rectangular position of those members, and, consequently, the plane of the top and bottom members. Lateral movement is provided against by the insertion of diagonal bracing between each cross girder, from pier to pier. Longitudinal girders are placed under each rail and between each pair of cross girders.

It is argued by Mr. Schwedler that the apparent distortion in the outline of his truss would be much less marked in a road bridge, on account of the comparatively small proportion of rolling load. In other words, under such conditions his system would be almost merged in that of the ordinary bowstring.

The first bridge erected on Mr. Schwedler's system was the Weser bridge, on the Altenbecken-Holzminder Railway. The truss, 185 ft. span and 24 ft. deep, was divided into 18 ft. bays; but as double bracing was introduced, the span of the girders under the rails was reduced to 9 ft. The gross weight of iron employed in the construction is stated in the "Wochenblatt des Architekten-Vereins" to be but 12½ cwt. per foot run. We think, however, there must be some error in this amount.

The viaduct carrying a double line of railway across the Oder, at Stettin, was the next structure erected. The openings (fourteen in number) are each 72 ft. span in the clear, the length of the girders over all being 81 ft., the depth 14 ft., the width of bays, and consequently length of rail girders, 12 ft., and the gross weight of iron 11½ cwt. per foot run. Each span was first conveyed on a couple of six-wheel wagons, and then lifted into its place by four hydraulic presses.

The Parnitz bridge, of which we give an engraving, is also constructed for a double line of railway. The two main openings are each 108 ft. span in the clear, and the weight of iron used in the construction averages 14 cwt. per foot run. The swing-bridge, 117 ft. long over all, weight of iron 11.1 cwt. per foot run, turns on four wheels at the centre pier, and affords a clear

opening of 40 ft. on each side for the passage of vessels. The piers were sunk by the pneumatic process. The centre pier upon which the swing bridge works is 26 ft. diameter. In the construction of this pier, a ring of iron, the full diameter of the pier by 4 ft. 6 in. high, with a bracketed flange 8 ft. wide, was suspended by thirty-two chains, and the wall of the well, 4 ft. thick, was carried up from the flange in brickwork in cement. After sinking, the interior of the iron ring was filled in with concrete, and the rest of the pier with solid brickwork. The side piers consist of a pair of cylinders 18 ft. diameter at the lower portion and 12 ft. diameter above, coupled together at the top by an arch, so that the size of the piers at the level of the girders is 38 ft. by 12 ft. These piers are about 48 ft. high, of which a length of 22 ft. is above the level of the water, 16 ft. in the water and 10 ft. below the bed of the river. The rate of sinking averaged 12 in. per diem for the centre pier, and 18 in. for the side piers.

CHATWOOD AND STURGEON'S HAMMERS.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been directed to a description of a 50-ton steam hammer in *ENGINEERING* for June 28th, in which my name has been put forward with that of Mr. Chatwood, of Bolton, as part inventor of the plan described.

I beg to state that I have nothing whatever to do with it. It is no doubt true that on the 15th of December last I obtained provisional protection along with Mr. Chatwood for improvements in steam-hammers, but certainly not for anything of the kind you have described. Mr. Chatwood introduced this plan himself into the complete specification of that patent without consulting me, having, I suppose, a degree of faith in it, which, as it would need a slight knowledge of mechanics to destroy, is quite excusable.

I shall feel obliged if you will insert this letter in your next number, as I am sure you will understand my unwillingness to appear before your readers in connexion with such a scientific invention.

Yours respectfully,

JOHN STURGEON.

Bolton-le-Moors, August 7, 1867.

SCHOOLS OF STEAM ENGINEERING.

TO THE EDITOR OF ENGINEERING.

SIR,—In an article of your impression of 26th ult., I notice: "We need a school of steam engineering even more important to us than our school already established of naval architecture." I presume you refer to the School of Naval Architecture and Marine Engineering recently established at South Kensington. I beg to state that naval architecture and marine engineering are equally represented at this school, which might equally be known as the School of Marine Engineering and Naval Architecture. The fees and (nominally) the advantages of naval architects and engineers are the same.

I am yours very truly,

X. Y. Z.

August 1, 1867.

THE MILLWALL DOCKS.

It is not very many years since the Isle of Dogs was one of the most desolate tracts in the neighbourhood of London. With a surface considerably below high-water level, undrained, and traversed by bad roads, it might be fairly called a waste. Now the case is very different. Its position on the river has caused it to become almost completely fringed with engineering factories and shipbuilding yards, and, as a necessary consequence, its roads have been improved, and it has become a comparatively populous district. The low-lying general surface of the Isle of Dogs, and the fact of its being almost entirely surrounded by the Thames, render it an admirable site for docks, and the consequence has been the carrying out at Millwall of the works which form the subject of the present notice, and of which Mr. John Fowler and Mr. William Wilson are the engineers.

The total area of the land purchased by the Millwall Dock Company is 204 acres, and the area of the water in the docks, when completed, will be 52 acres, leaving 152 acres available for wharves, &c. The portions of the work already constructed have a water area of rather more than 33 acres, and present about 2600 yards of wharf frontage, and they include a graving dock 413 ft. in length, with an entrance 65 ft. in width. The arrangement of the docks and their position with regard to the river will be seen from the general plan which is annexed, whilst the various views on pages 104 and 105, and on the two-page engraving, which we give this week, show some of their principal constructive details. For convenience, we subjoin the references to the figures in a tabular form.

- Fig. 1. West entrance from river, plan at coping level.
 " 2. " " " plan 13 ft. 6 in. below coping.
 " 3. " " " plan of foundations.
 " 4. Transverse section of entrance, through holes for gate-closing chains.
 " 5. Transverse section of entrance through holes for gate-opening chains.
 " 6. Longitudinal section through culverts by the side of the entrance-locks.
 " 7. Transverse section through caisson groove at entrance
 " 8. " " " on line F F, Fig. 3.
 " 9. " " " gate recesses and platforms; on line D D, Fig. 3.
 " 10. Transverse section through chain-hole under the abutment for the swing-bridge; H H, Fig. 2.
 " 11. Transverse section through lock, showing side-walls, &c.
 " 12. Transverse section through lock on the line K K, Fig. 2, showing the subway for gas and water pipes.
 " 13. Horizontal section of shaft of subway on line, a a, Fig. 12.
 " 14. Vertical section of shaft of subway on line b b, Fig. 12.
 " 15. Horizontal section on line d d, Fig. 12.
 " 16. Vertical section through subway on line, c c, Fig. 12.
 " 17. Transverse section of lock through the abutments of swing-bridge, on line L L, Fig. 2.
 " 18. Transverse section of lock through machinery-chamber of swing-bridge, on line M M, Fig. 2.
 " 19. Part longitudinal section of entrance-locks, showing platforms and chambers for middle and inner gates.
 " 20. Geological section in lock.
 " 21. Section of river wall.

From the general plan above referred to, it will be seen that the Millwall Docks are situated just to the south of the West India Docks, and that they will, when the proposed extension is completed, have two entrances to the river, one on the eastern and the other on the western side. The docks will thus be of a $\perp$ form in plan, there being an outer dock extending right across the bend of the river from one entrance to the other, and an inner dock running at right angles to the outer one. At present the inner dock and one arm only of the outer dock have been completed, there being but one entrance—that on the western side. The graving dock is situated on the south side of the outer dock, as shown on the general plan on which the dimensions of the docks are marked. From what we have said, it will be seen that the docks are exceedingly well situated for access from the river, and when the London, Blackwall, and Millwall Extension Railway—a line already authorised—is completed, they will be placed in direct railway communication with all the principal lines in the kingdom.

Of the west entrance we give an enlarged plan and sectional plans in Figs. 1, 2, and 3. It is fitted with three pairs of gates, forming two locks, the distance between the outer and middle pairs of gates being 250 ft., and that between the middle and inner pairs 200 ft. The clear width of the locks between side walls is 80 ft., and the cills of the gates are 28 ft. below Trinity high-water mark at the centre and 23 ft. at the sides. The inverts at the gate-platforms are 7 ft. below the levels of the cills, as shown in the cross-section, Fig. 9, and longitudinal section, Fig. 19; the recesses thus formed being filled with concrete, covered with stone landings, to a depth of 4 ft. 6 in. at the centre, the top of the platforms thus formed being 30 ft. 6 in. below Trinity high-water mark.

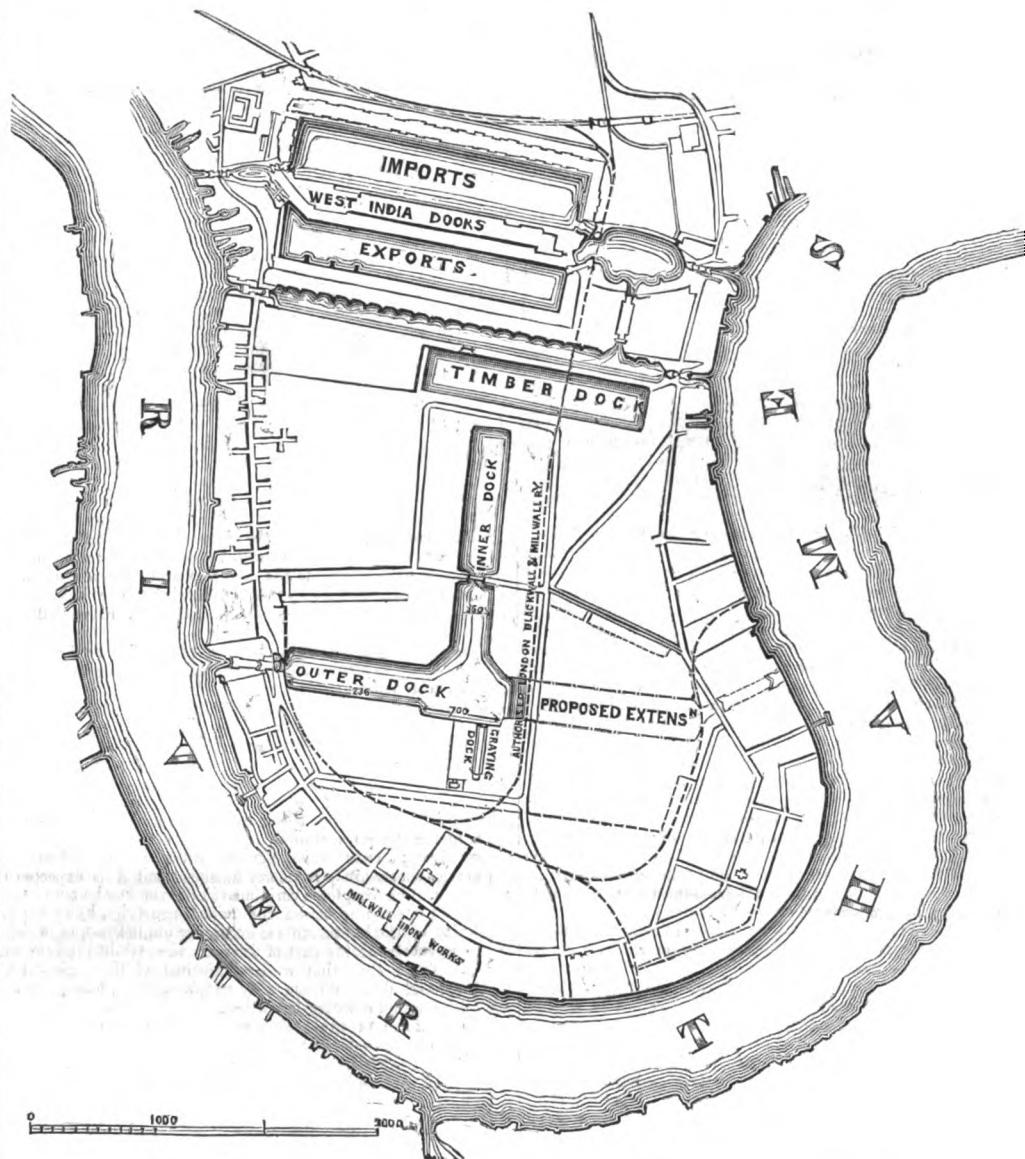
The inverts of the locks are on the same level as the cills, and they are formed of brickwork 3 ft. 9 in. thick, placed on a layer of concrete 3 ft. 4 in. thick at the centre and 4 ft. at the sides. The sides of the locks vary in section at different points, as shown by the various cross sections; they are faced with Staffordshire blue bricks, to 24 ft. below the top, and have stone copings 1 ft. 6 in. deep, formed of blocks not less than 4 ft. long, well united by stone joggles. The coping level is 4 ft. above Trinity high-water mark. The inverts of the locks are finished at the gate-platforms with stone quoins, these quoins being of Bramley Fall, except in the case of the central quoins, into which the greenheart gate-cills are recessed, which are of granite. The hollow quoins, against which the heel-posts are fitted, are also of granite, and so are the heel-post stones; the segment stones, on which the roller-paths are laid, are of Bramley Fall. At a distance of 25 ft. outside the line of the heel-posts of the outer pair of gates is formed a caisson groove, as shown at E E, in the plans Figs. 2 and 3, and in the trans-

verse section, Fig. 8. This groove is formed in blocks of Bramley Fall, and immediately outside it is driven a line of 13 in. by 13 in. piles 20 ft. long. Outside these piles the bottom of the entrance is formed, for a length of 69 ft., of granite pitching bedded on concrete. A caisson groove is also formed at the inner end of the entrance, 14 ft. inside the inner gate platform; and within the line of this groove the bottom is covered with granite pitching for a length of 14 ft. The whole of the inner end of the entrance is shown in longitudinal section, in Fig. 19.

The section of the side walls of the lock at those points where no special construction is required is shown on the right-hand side of Fig. 11. For a depth of 6 ft. below the top of the coping, the brickwork is 3 ft. thick; then its thickness is increased to 3 ft. 4 in. for a depth of 10 ft.; and then, for a further depth of 10 ft., the thickness is made 3 ft. 9 in. Below this, the brickwork is thickened to 13 ft., a culvert being formed in it as shown. The upper part of the wall is well backed with concrete, courses of brickwork running back into this concrete to bind the whole together. Including the concrete backing, the thickness of the wall is, at the top, 6 ft.; at a depth of 6 ft. below the surface, it is 7 ft. 9 in.; at a depth of 11 ft., it is 9 ft. 6 in.; at a depth of 16 ft., it is 11 ft. 3 in.; and at a depth of 21 ft., it is 13 ft. The side walls of the lock are perpendicular on their faces.

	ft. in.
Clay	5 6 thick
Peat	7 0 "
Green sand	7 0 "
Sand and gravel	5 6 "
Blue sandy clay	4 0 "
Hard sand and gravel	4 0 "
Sandy green clay	8 0 "
Rock	1 0 "
Running sand	1 6 "
Clay	

The lock-gates, the sluices, the capstans, the caisson for the graving dock, the swing and draw bridges, which we shall describe presently, and all the hydraulic machinery by which these details are to be worked, have been made by Sir William Armstrong and Co., at their works at Elswick, and they are being erected under the direction of their representative, Mr. James Hendry. The lock-gates, which are each 43 ft. wide by 31 ft. high, differ in the details of their construction from any that have been hitherto erected in this country. They are "box" gates, but instead of its being attempted to make the box formed by each leaf water-tight, as is usually done, the river side of each gate is perforated so that the water flows freely into or out of the box.



The river walls on each side of the entrance to the lock are of the section shown in Fig. 21. They are 34 ft. high above the bottom of the entrance, and have a batter on the face of 4 ft. 3 in. in this height. The brick face of each wall is 1 ft. 10 1/2 in. thick at the top, and its thickness is increased at a depth of 6 ft. to 2 ft. 3 in.; at a depth of 14 ft., to 2 ft. 7 1/2 in.; and at a depth of 22 ft., to 3 ft. As in the case of the side walls of the lock, the brick face is well bonded to concrete backing by courses carried back into the latter, as shown in the section; and the total thickness of the wall is 7 ft. 6 in. at the top and 16 ft. 3 in. at the bottom. The concrete foundation is carried to a depth of 2 ft. 9 in. below the footing of each wall, and 5 ft. 9 in. below the bottom of the entrance. Cast-iron fenders, 21 ft. long, will be placed vertically at intervals along the face of the river walls, as shown in the plan, Fig. 1.

At present the entrance to the locks is closed by a cofferdam formed of a double line of piles with puddle between, the whole being well supported by struts and braces. Preparations are, however, rapidly going on for removing this dam; and it is expected that water will be admitted to the docks on the 29th instant. The nature of the ground at the points at which the entrance locks have been constructed is shown by the geological section, Fig. 21. From this it will be seen that the surface was 7 ft. 4 in. below Trinity high-water mark, and below the top sods the strata were as follows:

The upper side of each gate, or that next the dock, is of course made water-tight. Box gates of the ordinary kind, although they may be water-tight when new, rarely continue long in that condition, the vibration caused by the shocks to which they are subjected soon giving rise to leakage. In the gates at Millwall, the water being in contact with both sides of the water-tight surface of the gates, the vibration caused by any blows that surface may receive will be much less, and it is probable, therefore, that much less leakage will be the result. The water-tight side of each gate, too, will be but little exposed to injury, as when vessels are being taken through it will be closed against the wall of the recess into which each gate folds when open. Each leaf of each pair of gates weighs about 60 tons.

The gates close against greenheart cills which are let into rebates cut in the stone quoins already mentioned. The cills are curved to an arc of 200 ft. radius, whilst the upper sides of the gates are curved to an arc having a radius of 100 ft. The toe-posts of the gates are, like the cills, of greenheart, and so are the heel-posts, these latter being carefully fitted to the polished surfaces of properly shaped granite hollow quoins. The heel of each leaf rests upon a chilled cast-iron pin placed on a block of granite, and the overhanging weight is carried partly by the upper bearing of the heel-post, and partly by a chilled cast-iron roller working on a cast-iron roller path, arranged as shown in the plan, Fig. 1. The arrangement which has been adopted to

enable the rollers to be readily removed for the purposes of repair or renewal is very simple and effective. The trunnions of each roller work in suitable bearings on the underside of a cast-iron semicircular case or cap by which the roller is covered. A kind of knuckle on one end of this cover fits into a corresponding recess in a casting fixed to the bottom of the gate to which the roller belongs; whilst the other end of the cover is kept down by a pair of massive pins or bolts, which press on it, and which, passing up through a casting fixed to the gate, are united by a crosshead, and are kept from rising by a pair of keys or wedges driven between the top of latter and another casting fixed to the gate. When a roller has to be renewed, the process will be as follows: A diver being sent down, a jack will be placed under the toe of the leaf, and the weight taken off the roller. The wedges above the crosshead will then be driven back, and a chain attached to the latter so that it and the bearing pins may be lifted a sufficient height to leave the roller-case free. When this has been done, the case will merely have to be tipped on the roller trunnions, so as to bring the knuckle on one end of it clear of the casting in which it fits, and the roller and case together can then be run out clear of the gate and lifted out of the lock in the ordinary way.

The lock-gates are to be opened and closed by chains arranged as shown in the plan, Fig. 1, there being two chains to each gate, one for opening and one for closing it. Each chain is led up through chain holes formed in the side walls, as shown in Figs. 4, 5, 7, and 10, the latter figure showing the chain hole under the abutment for the swing bridge; and each chain is acted upon by an independent hydraulic engine, there being thus four of these engines to each pair of gates. Each engine has two oscillating cylinders, and drives a winding drum of sufficient length to take up the required amount of chains without the latter overlapping. The winding drums for the closing are longer than those for the opening chains, as the former extend across the lock when the gates are open, and they have consequently to be slackened off sufficiently to allow of vessels passing over them. The second motion-shaft of each of the winding engines can, if necessary, be thrown into gear with a capstan, so that the gates may be opened or closed by hand in the event of the hydraulic machinery breaking down.

On each side of the river entrance is being erected a capstan worked by hydraulic power, these capstans, which will respectively occupy the positions shown in Fig. 1, being each capable of exerting on a hawser a pull of 5 tons at the rate of 80 ft. per minute. Two smaller hydraulic capstans, each capable of exerting a pull of 3 tons at the rate of 80 ft. per minute, are also being erected near end of the inner entrance lock, as shown in the plan, Fig. 1. The entrance lock is crossed near its inner end by the West Ferry-road, this road being at present carried over the lock by a temporary wooden bridge. At this point an iron swing-bridge is in course of erection, and it is expected that it will be completed and ready for use early in September. The bridge is arranged as shown in the plan, Fig. 1, the two arms being 110 ft. and 50 ft. in length respectively. The bridge consists of three girders carrying the two roadways—each 12 ft. 6 in. wide—between them, with two footpaths outside. The total width of the bridge is 44 ft. The centre pin of the bridge is a plunger working in a hydraulic press cylinder, and the bridge will be raised by the aid of this press before it is turned round. The turning gear consists of a pair of hydraulic cylinders, the pistons of which are connected to a chain passing round a chain-wheel fixed to the underside of the bridge, the one cylinder being used for opening and the other for closing the bridge. Provision is also made for working the bridge by hand in case of any failure of the hydraulic machinery, the hand gear being connected to pumps, by which water can be forced into the cylinder in which the centre-pin works, for the purpose of raising the bridge off its bearings.

The arrangement of the culverts and sluices connected with the entrance-lock is shown on the half-sectional plan, Fig. 3, the culverts on each side of the locks being similarly arranged. From the figure referred to, it will be seen that one main culvert, 6 ft. high by 4 ft. wide, is carried along each side of the lock from the dock to outside the outer pair of gates, and that there are, besides these, shorter culverts communicating with the locks on opposite sides of each pair of gates, and also—except in the case of those belonging to the inner pair of gates—communicating with the main culverts. The positions of the sluices will be better understood from an inspection of the plan than they would be from any written description, and it will be seen that they are so arranged that communication can be made between either lock and the dock or river, and that water can also be discharged direct from the dock into the river through the main culverts. The culverts communicate with the locks and entrance by openings varying from 2 ft. high by 2 ft. wide, to 4 ft. high by 3 ft. in width, these openings having Bramley Fall cills and covers, and being divided from each other by cutwaters of Darley Dale stone. The openings are shown in the sectional plan, Fig. 3, in the longitudinal sections, Figs. 6 and 19, and in transverse section, Fig. 8, whilst the culverts are shown in the various other transverse sections. The culverts are provided with air shafts 2 ft. square at various points, and it will be seen that the openings into the locks are arranged so that the water discharged through them tends to scour the gate platforms. It will be seen also from Fig. 1 that a low-water discharge culvert is laid from the graving dock to a point in one of the river walls a short distance outside the outer pair of entrance gates. The various sluices are of wood, and they fit against stone faces built into the brickwork of the culverts, as shown in Fig. 6. Each sluice is lifted by a screw driven by a three-cylinder hydraulic engine, which is connected to it by gearing.

Of the graving-dock we do not propose entering into any description here, as we hope shortly to be able to place engravings of it before our readers. We may, however, remark that the amount of brickwork beneath the altars is reduced by turning a series of arches under them, and that the caisson by which the entrance to the dock is closed, instead of being dropped into grooves in the usual way, is to be kept up against the stone faces provided for it by the pressure of water on the outside. The caisson is being constructed by Sir W. Armstrong and Co., and is nearly completed. The machinery for emptying the graving-dock has, we believe, not yet been decided upon; but it is probable that a "bucketing-engine," similar to that erected by Sir W. Armstrong at one of the new graving-docks at Liverpool,

will be adopted. This engine consists of a large tank or bucket, which is capable of containing 14 tons of water, and which is raised and lowered, in a well connected with the dock, by hydraulic power. The bucket is tipped during its down stroke, and brought into a horizontal position again after it has dipped into the water, and it thus bales the water out of the dock, taking up 14 tons at each stroke. The number of strokes made per minute varies according to the height of the lift, and the arrangement is said to work exceedingly well. We shall probably give some further particulars of it on a future occasion.

A new road—marked the Glengall-road in the general plan—is now in course of construction across the Isle of Dogs, and this road will cross the inner dock by a drawbridge of 80 ft. span. This bridge, which is in course of erection, is of somewhat peculiar construction. The balance portion of the bridge resting on one abutment bears near the edge of that abutment on rollers, which can be raised by hydraulic power, whilst the overhanging, or what we may term the front end, of the bridge is furnished with horns which pass under rollers fixed to the opposite abutment. When the rollers first mentioned are raised, the front end of the bridge is held down by the horns, and the whole structure is thus tilted, so that the hind end is raised above the road level, and the bridge is then drawn back over the road by hydraulic power, rails fixed on under side of the bridge running on rollers properly placed to receive them. Several bridges on this plan have been erected in various situations by Sir William Armstrong and Co., and they are found to be very convenient, as they do not leave any gap in the road when moved forward, a gap which in the ordinary construction of drawbridge has to be filled up by a traverser shifted laterally into it.

We have in the present notice only given a few general particulars of the hydraulic machinery at the Millwall Docks, but we hope to be able shortly to describe it more fully, and to give illustrations of the most important parts. The water by which it will be worked will be supplied at a pressure of 700 lb. per square inch, by a pair of horizontal engines placed in an engine-house near the graving dock. These engines, which are coupled to the same crank-shaft, have each a cylinder 18 in. in diameter by 24 in. stroke, and they will work double-acting pumps, forcing the water into an accumulator, from which it will be conducted by pipes to the various hydraulic engines. These pipes, which are already laid, pass along by the side of the graving dock and southern side of the outer dock to the entrance, where they are taken through a subway under the entrance-lock, and thence along the northern side of the outer dock and western side of the inner dock to the draw-bridge. There are two lines of pipes, one for conveying the water under pressure, and the other for the waste water discharged from the hydraulic engines, the water not being thrown into the docks, but being conducted back to a tank in the pumping engine-house. The subway through which the pipes are taken under the entrance-lock is shown in the plans, Figs. 1, 2, and 3, in the longitudinal section, Fig. 19, and in the transverse and other sections, Figs. 12, 13, 14, 15, and 16. It is elliptical in section, its horizontal diameter being 6 ft., and its vertical diameter 5 ft. The gas as well as the water pipes are taken through the subway.

As we mentioned at the commencement of the present article, the engineers of the Millwall Docks are Mr. John Fowler and Mr. William Wilson, Mr. Blandy being the resident engineer. The contractors for the whole of the works are Messrs. Kalk and Aird, their agent being Mr. Hall, and the workmanship and materials employed appear to be excellent throughout. The dock gates, swing and draw-bridges, and the hydraulic machinery have, as we have stated, been constructed under a sub-contract by Sir William Armstrong and Co., and the whole of this portion of the work has been erected under the direction of Mr. James Hendry. It was not until after the middle of May last that the erection of any of the gate work or hydraulic machinery was commenced, yet the gates and the caisson of the graving-dock are now nearly finished, and it is expected that they will be completed in time to allow of the water being admitted into the docks on the 29th inst. Considering the large size of the gates, &c., this is exceedingly quick work, and shows great energy on the part of those concerned in it. In conclusion, we should state that we are indebted to the engineers, Mr. Fowler and Mr. Wilson, for the use of the various working drawings from which our engravings have been prepared, as well as for much other information concerning the works.

THE RUTHVEN HYDRAULIC PROPELLER.

TO THE EDITOR OF ENGINEERING.

SIR,—Will you kindly allow me a few words in reply to "Twin-Screw," which appears to have become alarmed for the safety of its laurels through the pretensions of a rival—the hydraulic propeller—lately put forward in your columns?

"Twin-Screw," in order to maintain its own position, seems to think it safer to "abuse the adversary" than to rely upon a statement of its own merits. This is to be regretted, as it leads to a very desultory, incomplete, and unsatisfactory discussion of the question at issue.

Putting the objection very mildly, "Twin-Screw" proceeds to say it "would not recommend the hydraulic propeller for various reasons. And, firstly, it has not passed through that ordeal which all other propellers have, namely, the mercantile marine; not that it is necessary that a good invention should undergo that severe test; but about twenty years' experience 'with the hydraulic have twenty ships been so fitted?'"

It is not likely that "Twin-Screw" would recommend the "hydraulic" for the navy on any terms; but the reason given, because of its "not having been first proved in the mercantile marine," is very weak. "Twin-Screw" forgets, perhaps, that the screw itself was introduced by the Admiralty, and not by the mercantile marine. But this absence from the mercantile marine goes for nothing, as "Twin-Screw" afterwards admits that "it is not necessary that a good invention should undergo that severe test," and the real question is thus brought to this: Is the hydraulic such a "good invention," and what are its merits compared with the screw?

A short time ago these were debatable questions; but not so now, as "Twin-Screw" might easily have discovered from the trials of H.M.S. Waterwitch, fitted with the hydraulic propeller,

and which attained a speed of above 10 knots at the measured mile, while her sister ships, the Viper and Vixen, with the same power and displacement, made little over 9 knots, thus showing a superiority of more than 30 per cent. in favour of the hydraulic. The "good invention" is thus proved, for one case is just as good as a thousand. If the hydraulic work well in one vessel, it must, *ceteris paribus*, do so in any given number.

The hydraulic has been kept back, like many other great inventions, for the last twenty years, mainly through the influence of the men of science. They always represented, as they do to this day, that the hydraulic must be a failure, as it wastes about four-fifths of the power expended. In your contemporary, *The Engineer*, of 4th January last, there appeared a long communication from Professor J. A. L. Airey, M.A., proving, by the clearest scientific analysis that the Waterwitch utilised only 14 to 18 per cent. of the power employed. The Waterwitch had beaten the double screw Viper and Vixen of same horse power and displacement; but this had not occurred to the professor, or he could hardly have believed that the hydraulic, utilising only one-fifth of her power, could possibly have beaten the double screw. After showing what a failure the Waterwitch had proved—though she had made 10 knots against 9 knots for the double screw—the learned professor, forgetting, apparently, his scientific proofs of failure, goes on to say that "he sees no reason 'at all why, with suitable propelling machinery, we might not, 'with same engine power, get nearly 13 knots out of the Waterwitch instead of 9.'" Now, to raise the speed from 9 to 13 knots would take just three times the horse power, so that having already beaten the double screw by about 30 per cent. with the Ruthven propeller, the Professor, by some alteration of the hydraulic machinery (which he knew of), did not see any reason why he could not beat the double screw by about 200 per cent.!! Such, however, are the vagaries of science, and yet they have had the power of keeping back the hydraulic propeller for more than twenty years.

"Twin-Screw," having shown that the hydraulic is not to be recommended, proceeds to say, "the best location for the hydraulic is where the turbine is placed, at or near the water-line." Having so placed it, "Twin-Screw" triumphantly asks, "with our top-heavy broadsides this distribution of 'the weights improve the rolling propensities?'" The answer to this is, simply, that the water-wheel may be placed at any level thought necessary for the distribution of weights, from the keel up to the water level; and has thus an advantage over the twin screw, which demands its own particular level.

Next it is objected that the nozzles are placed at the water-line, and so present a conspicuous mark to the enemy. Theory and practice have shown that the best effect is produced with the nozzles at the water-line; but the trials with the Waterwitch have shown that the nozzles may be immersed without much, if any, disadvantage. At the light-draught trial, the Waterwitch, with the nozzles half out of the water, made above 10 knots as against about 9 for the Vixen. At deep draught with nozzles immersed, the Waterwitch made 9.8, and Vixen 8.8 knots. Going round from Greenhithe to Portsmouth the other day, with the nozzles still further immersed (some 6 in. under water), the Waterwitch made the distance in 24 hours, at the rate of 8 knots with an indicated horse power of 350. The Viper and Vixen attained about the same speed with 450 horse power.

"Twin-Screw" thinks the engineer the most competent person to reverse the engines, and that the hydraulic has no advantage over the screw for manœuvring a vessel. Now the hydraulic requires no reversing of engines at all. The water current is changed, either fore or aft, with one-third turn of a valve—which may be performed in two seconds—and that either by the engineer below or by any one on deck. The Nautilus, for example, going twelve miles an hour, can be stopped dead in one-half her length, a feat which requires to be seen almost to be believed. Twin-Screw can hardly back at all, and could not get sternway in less than many times the length of the vessel.

"Twin-Screw" has not an advantage of any kind over the hydraulic, and the latter possesses the following advantages of great value and peculiar to itself:

1. The hydraulic does not require any peculiar shape of hull. The finest lines for sailing may therefore be obtained.
2. The action of this propeller is uniform and continuous. The motion is smooth, and the vessel free from vibration, and from the great tear and wear caused by it.
3. No re-action on the engines from pitching and rolling in a heavy sea. The power remains efficient as in a calm, thus obviating the breaking of shafts, screws, or paddles, of such frequent occurrence in other steamships, and saves the harassing attendance of engineers to prevent the "racing" of engines and possible, destruction of the engine.
4. The vessel at full speed can be almost instantaneously backed astern. The Nautilus can be stopped dead in half her length. The engines never require to be "slowed," "reversed," or "stopped," and no communication is required with the engineer below. All the movements can be made by the commander on deck.
5. The propeller being within the vessel, the risks to paddles or screws from shot, fouling, or other accidents are avoided.
6. This propeller will act efficiently at any draught of water. If the vessel float, she can be propelled, and can ascend rivers against any current, if less than the speed of the vessel, and where screw or paddle would be useless.
7. Should the vessel be pierced with shot or spring a leak, the outward supply of water can be shut off, and the water from the leak taken up to supply the centrifugal wheel. A 500 horse power engine could discharge 1000 tons of water per minute through the nozzles.
8. The hydraulic propeller attains greater speed than the screw or paddle with the same horse power. In the case of the Waterwitch, a saving of 30 per cent. over the Viper and Vixen has been shown.

W. B.
London, August 5, 1867.

[W. B. is not apparently aware that the drawings of the machinery of the Waterwitch and a complete analysis of her performance appeared in *ENGINEERING* prior to any corresponding publication elsewhere. The Mr. Airey to whom he refers is not, we believe, a "professor," and is not of course Professor Airey (not Airey) of Greenwich Observatory, as has been supposed.—Ed. E.]

THE MILLWALL DOCKS; SECTIONS OF ENTRANCE LOCKS.

MR. JOHN FOWLER AND MR. WILLIAM WILSON, ENGINEERS.

(For Description, see Page 102.)

FIG. 4. SECTION A - A.

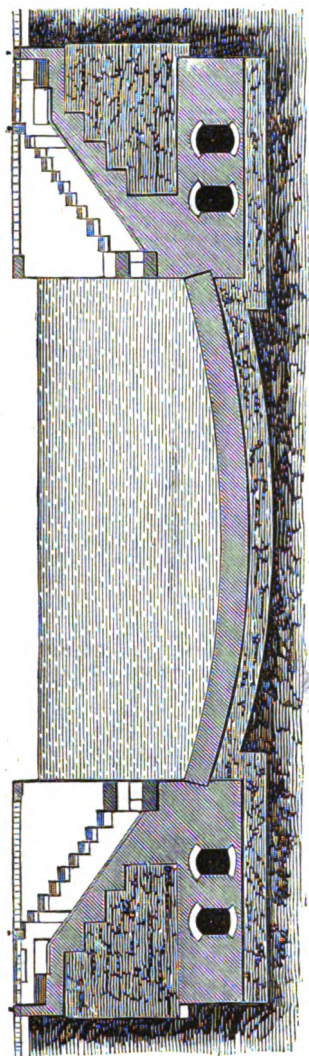
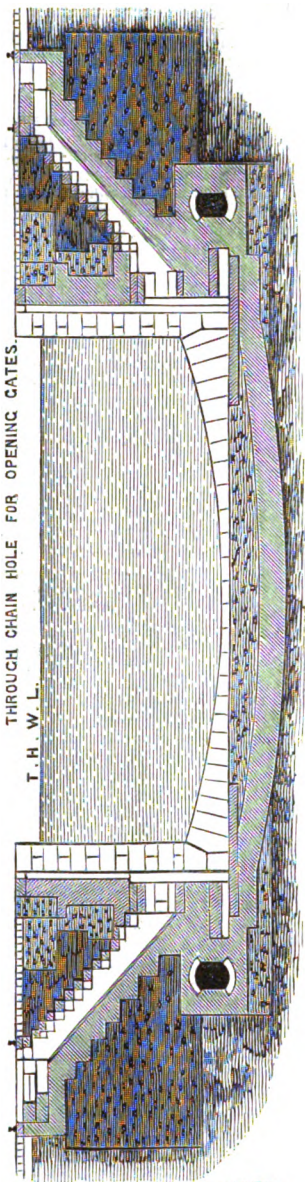
FIG. 5. SECTION B - B
THROUGH CHAIN HOLE FOR OPENING GATES.
T. H. W. L.

FIG. 6. SECTION CC

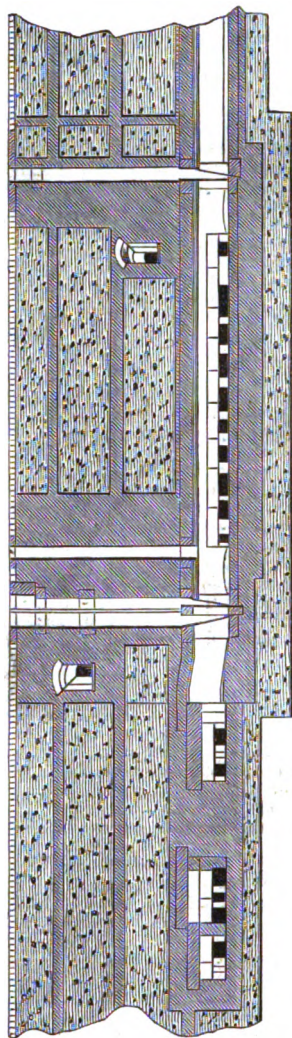
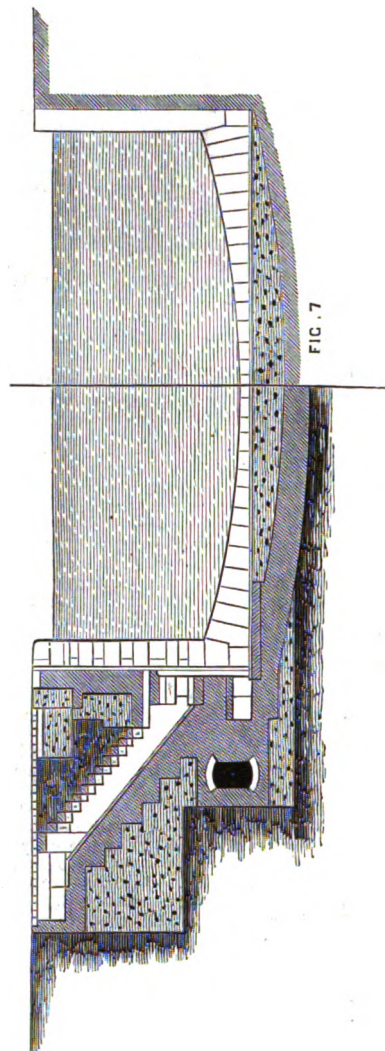


FIG. 7



SECTION F - F

FIG. 8. RIVER ENTRANCE.

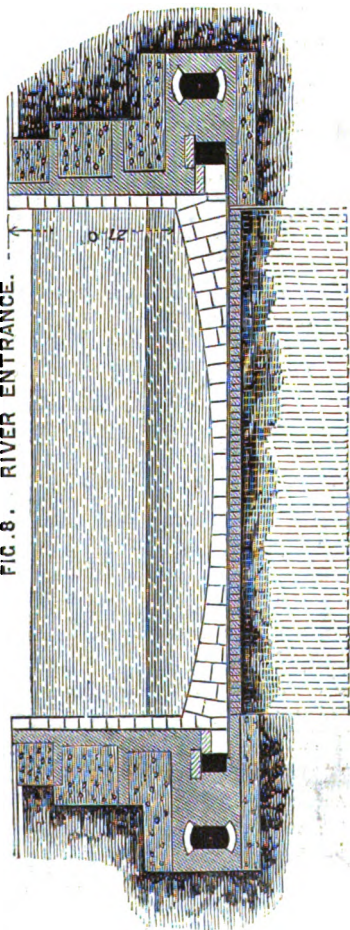
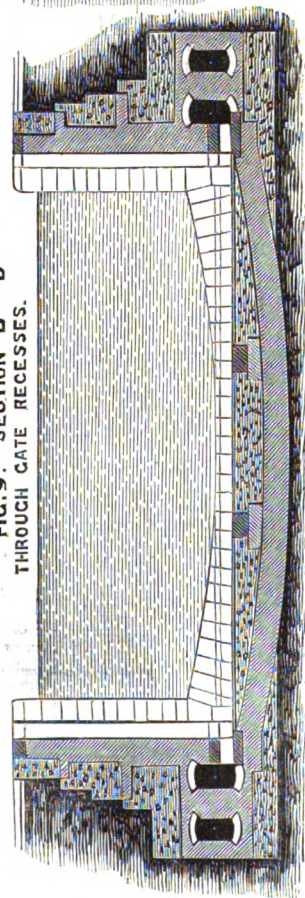
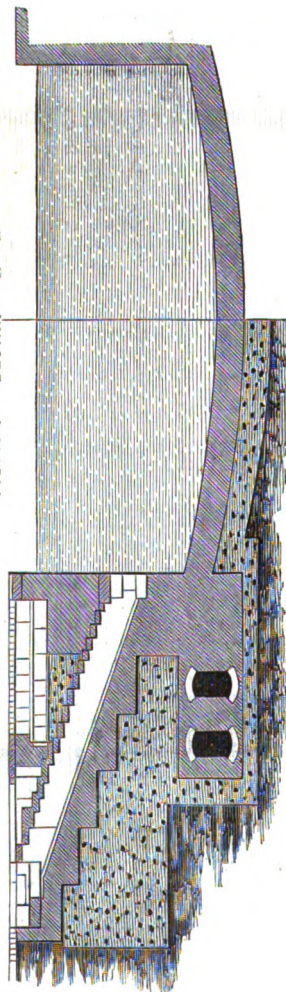
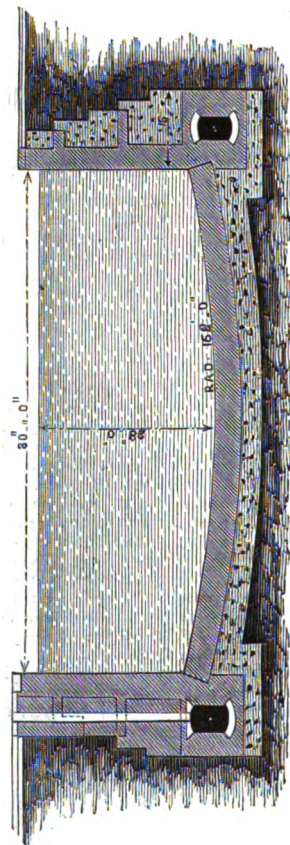
FIG. 9. SECTION D - D
THROUGH GATE RECESSES.

FIG. 10. SECTION H - H



SECTION I - I.

FIG. 11. SIDE WALLS

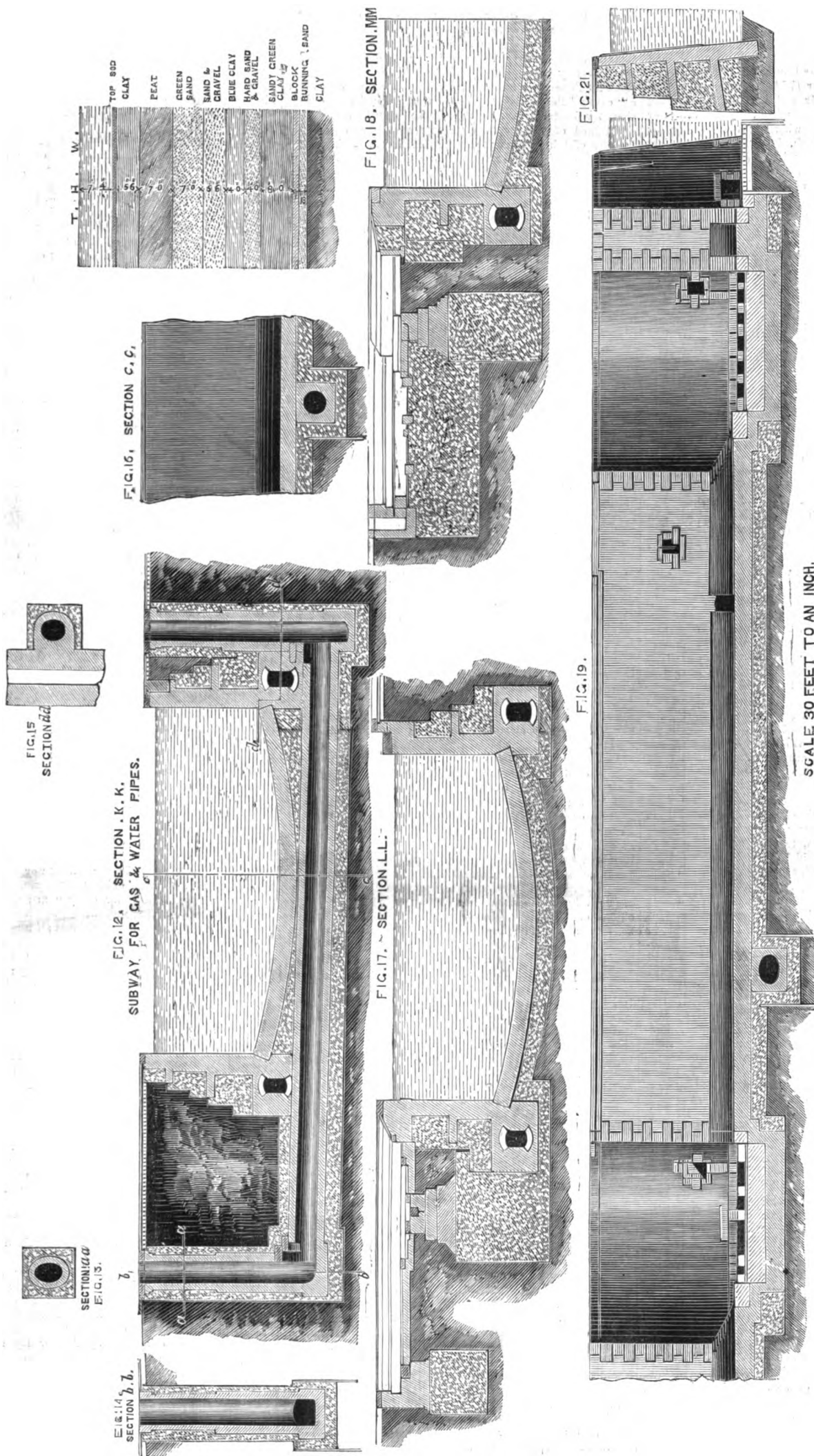


J. H. B. 1867

THE MILLWALL DOCKS; SECTIONS OF ENTRANCE LOCKS.

MR. JOHN FOWLER AND MR. WILLIAM WILSON, ENGINEERS.

(For Description, see Page 102.)



THE SOCIETY OF ENGINEERS.
On Friday last a party of eighty members and associates of the Society of Engineers paid a visit to the Millwall Docks, permission to inspect the works having been kindly given by the engineers, Mr. John Fowler and Mr. William Wilson. Of the docks themselves we have given a description on another page, and it therefore will be only necessary that we should say here that the visitors were shown over the works by Mr. Wilson, and by Mr. Hall, the agent for the contractors, Messrs. Kelk and Aird; Mr. James Hendry, the representative of Mr.

William Armstrong and Co., explaining the construction of the lock-gates, hydraulic machinery, &c. After a pleasant afternoon spent in examining the various works, a number of the party dined together at the Ship, at Greenwich.

MODEL PUMPING ENGINE.—A few days ago we witnessed the trial of a beautifully finished model pumping engine, constructed by Mr. Thomas Smith, of 10, Walnut Tree-walk, Lambeth, the maker of the celebrated working model of the

Warrior's engines, now in the possession of Mr. Penn—a model which, we may mention, weighs less than a three-penny piece. The model pumping engine above alluded to was constructed by Mr. Smith some time ago, and was exhibited by him to the late Prince Consort. It is a table engine with a cylinder $\frac{1}{2}$ in. in diameter and 1 in. stroke, and the crank-shaft is connected by gearing, having the proportion of 1 to 3, to a three-throw shaft by which the pumps are worked. The three single-acting plunger pumps are arranged below the engine, and the plungers are each $\frac{1}{4}$ in. in diameter, and have a stroke of

$\frac{1}{4}$ in. The pumps are perfect in every detail. The engine, when at work, draws water from the basin of a table fountain, and readily throws three excellent jets to a height of about 5 ft. A single jet can be thrown to a much greater height. The engine is supplied with steam from a small boiler heated by a spirit lamp; but Mr. Smith proposes to construct small engines of this class for supplying fountains in conservatories, the steam being in such instances drawn from the pipes by which the conservatories are heated. For such a purpose the engines appear well adapted.