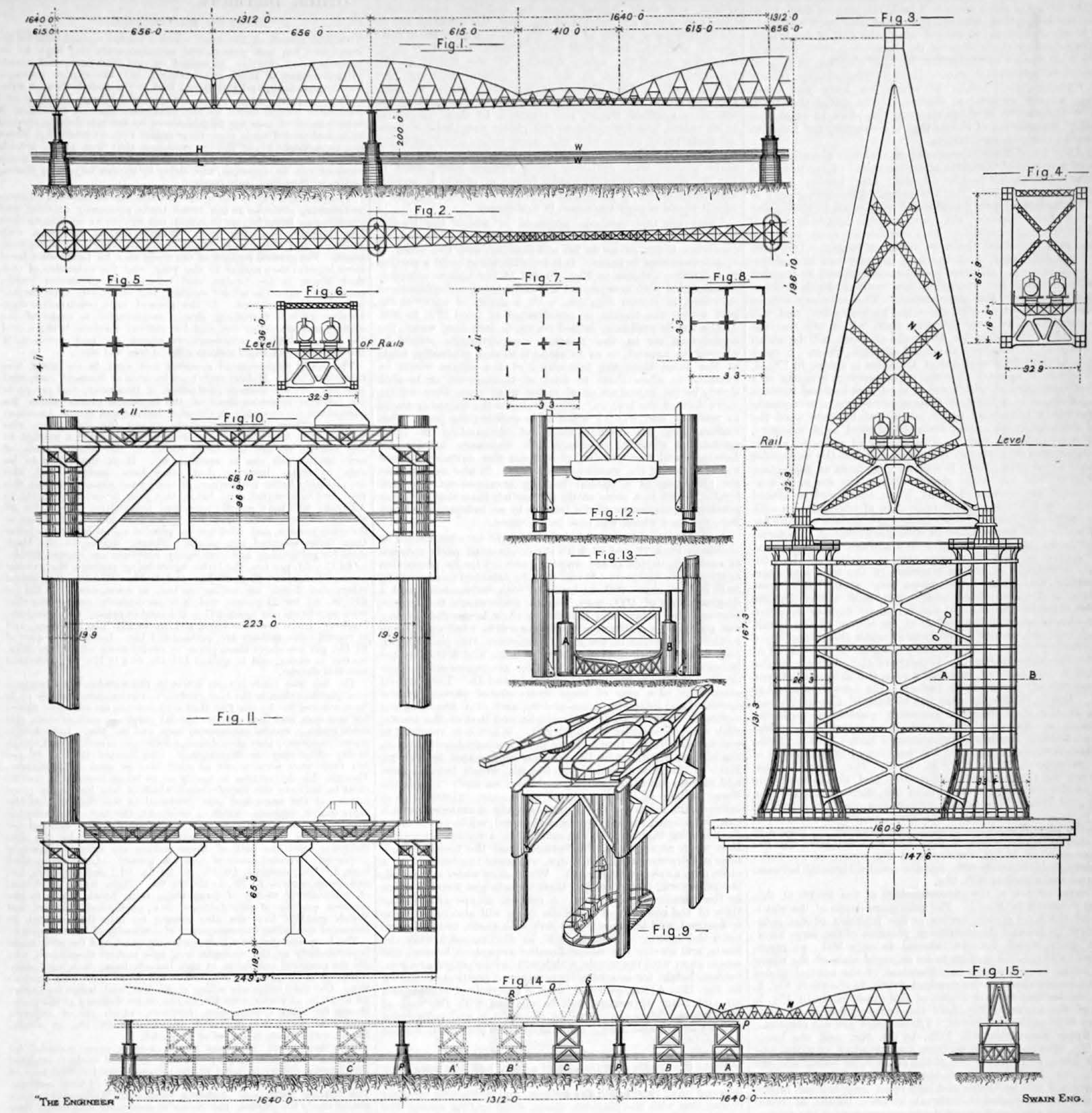
THE PROPOSED CHANNEL BRIDGE



THE PROPOSED CHANNEL BRIDGE.

BEFORE proceeding to describe in detail the design and construction of a bridge over the Channel, which forms the subject of a very interesting and able communication in a recent number of *Le Genie Civil*, we may briefly advert to the origin and history of this great project, as sketched out in the pages of our contemporary. It is rather more than fifty years since the first idea of this stupendous undertaking was promulgated by M. Thomé de Gamond, the engineer-in-chief of the Department of the Straits of Calais. It was further proved by the geological researches of MM. Combes and Elie de Beaumont that a sound and solid foundation could be obtained for a structure of this description. Another French engineer, M. Vérard de Sainte-Anne, developed the idea until it assumed the practical form of an iron bridge, supported by 340 piers. This gentleman, in prosecution of his design, established in London a society, under the name of the International Railway Company, Limited. Unfortunately M. Vérard de Sainte-Anne died before his work was much advanced, but several of his former colleagues, who had not given up the great enterprise, registered a society in London on the 12th December, 1884, called the Channel Bridge and Railway Company, Limited. The object of this newly-formed company was to elaborate and carry, if possible, to a successful termination the railway scheme uniting France and England, and to obtain the necessary concessions for the erection of the bridge.

Under these auspices, the company set vigorously to work. In 1887 the president, Admiral Cloué, made arrangements with MM. Schneider and Hersent, in virtue of which, those gentlemen agreed to undertake a thorough and complete investigation of the Channel Bridge project. They placed themselves in communication with Sir John Fowler and Sir Benjamin Baker, and the result of this judicious combination was the preparation of a complete set of plans and calculations relating to the construction of a bridge stretching from Cape Gris-Nez to the opposite shore at Folkestone, constituting an iron roadway nearly twenty-four miles in length, carried by 120 piers. This undertaking, the cost of which was estimated at £38,400,000, received the favourable consideration of the Society of Civil Engineers in Paris, as well as of the English Iron and Steel Institute. The possibility of the erection of a structure of this magnitude having been satisfactorily demonstrated, the company next gave its attention to a careful inquiry into the nature of the bed of the Channel, in order to determine the most favourable route for the alignment of the proposed international work. Accordingly, in the year 1890, during the months of July and August, a reconnaissance was made of the Straits of Dover by M. Renaud, the hydrographic engineer, whom the Minister of Marine had very obligingly placed at the service of the Society, and with whom were joined M. Georges Hersent and M. Duchanoy, engineers of mines. Subsequent soundings were made in French waters, on board the Ajax, and in the English by a party on board the steamer Jubilee, which was placed at their disposal by the courtesy of Sir Edward Watkin, M.P. These experiments confirmed the opinions already formed regarding the solidity and stability of the foundations of the intended design.

But at this juncture, M. Renaud discovered that by starting a little more to the north, and by keeping a straight line from Cape Blanc-Nez to the South Foreland, a better route could be obtained for the bridge than the one at first laid out. The advantages of this alternative trace consisted in enabling the foundations of the piers to be bedded on the chalk, in limiting the greatest depths to a maximum of 167ft., and in reducing the total length by rather more than three miles. This new alignment was adopted by the company, the project revised and modified, the number of piers altered to seventy-three, and the spans arranged alternately in distances of 1312ft. and 1640ft., as shown in Fig. 1. Our contemporary devotes considerable space to the influence which the execution of the proposed undertaking might have with respect to other countries generally, to its importance especially for the two nations it would more intimately unite, and to the respective merits of itself and its rival the tunnel. Into these considerations we shall not at present enter, but restrict ourselves to the description and details of the bridge itself.

To the question whether the actual building of a bridge over the Channel is feasible, it is stated that so far as the foundations are concerned, the success, upon a very extensive scale, of the employment of compressed air in deep water has put the matter beyond doubt. The use of steel is also quoted as a sufficient answer to any objection raised with a similar object against the construction of the superstructure. In addition to the Forth Bridge, which has foundations 88ft. in depth, the example afforded by the Brooklyn Bridge is adduced. Here the foundations are 65ft. under water, and upon them are raised piers of masonry 275ft. in height, over which pass the chains, supporting spans of 1640ft. between bearings. Again, the Americans contemplate throwing a bridge over the Hudson to join by a railway New York and New Jersey, which is to consist of a single span of 2860ft., placed at a height of 459ft. over high-water mark. Those who may be inclined to assert that a bridge of the dimensions of the proposed Channel structure would never withstand the pressure of the wind, are replied to, by being referred to the Forth Bridge, as well as to numerous suspension bridges of sixty years of age and upwards which for that period have been exposed to the terrific assaults of the mistral, which are equally violent as the storms in mid channel. Besides, people are no longer scared now by the "force of the wind," as they were at the time of the building of the Britannia bridge over the Straits of Menai, which many competent authorities confidently predicted would be swept away by the first heavy gale. A far more important objection against the Channel scheme lies in the question—Will not the bridge seriously interfere with the navigation? The platform of the structure will be carried at a height of

200ft. above the level of low water, upon alternate spans of the length already mentioned, while the piers, which will be lined in the most favourable position to suit tidal currents and the sweep of the waves, will be 147ft. long by 65ft. wide. Thus, the proportion between the closed and open waterway will be one-twentieth, measured along the axis of the bridge. It is proposed by the author of the communication to guard against all danger to navigation by the adoption of a most comprehensive and elaborate system of illumination signals and foghorns, the details of which we have not space enough at our disposal to discuss. It is stated that there will be no difficulty in ships clearing the piers in calm, fine weather, a condition of things that is frequently not found to prevail in those stormy Straits.

In Figs. 1 and 2 are represented a skeleton elevation and plan of a couple of complete alternate spans of the projected Channel Bridge, as finally adopted, and having a total reduced length of 20·8 English miles. The shorter span of 1312ft. consists of two cantilevers, each equal to 656ft., and meeting at the centre of the span, and the longer of a total span of 1640ft., comprising two cantilevers each equal to 615ft., and a central girder of 410ft. in length. One pier will be a land pier, and the rest, seventy-two in number, will be in the sea. Of these piers the deepest will be founded at 167ft. beneath low water, but the average depth will not exceed 118ft. below the same datum. The masonry will be carried to a height of 46ft. above the highest tides, and will be surmounted by steel columns, upon which will rest the main girders of the bridge, the soffit of which will be at an elevation of 177ft. above the level of high water. A cross section of the bridge over one of the piers is shown in Fig. 3, from which it appears that the superstructure consists of a pair of main girders, which are of steel, and inclined towards each other, so as to meet at their upper booms, thus forming in outline a triangular figure, resting at its base upon the steel columns which spring from the piers of solid masonry, as shown in plan in Fig. 2. The cluster of columns at the base measures 38ft. 4in. in diameter, and for the remainder of their height 26ft. 9in. It will be seen from an inspection of Fig. 1 that the main girders themselves are each constructed of an upper and lower boom, connected or braced together by a single or Warren system of triangulation with very large openings. The alternate lower halves of these are stiffened by the introduction of subsidiary bracing, thus forming a series of alternate pairs of diamonds tied together at the centre of the diagonals by a horizontal longitudinal stretcher. At the intersection of the long and short diagonals with the lower boom are placed the cross girders, and above them is the rail level shown by the double line in Fig. 1. A slight rise or camber is given to the lower boom of the girders at the centre of the spans, which otherwise would be horizontal, while the upper has a polygonal contour. Throughout the whole of the shorter or double cantilever spans the breadth of the platform of the bridge is constant, or, in other words, the distance between the centres of the two main girders is the same and equal to 82ft. But in the larger spans the breadth of the superstructure at the piers becomes gradually reduced towards the junction of the cantilevers and the central independent girder, until it reaches a minimum of 33ft. In Fig. 3 the distance from the centres of the upper and lower booms of the principal girders is 196ft. 10in. The cross bracing between the two inclined main girders and the comparative size of the ordinary locomotives in the same figure afford a very good idea of the actual proportions and magnitude of the proposed undertaking. This great height of the girders over the piers diminishes progressively towards the centre of the shorter spans, where it does not exceed 131ft. In the longer spans of 1640ft. the depth at the centre of the independent girder is nearly 66ft., and the constant breadth between the two main girders 32ft. 9in.

A cross section of the superstructure of the bridge at this point is shown in Fig. 4. The minimum depth of the elevation of the large girders occurs at the junction of the independent girder and the cantilever portions of the large alternate spans, which become reduced to only 36ft., as represented in Fig. 6. A section to an enlarged scale of the upper and lower booms, which are identical, of the central girder in the longer spans at its greatest depth is shown in Fig. 5, and similar sections are shown of the upper boom in Fig. 7, and of the lower in Fig. 8, of the same girder, at its ends where it joins the cantilever. These latter are not identical, the upper measuring 4ft. 11in. by 3ft. 3in. and the lower 3ft. 3in. square. All the sections are composed of plates and angle irons, and remind one of the old cellular booms adopted in the now obsolete tubular bridges and box girders.

The track will be double and laid upon longitudinal lattice girders, and supported at intervals by cross beams, as shown in the three cross sections of the superstructure of the bridge. The rails themselves will be laid in steel troughs in a manner very similar to that obtaining at the Forth Bridge, while the expansion of the girders will be limited to the extent of half a span. Steel is the material proposed for the construction of the bridge, and the total weight required has been estimated at 755,000 tons.

Along the whole of the surveyed route of the Channel Bridge, the bed of the Straits is composed of a description of cretaceous rock, remarkably uniform and homogeneous, which has been swept so closely and vigorously by the currents as to be entirely denuded of all alluvium. Each pier of the bridge will consist of two distinct parts, the upper and the lower. Of these two, the former, which will be above the level of low water, will take the form of an oblong vertical tower, 65ft. broad in the direction of the axis of the bridge, and 147ft. in length between the extremities of the semi-circular cutwaters or starlings. There would be no especial difficulty to be overcome in the building of this portion of the structure. It is with the lower or foundation part of the piers, which extends from low-water mark to the bed of the sea, that the trouble begins. There are three methods of accomplishing the task—one by floating metallic caissons, a second by means of sunken *béton*, and the third by the deposit of blocks of artificial stone by the aid of movable metallic trestles or scaffold frames. It is the last of these we shall now proceed to describe. Fig. 9 represents one of these adjustable trestles, placed in position over the site to be occupied by one of the bridge piers. A steel girder cradle rests directly on the bed of the sea, ready to receive the artificial blocks, while the floor is 210ft. by 173ft., and is supported by four columns or pillars, which can be caused either to slide or to remain fixed within four other hollow pillars, which act as sockets or sheaths for them. In shape these pillars are not circular, but the section is composed of a central square, 13ft. being the length of each side, and terminated by two hemispherical ends. Steel plates, varying in thickness from ⅜in. to 2in., are built up to form the pillars, and each trestle will weigh some 4000 tons, a weight sufficient to insure its stability.

Upon the steel cradle—see Fig. 9—are lowered the blocks, which form an external ring 16ft. in thickness. Each block measures 23ft. in length, 16ft. in breadth, and 10ft. in height, and their lateral joints are bevelled, commencing from nothing on the outside of the ring, but opening out on the inside to a width of over 3ft. It is within these open spaces that the steel wire guide blocks, with the cables extending from the upper flooring of the trestle to the foundation, are fixed to the cross girders forming part of the cradle. The blocks, having been raised to their proper position and adjusted on the upper platform of the trestle or scaffold frame, are attached to their respective guide cables, and lowered into the places provided for them. At their lower extremities the guide cables are fixed to the annular elliptical steel frame, constructed of two concentric main girders with radiating cross girders, represented in Fig. 9. The horizontality of this frame or cradle is secured and maintained by particular appliances, the description of which would occupy too much of our space.

There are two methods proposed by which the trestles could be floated to their respective situations. One is to construct them so as to be self-floating, and the other to attach pontoons to them. It is not difficult to build a portion of the frame—shown in Figs. 10 and 11—in hollow compartments, filled with compressed air, and having a displacement sufficient to insure flotation, with a depth of water at the port where the trestle is constructed of from 17ft. to 26ft. As the trestle gradually drifted seawards into deep water, the compressed air in the floating compartments would be allowed to expand, so as to cause it to sink gradually, while at the same time the fastenings of the pillars would be loosened to allow them to float of themselves, or to sink slowly by the introduction of water until they were within some feet of the bottom. Fig. 10 shows the trestle or frame in position, and Fig. 11 when it is quitting the port. This system has the disadvantage of demanding a large amount of material to obtain the necessary volume for flotation, and also sensibly to increase the surface exposed to the action of the waves and currents. It also necessitates the providing of a special floating arrangement for each trestle, which is a more costly proceeding than that of transporting in succession all the trestles by an independent floating appliance which will now be described.

According to this method the trestle will be constructed as shown in Figs. 12 and 13, with the component parts reduced to such dimensions as are simply necessary for its protection against wave violence. It will then be attached to a specially built lighter, some 90ft. in breadth, with twin-screws, and a displacement of 5000 tons, run in underneath the trestle, between the pillars and parallel to their larger dimensions, and upon it the platform of the frame will be fixed up. Owing to the great height of the rigid framework, this position can only be insured in water of a depth of 70ft., and it is therefore necessary to provide special floating arrangements for less depths, which are indicated in Figs. 12 and 13. They consist essentially of a pair of large floats placed parallel to one another, and joined by cross-girders, and of a displacement sufficient to carry their own weight and that of the trestle, with a depth of water of about 22ft. When it is required to put to sea with the trestle, these floats are introduced between the pillars, which are in the position represented in Fig. 13. Each of the floats carries two funnels, which being hollow add to the total displacement, and carry on their summit the lower surface of the flooring of the trestle. There is room between the floats for the lighter already mentioned, which can be fastened to them by rings of metal, while at the same time leaving them free to rise and fall in a vertical direction. It is when arranged in this manner that the trestle, which does not draw over 23ft. of water, will leave the harbour on a calm day, as shown in Fig. 13. When deep water is reached, the pillars will be loosened in their sockets and lowered down by the introduction of water. A gradual escape at the same time of the compressed air in the floats will also cause them to descend, and the trestle will sink with them, until it rests upon the lighter. The latter will be disconnected with the floats, and leaving the whole floating apparatus behind, will steam away with the trestle, which will be now placed at a convenient height for attaining its permanent position, as shown in Fig. 12. A tug, provided with a reservoir of compressed air and other apparatus, will be charged with the task of rescuing the floats abandoned by the lighter, and submerged in deep water, and towing them safely into port ready for the next expedition.

By either one or other of the methods described, we have brought the trestle over the site of a pier, and the next step is to adjust it in place by allowing the pillars to gently descend until they touch the bottom, and tightening up their connection with the platform above, until by this means the whole trestle rests upon the bed of the sea. In order to check the vertical oscillations produced by the grounding of the pillars, spring buffers will be introduced at one or other of the extremities of the pillars, or at their junction with the upper flooring. The exact horizontality of the frame will be insured by the employment of hydraulic jacks placed between the heads of the columns and the platform. Should the weight of the whole frame and its load not be sufficient to prevent the slipping of the feet of the columns, it will be a simple matter to increase the insistent weight by filling them with gravel or concrete. After the construction of the pier is sufficiently advanced to permit of the removal of the trestle, it can be readily disengaged by reversing the operations which sufficed to fix it in position, and which need not be detailed. These adjustable trestles, besides acting temporarily in the building of the piers, might be found very useful for the erection of the ironwork of the superstructure of the bridge. Figs. 14 and 15 show in elevation and cross-section the main girders supported by them. The total cost of this stupendous fabric is estimated at £32,740,000, and our contemporary adds a financial statement of the probable traffic and receipts, which more than provide for a 5 per cent. dividend on the capital expended. Such then is a brief summary of the manner in which it is contemplated to carry out this gigantic undertaking. The realisation of the project would constitute one of the most colossal engineering works of the age. As to the political and international questions involved, it is not necessary here to say anything.

SOCIETY OF ARTS.—Professor Fleming, F.R.S., will deliver on Monday evening, 30th inst., the first of a course of Cantor Lectures on the "Practical Measurement of Alternating Electric Currents," and the lectures will be continued on the following three Monday evenings. The lecturer will deal with the "Measurement of Alternating Current Strength" on January 30th; with "Alternating Current Potential" on February 6th; with "Alternating Current Power" on February 13th; and with "Alternating Current Energy" on February 20th.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

THE first month of the year, which is always a quiet time for the iron trade, has now passed, and manufacturers may hope to see more activity shortly. It cannot be said that just yet the trade gives evidence of much improvement, but the export season is now approaching, and this should lead to the distribution of more orders on merchant account. Colonial and foreign buyers should soon have settled down to the conviction that no reduction in other classes of iron was foreshadowed by the late drop in marked bars, and should again place their orders without hesitancy. There can be no doubt about the circumstance that iron prices, outside marked bars, are already so low that no further drop of much moment can be expected, and delay by export buyers in placing orders is, therefore, only futile.

The passing away of the frost is certain also to improve business as removing obstacles to the home trade previously existing, and encouraging home buyers to launch out with more confidence than has recently been the case. Winter always interferes with business, and the spring should certainly bring about improvement. The general outlook of the trade may be fairly considered more hopeful than earlier in the year, and the extension of outdoor labour in the bridge, and boiler, and gasometer yards, consequent upon the milder weather, will necessarily cause further orders to be distributed. At the present time constructive engineering work is furnishing steady employment to some of the makers who are under contract for railway stations, bridges, and the like, and these consumers are among the best customers of the bar plate and angle makers alike in iron and steel.

The slight improvement reported last week in the sheet iron trade is upheld. Makers report an increase of business compared with the very low average production of December, and prospects are brighter in consequence of the increased orders which the galvanisers are receiving on Colonial, Indian, and South American account. There are some makers among the galvanisers who suggest that Australia will never again be as good a market to this district as she has been, owing to the lessened area of new land which she is opening up. It is gratifying to be able to state, however, that other local makers, and who are probably better authorities, do not by any means entertain this view, but believe that even before this year is out the exports to Australia will have greatly recovered themselves. Prices for all classes of sheets, both black and galvanised, have been irregular for some months, and continue so, present values being now lower than those accepted last month. Sheets, singles, in the black state for galvanising and working-up purposes are quoted £6 15s. to £6 17s. 6d. per ton, the latter figure being perhaps the general average; doubles, £7 to £7 5s.; and trebles, £7 15s. Galvanised corrugated sheets are selling as low, in some cases, as £11 to £11 2s. 6d. for 24 gauge, and it is particularly noteworthy that even merchants now quote £11 as the market price. Other makers, however, there are who quote £11 5s. to £11 10s. Liverpool, and in special cases makers are getting £11 15s. Lattens are quoted £1 10s. per ton above these prices by pretty much all makers alike. Spelter is easier, and is quoted £18 15s. to £18 17s. 6d., delivered into this district.

The bar iron trade is more active in the merchant and common iron qualities than in the best grades—a circumstance which is to be accounted for by the fact that very few buyers will give prices for best iron, and then only for special purposes, such as chain and cable making, special engineering uses, and the like. Indeed, it is scarcely necessary they should do so, for there were makers on 'Change to-day—Thursday—in Birmingham, who boasted that at £6 per ton they were turning out as good bars as marked-bar makers. Though this declaration is hardly to be taken literally, it is sufficient to indicate the improvement which of late has taken place in some of the unmarked iron produced in this district. At the same time it suggests—which is, no doubt, the fact—that branded iron is not now almost so good as formerly. The demand for marked bars has not been materially improved by the late reduction, and the bulk of these makers are only indifferently employed. Present prices of bars are quoted:—Common marked bars, £7 10s.; medium, £6 10s. to £6 7s. 6d.; ordinary bars, £6; and common sorts, £5 10s. to £5 12s. 6d. There was a good deal of complaining to-day of competition from South Wales in the common qualities of manufactured iron, particularly in bars, and Welsh puddled bars are also coming up into this district in increased quantities in consequence of a scarcity of local supplies.

The hoop and strip iron trades are only quiet, and the strip trade is particularly so, the wrought iron tube makers themselves, who are the principal customers in this branch, being in a very slack condition at the present time, and at not more than half production. Gas tube strips are selling at £5 15s., and hoops for export £6 to £6 5s. at works, with 10s. to 15s. on for delivery at the ports. Hoops for home consumption, however, which are of superior quality to hoops for shipment, are quoted £6 10s. at works. Drawn wire at date is quoted at £7 7s. 6d.

The steel trade continues active, largely upon material for constructive engineering purposes, and one local works is credited with having orders in hand at the present time for 6000 tons of plates, large bars, channels, and other steel work of large sections. The Patent Shaft and Axletree Company, Wednesbury, have almost ready for starting the powerful new plate mill which they have lately been laying down, and which, when started, will prove an important addition to the heavy steelmaking capabilities of Staffordshire. It is stated that the extensions which this concern are now completing at their steelworks represent an expenditure of something like £50,000.

For basic Bessemer steel the Staffordshire Steel and Ingot Iron Company quote present prices:—Blooms, £4 15s. per ton; angles, £5 10s.; bars, £5 15s.; girders, £5 15s.; plates, ordinary, £6; and boiler, £7, at makers' works. Compared with the prices of October last, these quotations are a drop of 10s. per ton on blooms, 10s. per ton on ordinary plates, and 5s. per ton on angles, bars, and girders, while boiler plates are unaltered. At the beginning of last year, the company quoted bridge and girder plates £6 15s., angles £6, and large bars for shafting purposes £6 10s. to £7; so that compared with that date, girder and bridge plates are down £1 per ton, angles 10s., and bars 15s.

The New British Iron Company quote their basis price at date for Siemens-Martin acid steel as follows, but mostly prefer to quote against specification:—Bars, £7 5s.; angles, £7 10s.; slit rods, £7 5s.; and plates and sheets each £7 10s. January two years ago the same firm quoted bars £7 10s., boiler-plates £8 5s., and ship or tank plates £7 15s.

Local steelmakers announce this week that the great advance which has been made by the railway companies in the rates on carriage of timber will give an important impetus to the trade in iron and steel girders, and props to take the place of timber for colliery, roof, and other purposes. Already steel girders have been found in the Staffordshire collieries to answer very satisfactorily. Though their first cost is three times that of timber, their "life" is ten or twelve times as long, and the extra cost is quickly recouped.

The crude iron producers are receiving inquiries for supplies from the middle of next month to the end of March. These are necessitated by the fact that in some cases negotiations at the opening of the year were for only half the quarter, the uncertainty of the position precluding at that time arrangements for the whole three months.

Quotations of Staffordshire pigs are: All-mine hot-air, 57s. 6d. to 62s. 6d.; cold-air, 97s. 6d. to 100s.; part-mines, 42s. 6d. to 43s. for forge, and 45s. to 50s. for foundry. Hydrates from Sir Alfred Hickman's Spring Vale furnaces are quoted 52s. 6d., foundry 40s., and common forge 36s. The Caponfield foundry pigs of Messrs. I. and J. Bradley are quoted 55s. to 57s. for best