Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for scanning. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of scanning are checked below.

L'Institut a numérisé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de numérisation sont indiqués ci-dessous.

- [ ] Coloured covers / Couverture de couleur
- [ ] Covers damaged / Couverture endommagée
- [ ] Covers restored and/or laminated / Couverture restaurée et/ou pelliculée
- [ ] Cover title missing / Le titre de couverture manque
- [ ] Coloured maps / Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black) / Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations / Planches et/ou illustrations en couleur
- [x] Bound with other material / Relié avec d'autres documents
- [ ] Only edition available / Seule édition disponible
- [x] Tight binding may cause shadows or distortion along interior margin / La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure.
- [ ] Coloured pages / Pages de couleur
- [ ] Pages damaged / Pages endommagées
- [ ] Pages restored and/or laminated / Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached / Pages détachées
- [x] Showthrough / Transparence
- [x] Quality of print varies / Qualité inégale de l'impression
- [ ] Includes supplementary materials / Comprend du matériel supplémentaire
- [ ] Blank leaves added during restorations may appear within the text. Whenever possible, these have been omitted from scanning / Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été numérisées.

- [x] Additional comments / Commentaires supplémentaires: Continuous pagination.

CANADIAN MAGAZINE OF Science and the Industrial Arts.

Patent Office Record.

Vol. 13. AUGUST, 1885. No. 8.

Communications relating to the Editorial Department should be addressed to the Managing Editor, P. O. Box 128, Montreal.

Business communications and subscriptions to be sent to the Burland Lithographic Co., Montreal.

The Editor does not hold himself responsible for opinions expressed by his correspondents.

No notice will be taken of anonymous communications.

THE DEFENCE OF CANADA.

At this stage of the history of Canada it will naturally occur to our minds, in what manner such and even more serious troubles than those which have lately taken place, the Dominion can be protected. It seems to us, that though the late rebellion was suppressed within a comparatively short time, the sacrifice of the volunteers in leaving their homes and business to restore order and harmony in the North-West, is so great that it behoves the Government to be prepared to quell any other disturbances that may occur in the future, by other means than by the aid of our gallant volunteers. There can be no doubt that many of our citizen soldiers would fain have remained at home, attending to a more prosaic life than fighting the half-breeds and Indians, and we can scarcely blame them for that wish. In the present state of commercial depression, many could ill afford to leave their business, which requires so much of their attention. As a consequence of this, the question naturally arose. "Could not some other method than calling out the volunteers be devised to preserve peace in the Dominion?"

A great many suggestions were made, and the one that seemed to be most in favour was that a small standing army of say from 3000 to 5000 men would be sufficient to protect us against any ordinary rising. The advantages of possessing such an army would more than repay the extra outlay of the Government. They could be despatched at once to the seat of the troubles, intimidate the intending insurgents, and thus check what might otherwise have proved a very serious rebellion. A great deal of time was lost by our volunteers not being properly equipped for a campaign, thus allowing the rebels to mature their plans, gather more forces and more especially to induce the Indians to become their allies. It was because one of his generals did not come to his support in time that Napoleon lost the battle of Waterloo. Time is an all important factor in such cases, and certainly of the utmost importance.

The only way in which the Government propose to be in readiness for a similar rising is by slightly increasing the number of Mounted Policemen, which in our opinion is entirely insufficient. Such a corps would certainly be of great service as scouts to a larger body of men, owing to their knowledge of the country, and the rapidity of their movements, but a larger body of men would certainly be needed.

On this subject a great deal more might be said, but our space forbids. We hope however that it will be many years before the Dominion will be required to defend herself by force of arms.

AN ELEVATED RAILWAY FOR MONTREAL.

We understand that a Company has been formed in Montreal for the purpose of building an elevated railway in that city. Not only is the railway to go through the principal streets of the city, but it is also intended to run it round the mountain and to the surrounding villages. The promoters of the above have a task set before them of no ordinary magnitude. It will likely be some years before it will be an accomplished fact, owing to the difficulties in the way of such an enterprise. Among the difficulties may be mentioned the disgraceful narrowness of the business and other streets, a fact which to strangers seems wonderful in such a large and wealthy city. Montrral possesses many magnificent buildings, the effect of which is almost entirely lost by this cause.

In this and other difficulties are overcome, as no doubt they will through time, the railway, when constructed will be a great boon to the city, and a remarkable contrast to the single track system, existing at present, of the City Passenger Railway.

We wish the promoters every success in their undertaking, and hope soon to congratulate them on their success.

A hot wave seems to have passed all round the globe. In England and other parts of the Eastern Continent unusually high temperatures have been recorded, while in the Western Continent of America excessive heat accompanied by severe and painful prostration, with a heavy death rate in many parts, has been experienced.

The average temperature for the seven months ending July is still low, and the inference is that great and continued heat will be the order of the day for August and part of September. It behoves all City Corporations and health authorities to be zealous in their endeavours to mitigate the evils generally attended with such conditions, the more especially as dire deseases are ravaging lands not for distant, and neglect of ordinary precautions might be a serious affair. It is hoped that the early and persistent warnings thrown out already in every direction will have the desired effect, and if absolute prevention is impossible we may have at least little to fear.

NIAGARA FALLS MADE FREE TO THE WORLD.

On the 15th of July last the formal surrender of the Niagara Falls owned by the United States took place in the presence of an immense assembly of distinguished visitors. The surrender and transfer was by the Board of Commissioners to the Governor of the State of New York.

It is only about seven years since our late distinguished Governor General, the Earl of Dufferin, suggested the establishment of an International Park at the Falls, and the freeing to the world one of its grandest and most sublime wonders. He had then the good fortune to meet his Excellency the Governor of the State of New York, and suggested to him the establishment of an International Park by the Government of New York and Ontario or Canada.

The response and encouragement which was then given to the idea gave every hope of an early and practical plan for its accomplishment, as far as the United States was concerned, but financial and other reasons precluded Canada from moving as vigorously as her cousins across the line.

While the honour of bringing the matter before the public of both countries belongs to Canada, the Americans with their usual enterprise and speed can lay claim to the honour of giving and carrying out practically the idea.

Lord Dufferin, before his term of office expired, further supplemented his efforts by writing to Governor Robinson of New York State on this subject; the letter was dated from Quebec on October 1st. 1878, and a very encouraging reply was received in January 1879.

A commission was appointed in May, 1879, to consider and report to the Legislature, in the hope that it would lead to a great public benefit.

The Report was favorable to the project and urged the securing at once of interests involved.

The claims of owners aggregated about $4,000,000, but the commissioners' awards amounted only to $1,500,000, which were afterwards confirmed by the Court, and agreed to.

It is needless to refer in detail to the festivities and ceremonies of the day; suffice it to say that it was one of the grandest events in the history of the last few years, and was participated in by many distinguished Americans and Canadians alike.

The chairman, Hon. Erastus Brooks, who took such an interest in the project from the very first, referred briefly to the history of the event, and was followed by the Hon. Wm. Dorsheimer, who formally handed over the grounds to Governor Hill, of New York State, and, in doing so, spoke of the many blemishes and drawbacks flaunted upon the scene, all of which would shortly be removed, and nature's charms allowed free scope to clothe the slopes and banks of the mighty cataract with trees and bushes.

Governor Hill, in accepting the Park, made a stirring speech, and threw out strong incentives for Canada to perfect and accomplish what was originally intended, viz., a grand International Park, and thus free for all time one of nature's greatest and grandest beauties.

The great speech of the day was delivered by Hon. James C. Carter, of New York, noted as a great orator; his oration was long and exhaustive, being listened to from beginning to end with appreciation and applause.

In describing the scene he spoke of no writer having yet felt that justice had been done to it, and he closed with the conception of Father Hennepin who, 200 years ago, attempting to describe the scene, broke down, and merely said that the universe does not afford its parallel. Although great conquests and discoveries have since then been made, the statement stands true as ever.

The profound interest with which Niagara is beheld and remembered, and which gives it the first place among the great spectacles of nature, is due to a variety of elements nowhere else to be found united. It is not owing chiefly to the sublimity of the scene, for the great mountain summits in many parts of the earth far surpass it in all the elements of the sublime. The loveliness of foliage and flower is displayed in more enchanting forms elsewhere in our own and in other lands. Finer examples of more picturesque beauty in falls or rapids may be found amid the wonders of the Yosemite and Yellowstone valleys, and in other parts of the world. Undoubtedly, the master feature of the scene is the near exhibition of overwhelming power. Nowhere else among the works of nature is such an amount of physical energy concentrated within so narrow a compass. Here the soul, confounded and bewildered by the overwhelming sense of resistless power, has but to turn for an instant and find recovery and relief in the spectacle of that same power, no longer let loose for destruction like the wrath of the hurricane, the eternally flowing, restrained, obedient, beneficent, and arrayed in every robe of the beautiful. It is this combined appeal to every sense and every faculty, exalting the soul into a higher sphere of contemplation, which distinguishes this spot over all others.

(To be concluded in next issue.)

LARGE shipbuilding contracts have been entered into on the Clyde. Messrs. John Elder and Co., of Govan, Glasgow, have contracted to build three steamers of 5,500 tons for the North German Lloyd's. The steamers will be fitted with all the latest improvements. The news has been received with great satisfaction in Govan, where thousands of men are idle.

THE TAY BRIDGE.

On the Machinery and Methods for Founding the Pires of the New Tay Bridge.

In the construction of the foundations for large bridges in a tidal river where boisterous weather and strong currents exert their full force, and are seldom long absent, great difficulties have always been experienced, involving serious trouble and expense, as well as loss of time and material in constructing staging sufficient to act as a platform for the execution of the work. Previous experience of these difficulties in other cases, and a careful forecast of their character in the case of the new Tay Bridge, has led to the designing and construction of a peculiar staging or movable platform by Mr. Arrol, the contractor for that structure. These platforms have proved equal to all the work required of them, and have withstood the severity of wind and current without any mishaps. With the design, the construction, and working of these platforms, the present article proposes to deal. The largest will be selected for description, the others being all on the same principle, only varying in size.

In order to form an idea of the work to be done and the methods and appliances for executing it, reference may be made to Fig. 1 this view being a cross elevation of one of the piers of the new structure. The lower part, with which this paper is intended to deal, consists of two cylindrical shafts sunk into the bed of the river, these being carried up the low-water level, while on them are erected brick pillars, which are united in one at high water level to form a continuous cross structure on which the superstructure of the bridge is to rest.

The cylindrical shafts as sunk into the river bed are formed primarily of wrought-iron cylinders built up in annular sections as the work of sinking them proceeds. The first section placed in position is provided with a cutting edge, so that when the material within it is removed, and additional rings are added to it, the superincumbent weight causes it to descend. When these cylinders have been sunk to their proper depth they are filled with concrete, thus forming a cylindrical shaft encircled with an iron tube. To sink those cylinders truly, and to handle easily and safely the materials for the brickwork and concreting, was the work for which the appliances about to be described were designed.

The "movable platforms" (of which there are four at work) vary in sizes from 56 ft. long by 36 ft. 6 in. broad and 6 ft. deep, as in the case of the smallest, to 82 ft. long by 66 ft. broad and 7 ft. deep in the case of the largest. The essential feature in the construction of these platforms is that of uniting in one solid structure five watertight iron tanks, somewhat in the form of the letter H, each member of the letter representing a tank, while one tank is added at each end, thus forming two openings, corresponding to the position which the shafts of the pier occupy in horizontal plan. (See Figs. 1 and 2.) In the large platform these openings are 25 ft. square, and adapted to a pitch of 32 ft. centres of the shafts forming the pier. The two main tanks which form the ends are each constructed of a length equal to the breadth of the platform, and in the case of the largest which is being described are 12 ft. broad by 7 ft. deep.

Near to either extremity of these end tanks are openings 8 ft. 4 in. by 6 ft. 6 in., through which are passed the columns or legs which support the platform the river bed, and on which it is suspended at varying heights by hydraulic gear to clear it from the action of the tides. By this combination of watertight tanks in rectangular form, suspended on four cylindrical columns or "legs," there is formed what is really an amphibious staging, rigid at one time on the bed of the river, ready at another to raise its own "legs" or supports and sail away to another position of action.

On the platform thus constructed the following plant is arranged: On the end tanks are placed the engine and boilers for actuating the hydraulic and other pumps, and a workshop for renewal or repair of tools. The two side tanks which join the end tanks having a breadth of 12 ft. by the common depth 7 ft., carry the cranes, the concrete mixer, a centrifugal pump, etc., an additional breadth of 8 ft. being got on one of these tanks by the arrangement of a girder and planking, etc. On the centre tank, which has a length of 25 ft. by 7 ft. broad and 7 ft. deep, there is fitted a shelter for the men. At the openings in the end tanks through which the "legs" pass there are fitted steel plates in a vertical position, and to these are fixed the hydraulic gear for raising and lowering the platform. These are shown more particularly in plan in Fig. 2.

The "legs" of this platform are 65 ft. long and 6 ft. in diameter, with a conical shaped foot or bottom, 12 ft. in diameter. These "legs" are simply strong tubes open at bottom, so as to exert a cutting tendency when loaded, but fitted inside with a transverse plate at a distance of 30 in. up from the cutting edge to prevent the "leg" from sinking too deep into the sand or gravel of the bed of the river. After many experiments with different shapes of feet this arrangement was found to be the best, as the scour was trifling. It may be mentioned that in the construction of the South Esk Viaduct (a quarter of a mile in length) at Montrose by the same contractor, a "movable platform" was also used which had flat bases on its supports 12 ft. square, as the bed of the river was of a gravelly nature, and there was no chance of scour.

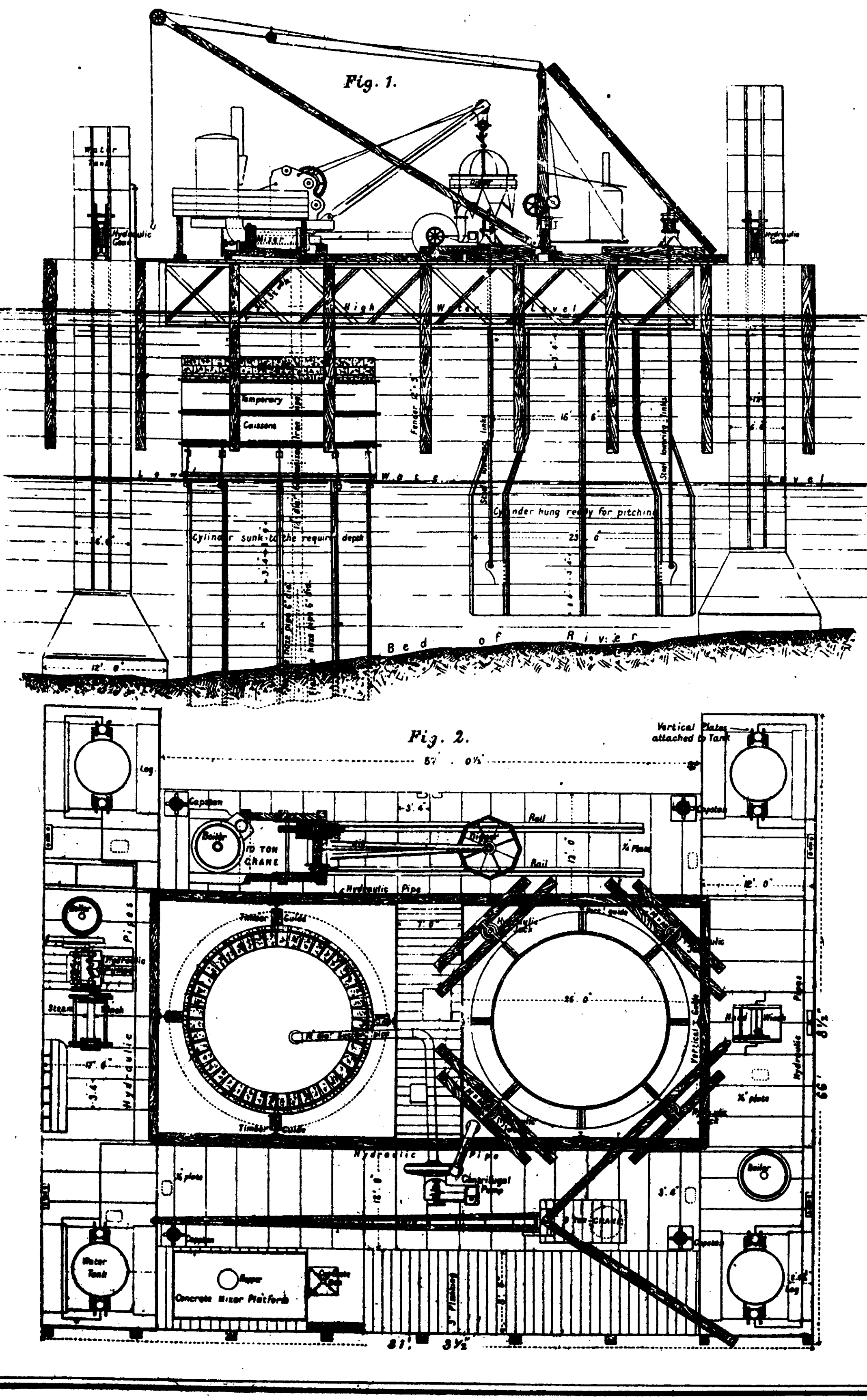
To the supporting "legs" or columns are attached four heavy steel plates in two opposite pairs having a distance of 21 in. between them; in these plates are cut holes 5½ in. in diameter, and spaced at 9 in. centres through which are passed the steel pins by which the platform is suspended. Sliding within these plates are the two plates before mentioned as attached to the platform which carries the hydraulic gear; these having also holes of the same diameter and pitch as the plates on the "legs" and also a slot opposite the crosshead to admit of the vertical travel of the pin. The suspension pins are 5 in. in diameter and 30 in. long, and are provided with a tapered point to facilitate their entrance into the holes.

The hydraulic gears, of which there are two for each "leg," wrought simultaneously, consist of a cylinder, 12 in. in diameter, piston, piston-rod, open crosshead, and the necessary valves for actuating them. (See Figs. 6 and 7.)

The mode of raising or lowering the platform is as follows: Suppose the piston to be at the top of the cylinder, a suspension pin is passed through the two outer plates and the crosshead. Water is then admitted, and the cylinder is forced up because the outer plates are fixed to the supporting column, which in turn rests on the bed of the river. The inner plates with the platform attached, have thus been lifted a distance equal to the travel of the piston; this being 18 in., coincides with the pitch of the holes in both sets of plates, and these are now exactly opposite each other. Another suspension pin is then placed in one of the holes, the pressure in the cylinder is released, enbling the first pin to be withdrawn and leaving the platform suspended on the second, while the crosshead is free to descend and take hold of the holes of the next pitch and to repeat the operation, this being repeated until the platform has been raised as far as desired. To lower the platform this action is simply reversed.

In order to float the platform from one pier to another, it is first lowered down by the hydraulic gear sufficiently to catch the tide two hours before high water. Ropes and chains are attached from one side to the piers of the old bridge (60 ft. centres from the new), and to three heavy anchors on the other side. These attachments are made sufficiently in advance of the platform to allow it to be drawn to the next point of operation. The steam crane is then applied as a winch, and the platform advanced to the position of the next pier. The necessary capstans, steam and hand winches, and fair leads are applied to bring the platform as near as posible to its true position for founding a pier. The supporting columns or legs are now lowered down by the hydraulic gear until they reach the bed of the river, and then the platform is raised up about 2 ft. so as to be clear of the action of the tides. The valves in the bottom of the main tanks are then opened, allowing the water to pass freely into the tanks, and thereby removing any tendency to float at high stream tides. The platform having now become stationary, the work of putting down the piers is proceeded with. The centres are carefully set off by the engineers, and vertical iron guides placed at the four sides of the well-holes and bolted to the top and bottom of the tanks in order to secure the sinking of the cylinder into its true position. Timber blocks are used above the taper portion of the foundation cylinder to maintain it in a perfectly vertical position, and at the same time to allow it to slide down as freely as possible. The foundation cylinders are rivetted together on shore and conveyed in convenient lengths by cargo boats to the platform. The various rings are lifted out of the boat by the 10-ton crane on the platform and placed inside the well-holes. A line of rails is laid on the platform so that the crane can be easily shifted from one well-hole to the other. The first ring is formed of ⅝ in. wrought-iron plate, is 23 ft. in diameter, and 13

THE TAY BRIDGE.



THE TAY BRIDGE.

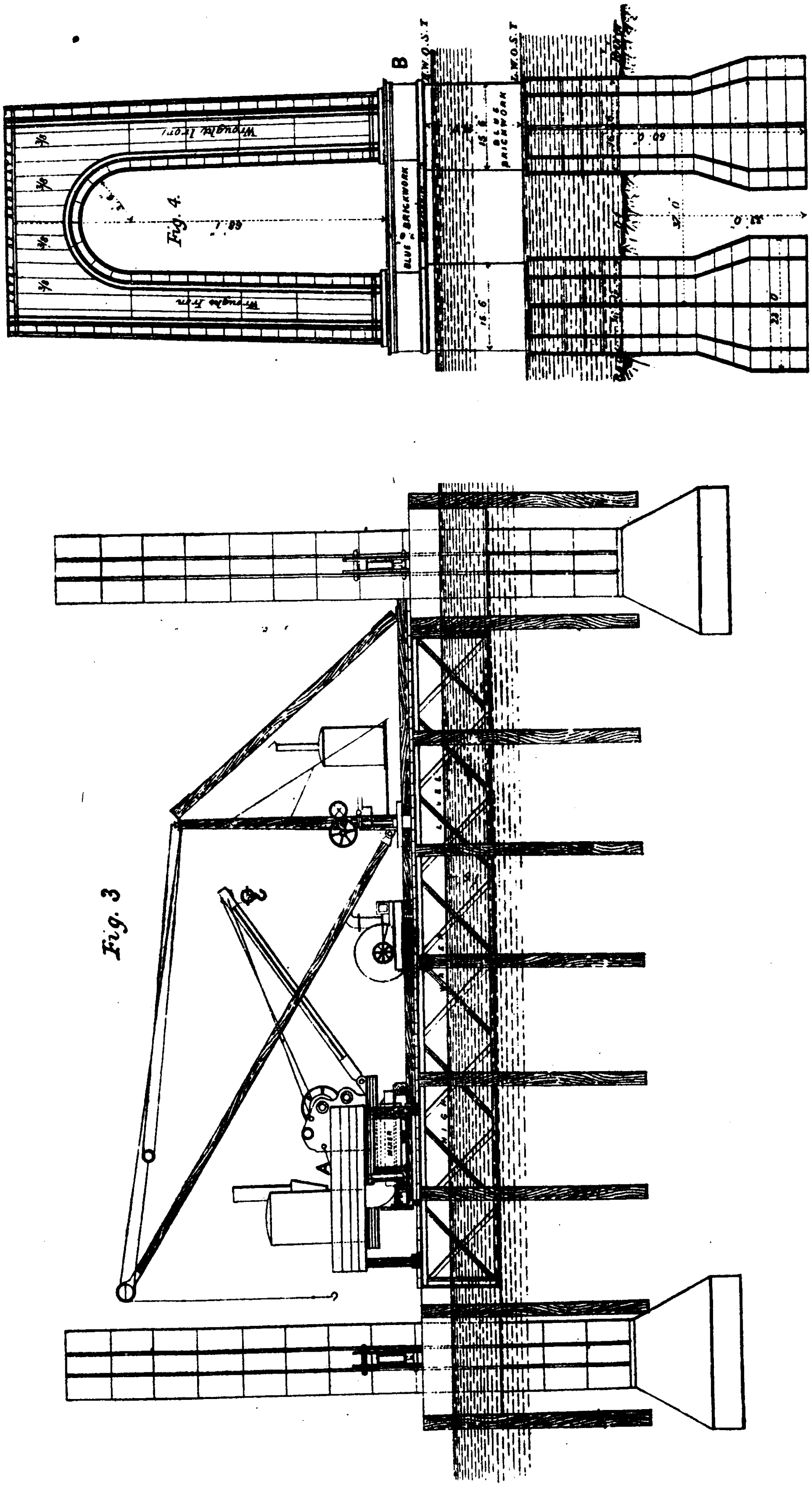


Fig. 3

Fig. 4.

ft. 4 in. deep, having T iron stiffening bars outside ; above this is the taper 7 ft. deep, and then the upper portion 16 ft. 6 in. in diameter. (See Fig. 4.) Each ring as it is lowered into the well-hole by the crane is bolted by an internal flange to the preceeding one. These rings are lowered down through the well-holes by hydraulic jacks specially designed for the purpose by Mr. Arrol, and shown in Figs. 8 and 9. These lowering jacks each consist of a cylinder, piston, and hollow trunk and are supported across the corners of the well-holes by two 14 in. square pitch-pine logs. Through the hollow trunk are passed a series of steel links bolted together in single and double lengths alternately, a cotter hole being formed in each link at a pitch of 10 in. On the top of the hydraulic cylinder is fixed a bow through which the links are passed, while they are also securely bolted to the lower portion of the foundation cylinder. The links are suspended by means of a steel cotter 10 in. by 3 in. by ⅞ in. resting on the bow of the jack.

The action in lowering is as follows : Suppose the combined piston and trunk to be raised almost to the top of its stroke by the admission of water through the cock at A, Figs. 8 and 9. A steel cotter is then inserted through one of the holes of the links and across the top of the trunk, water is again admitted, the links are slightly raised and with them the foundation cylinder, thus enabling the top cotter resting on the bow to be withdrawn and inserted in the next hole higher up. The water is then allowed to escape, and the piston descending carries with it the links and the foundation cylinder until the cotter again rests on the bow of the hydraulic cylinder. The lower cotter is now withdrawn and inserted in the first hole higher up, when the same processes are again gone through, gradually lowering the cylinder until the bed of the river is reached. The number of hydraulic jacks used for the placing of a cylinder is four. The pumps for supplying the water under pressure were made by Messrs Fullerton, Hodcart & Co., of Paisley, and a perspective view of a set of them is given in the preceeding page.

As each portion of the cylinder is bolted together a ring of brickwork about 18 in. thick is carried up inside resting on a bracket at the top of the tapered part. This brickwork assists the cylinder in sinking by giving it increased weight, it also serves to maintain the cylinder in its proper form. The cylinders are pressed down to their proper depth by cast-iron weights, each weighing ½ ton, these being placed on the top of the brick lining. While the cylinder with its added weight of brickwork and temporary weight of cast iron is being pressed into the bed of the river, the material is excavated from the inside, a steel digger of the Milroy pattern being used. This is of the same type as that used in the construction of the Clyde Viaduct. A hydraulic digger was also tried in the hard clay and stones formation. The strata penetrated by the cylinders is chiefly silty sand with occasional beds of gravel and boulder stones and beds of clay, the weight required to press the cylinder down through some of these latter being as much as 400 tons. In some cases the cylinders were sunk as far as 3 ft. into the red sandstone rock.

In the excavation of the silty sand it was found that the digger lost a considerable quantity of the material while being hoisted up through the water. This led to trials being made with several kinds of pumps in order to raise it. The best results, however, were obtained from a 12-in. centrifugal pump. The suction connections of this pump were arranged as follows : Two flexible hose-pipes, each 6 in. in diameter and 20 ft. in length, were placed in the bottom of the cylinder one of the ends of each were brought together and joined into one 12-in. pipe leading to the pump on the platform. A diver was then sent down who manipulated the suction pipe to the work, only one of the pipes, however, being used by him at a time for the sand, the other running up clean water and thus preventing the pump getting choked. As much as 40 cubic yards have been pumped up in an hour, giving a subsidence of over 2 ft. on the cylinder. When the tide was too low for pumping the digger was used. In strata of a clayey nature where the material would not pass up through the pumps, the two flexible hose-pipes were taken off and the water pumped down as far as possible, giving additional pressure on the bottom owing to the difference of level of the water. In this manner as much as 11 ft. length of the cylinder were sunk in thirty minutes, and the material afterwards taken out by the digger.

The material excavated from the inside of the cylinders is placed round the outside of them. The portion of the pier formed by these cylinders finishes at low-water level. While each section of the cylinders is being sunk, temporary caissons (see Fig. 1) are bolted to the upper flange in order to keep the weights in their proper position ; to exclude the silt from the river, and also to assist in securing the descent of the cylinders in a truly vertical position by the guides previously mentioned as bolted to the tanks. The cylinders having been sunk to their proper depth, and the interior cleaned out to the cutting edge, the concrete is then put in.

The gravel and cement are brought out to the platform by cargo steamers of a carrying capacity of 150 tons. The gravel is filled into tipping measure boxes, along with the necessary proportion of cement (six of gravel to one of cement), and lifted by the gearing of the boat on to the platform at a point above the cement mixer, which is one of Jamieson's patent, as shown at A, Fig. 3. The material is led into the hopper and watered from a rose fixed inside. For the water supply one of the supporting "legs" is utilised as a tank ; this tank being filled from the river by one of Root's rotary pumps. The revolving casing of the mixer is square in section. The obvious effect of this section in revolution is to produce a more overlapping movement of the material than is obtained by the use of a cylinder. The material is also longer retained, getting as many as thirty turns before being delivered into the receiving boxes.

The motive power for this machine is obtained from a steam engine of eight-horse power attached to the machine framing. Twelve yards per hour has been the amount of work turned out by this machine, but when the tide was high and everything favourable, as much as 15 yards an hour was got. The receiving boxes are fitted with hinged hopper bottoms, so that when they are lowered down through the water into the cylinder and touch the material already placed, the catches are withdrawn and the concrete deposited. When the concrete comes up to the flange carrying the brickwork, the diver is sent down to have it all carefully packed underneath. The concreting is then continued up through the cylinder, finishing at the same level as the brickwork. viz., low-water level. While this operation of concreting the cylinder is going on, the other foundation cylinder is brought out from the shore and sunk into position in the manner already described. When both cylinders of a pier are sunk to their proper depth, the temporary caissons are removed, thus allowing the platform freedom to be shifted over to the next pier, this being easily accomplished, since, as has been already stated, the cylinders themselves are not carried higher than low-water level. The platform having been removed the piers are tested with a load ranging from 500 tons on the 10 ft. diameter cylinders up to 2438 tons on the cylinders of 23 ft. diameter. The cylindrical shafts as sunk having been tested satisfactorily, the temporary caissons are replaced, and the brickwork carried up inside them and faced with blue vitrified Staffordshire bricks to withstand the action of the water. A connecting piece, shown at B, Fig. 4, 7 ft. in depth, resting on cast-iron girders and 18 in. above high-water level, forms, along with the brick shafts, the base on which the superstructure is erected for carrying the four girders of the railway. These platforms have already sunk 50 pairs of cylindrical shafts, the total number to be sunk being 73. They range from 10 ft. to 23 ft. To each of the platforms is allotted a squad of 20 men, and these are subdivided into a night and day shift. Of an adaptation of means to ends on the first principle of all true design (simplicity and directness) these platforms afford a good example. They have been found sufficient for carrying safely heavy cranes, men, machinery, and materials, while they have proved equally facile for removal from pier to pier. With them work can be carried on during all states of the tide, while they have been found capable of standing the fiercest gales and of sinking the cylinders in their true position.—*Eng*

OVER 400,000 subscribtions have already been received for General Grant's book. Before its publication in all probability another 100,000 copies will be demanded by the people. It is an evidence of the care of the people for the old hero, which could not have found more delicate expression.

THE dredger "Melbourne," which is the largest barge-loading dredger in the world, was successfully tried on Friday, the 12th inst. The principal dimensions are : Length, 207 ft.; breath, 35 ft.; and depth, 11 ft. 6 in. The vessel was built by Wm. Simons and Co., Renfrew, to the order of the Melbourne Harbour Commissioners, under the superintendence of Sir John Coode and his assistant, Mr. Mathews, and is the fifth dredging vessel which the builders have constructed of Melbourne.

VERTICAL LATHE.

The vertical lathe which we illustrate above will come as a novelty to most of our readers. It has been designed and constructed by the makers, Messrs. Rushworth & Co., of Sowerby Bridge, for Messrs. R. & J. Dempster, gas engineers, of Newton Heath, Manchester, and will take in work 10 ft. in diameter by 5 ft. in height. It will undertake almost any class of work that an ordinary lathe of the same size will accommodate, and, besides, has many special advantages of its own. The most noticeable is the great facility it offers for the fixing of objects to the horizontal faceplate, particularly when they are of irregular or eccentric form. The cross-slide, which carries the tool-boxes, is made exceedingly strong, so as to insure rigidity, and the production of perfectly smooth and accurate work in such objects as large valves, &c. The tool-boxes have self-acting feed in the horizontal direction, and one tool-box can be boring whilst the other is surfacing, if required ; both tool-boxes are also self-acting vertically with a range of 15 in., and are arranged when going over large surfaces to feed from the outer edge, etc. The cross slide will rise and fall by power all the way from the extreme height of 5 ft. down to the faceplate. This latter is 8 feet in diameter, and is very strong ; it has T slots for securing the work, and stands 2 ft. from the floor, a very convenient height for the workman to see both the tool-boxes. Fly-wheels or other objects can be readily got on to the table without the use of a crane.

On the under side of the faceplate is a spurwheel with a bearing running on the bed when doing heavy work. The faceplate is firmly secured to a cast-iron spindle 6 ft. long, with a large bearing at top close up to the plate, and a bearing at the bottom 11 in. in diameter, with an adjustable footstep. This footstep has a steel centre which can be raised on to a centre in the spindle end with one turn of the screw, so that all the weight is taken off the bearing at the top, and the faceplate can be rotated quickly and easily for fixing objects true or for boring at single speed, etc. All the oil which runs out of the top neck goes down the spindle into the bottom neck and footstep, so that the bottom is continnally running in oil and cannot possibly get dry.

The machine is very strongly geared with double-power gear, and has a positive variable feed motion from 1-16 to 7-16. It can be made in various sizes and should prove a useful and labour-saving tool in many large engineering works.—*Eng.*

THE GARABIT VIADUCT.

The railway from Marvejols to Neussargues, France, passes at about 10 miles south of St. Flour, near Gerabit (Department of Cantal), a deep gorge at the bottom of which there run the waters of the Truyère. This is crossed by a long viaduct of which we give an illustration on the opposite page. For this and also for the following particulars we are indebted to *Engineering*. The viaduct, which was designed and erected by M. G. Eiffel, of Levallois-Perret, near Paris, under the direction of Government engineers, carries a single line of rails, and has a total length of 1852 feet 6 inches, made up partly of girders and partly of masonry, as follows :

	Ft.	In.
The Marvejols masonry viaduct	229	11.4
The metal viaduct	1,470	9.8
The Neussargues masonry viaduct	150	7.52
Two spaces left to allow play	1	1.78
Total	1,852	6.5

The Marvejols viaduct has three arches of 49 feet 2.5 inches span ; that on the Neussargues side has only a single arch of the same opening.

	Ft.	In.
The rails stand at a height (above datum) of	2,741	2
The waters of the Truyère at a height (above datum) of	2,340	3
Difference	400	11

The iron viaduct is composed of straight girders resting upon masonry abutments at the ends upon intermediate wrought-iron piers rising from the sides of the valley, and upon struts standing upon an iron arch of 541 feet 4 inches span. We will describe these parts in succession.

The Horizontal Girders.—The girders are not continuous for their whole length ; they are interrupted at the two struts upon the arch, and comprise in reality three consecutive girders. These extend (1) from the abutment at Marvejols to the first strut on the arch ; (2) from the first to the second strut ; and (3) from the second strut to the abutment at Neussargues. The first is composed of five spans, as follows :

	Feet.	Inches.
Two end spans of 51.8 m. =	339	10.8
Three intermediate spans of 55.5 m, =	546	3.2
A panel resting on the abutment =	0	9.45
Total	886	11.45
The central girder measures	442	6
The third girder is composed of two equal spans =	339	10
A part resting on the abutment	0	9.45
Total	340	745

The end girders are fixed upon the main piers which form the abutments of the arch, and are able to expand freely in consequence of the play that is provided—10 inches on the abutments and 4 inches on the struts. The central girder is fixed to the arch at two points, and rests freely upon the struts.

The Roadway.—The roadway is placed between the upper and lower flanges of the longitudinal girders, at a point 5 feet 5 inches below the upper flanges ; by this arrangement two powerful guards are provided in case of derailment. The height of the girders is 16 feet 11 inches, and they are placed 16 feet 5 inches apart from centre to centre. The upper and lower members are united by a simple lattice and by vertical struts. The transverse girders are attached to the longitudinal girders at the uprights of the panels in the latter, and they are strutted from the bottom flange of the main girders to the centre. A tie-bar unites these struts at their bases, and two oblique bars crossing the struts complete the vertical transverse bracing, which insures the rigidity and security of the arrangement.

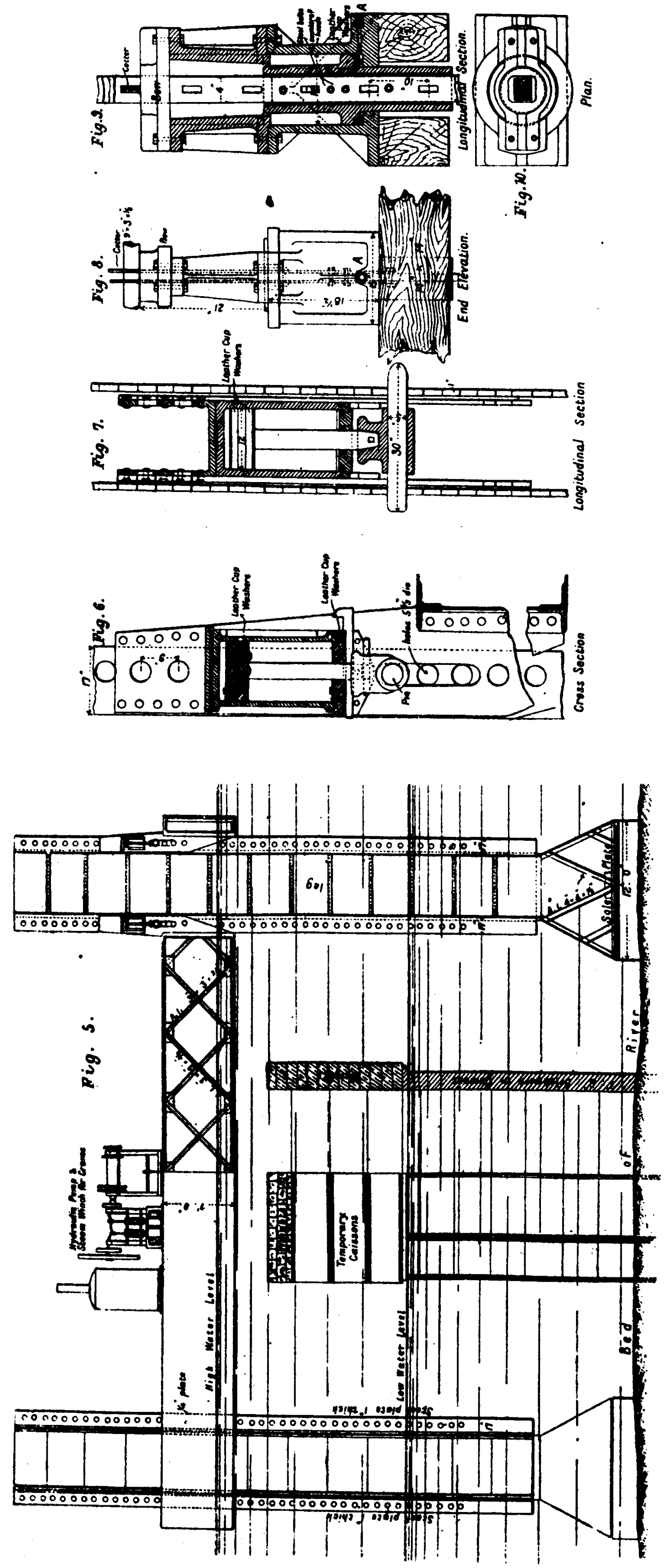
Five rows of longitudinal bearers carry the metallic floor, which is composed of iron plates 9⅝ inches by 4⅞ inches, sufficiently strong to support a locomotive in case of derailment. This flooring, which is almost continuous, presents, further, the advantage of forming an almost perfect wind bracing to the girder at the level of the roadway. A lower wind bracing of angle iron is also added. The girders rest upon hinged supports, some movable and some fixed. The cast-iron rollers are made in the form of segments, which permits of their being placed nearer together and of their number being increased. The use of hinged supports has the advantage that the vertical reaction of the support always passes through the axis of support, a necessary condition with metal piers of great height.

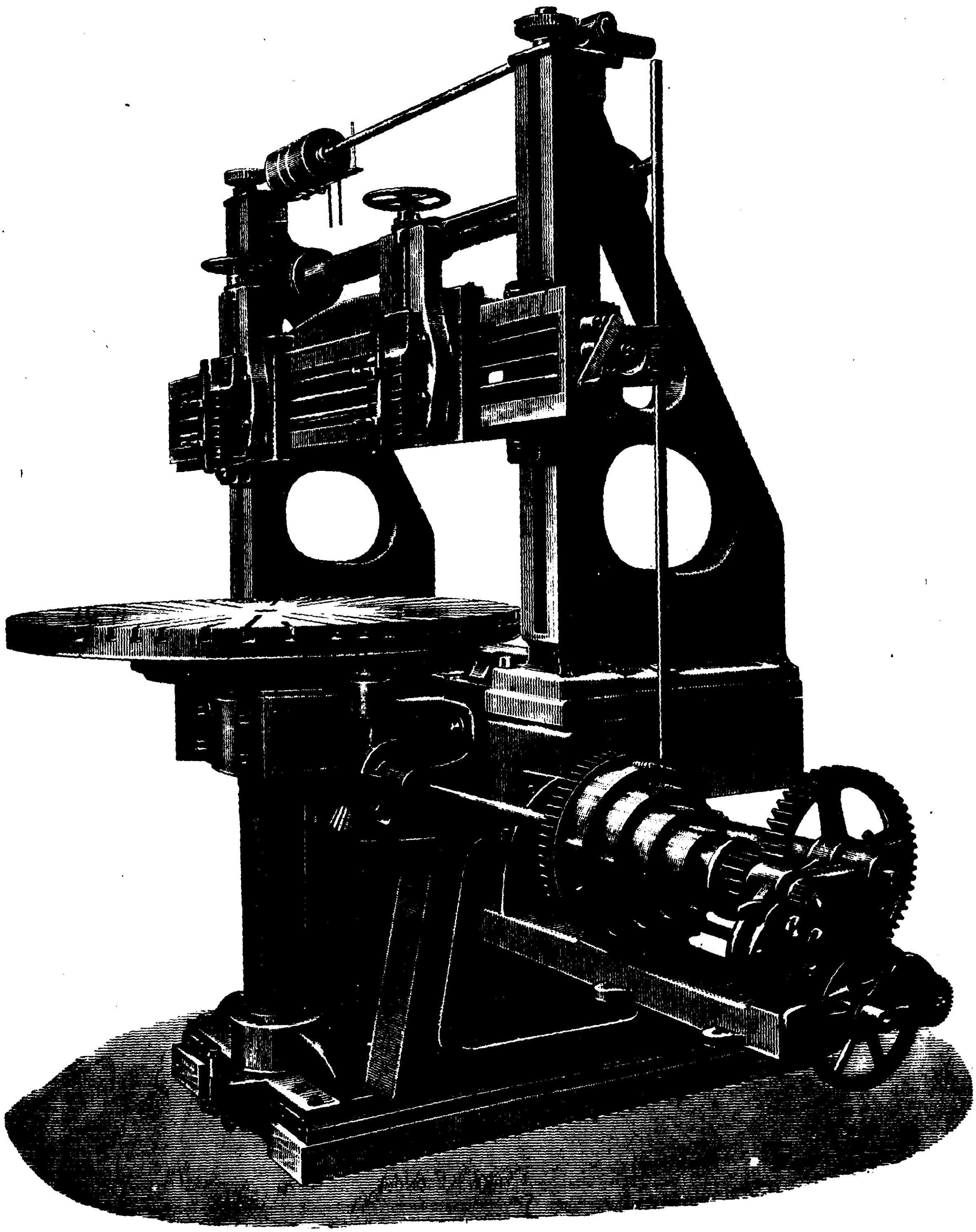
The Arch.—The arch has a chord of 541 feet 4 inches. The rise of the arch to the intrados is 169 feet 1.78 inches. The depth at the centre is 32 feet 9 inches. This arch is composed of two lattice-work principals, placed symmetrically with relation to the middle plane of the arch, but obliquely to it. The planes of these principals are separated by a distance of 65 feet 7 inches at the springing and of 20 feet 7 inches at the centre, whence it follows that the inward slope is .11088 per m. in relation to the vertical. The principle ribs are cruciform in section ; the central line is a parabola of the second degree, which has a very flat curvature near the abutments. The entire arch is in compression, and the curve of pressure never emerges from it. It was for the purpose of attaining this object that the struts which support the main girders have been placed as near the middle of the arch as possible. The arched ribs are of great depth at the crown, and terminate in points at the springing, where they rest upon the skewbacks by means of knee joints.

The arch is formed with upper and lower box members, of which the interior face is open and is latticed. These members are connected by latticed bars and by vertical struts, with plain panels near the joints. The verticals and diagonals are of trellis-work, of angles and flat bars. The arched girders are connected together transversely by horizontal lattice bracings, and in addition by vertical wind bracing.

The open frames formed of angle iron at the corners and of lattice-work upon the face are disposed in the form of crosses in the planes of the intrados and extrados ; they complete the framework of the arch, and at the same time secure the rigidity and solidity of the various elements of which it is composed. As already mentioned, the girder which carries the roadway is interrupted above the struts of the arch, the central girder being rigidly connected with the arch, while the side girders are fixed upon abutments, and rest at their extremities upon rollers carried by the piers. The arch is attached to the masonry of the abutments by strong holding-down bolts, although it can be shown by calculation that these are not required. This form

THE TAY BRIDGE.





VERTICAL LATHE.

of anchorage is, however, not expensive, and affords an additional security too important to be neglected.

The Piers.—The piers are of the following heights, measuring from the masonry foundations: 199 feet 3 inches; 168 feet; 119 feet 7 inches, and 80 feet 5 inches. The foundations are of granite masonry, and two of these are each pierced by an arched opening 39 feet wide, with its axis parallel to the roadway. The batters of these foundations are 12 in 100 for the abutments, and 9 in 100 for the other piers, longitudinally: transversely, it is uniformly 4 in 100. These figures are almost the same as for the metallic superstructure. The iron piers have the form of a truncated pyramid, of which the sides are inclined to the vertical at 11,088 in 100,000 for the two large piers and at 325 in 10,000 for the others longitudinally, and at 386 in 10,000 transversely. The height of the stage is usually 32 feet 9 inches. The piers are terminated at their summits by a bearing platform designed to receive the supports of the girder, the dimensions of which are 7 feet 7 inches longitudinally and 16 feet 4 inches transversely. The four principal members of the piers are in the shape of a U, of which the two branches resist the action of the wind. In the interior of the U horizontal and diagonal cross-pieces are inserted. This arrangement permits of easy access, and is capable of resisting compression as well as tension.

The Strains.—The calculations were made by M. Eiffel, and afterward verified by other methods by M. Boyer, who found them correct. The proof strain was fixed at a train consisting entirely of engines of the type known as 1001 of the Compagnie du Midi, weighing, together with the tender, all in running order, 74.8 metric tons. This works out to 4,800 kg. (10,580 pounds) per meter run of the girder. This figure is considerably above the 3800 kg. per meter, provided for the ministerial circular of July 9, 1877, for trusses of 55 meters span. The various sections have been so designed that the strain shall not exceed 3.81 tons per inch under the combined effect of the load and the wind. The effect of the wind is assumed to be 30.7 pounds per square foot at the time the trains are running, and 55 pounds at its maximum, at which time the traffic would be suspended. In the calculation it was supposed that the wind would act uniformly on the side presented toward it, but that it would act solely upon the bars of the opposite side. To this there was added the effect produced on the train. This being partly protected by the upper members of the girder, the effect was estimated as acting on 1.6 square metres per meter run. This figure of 1.6 is that which was adopted in the calculation for the great viaducts on the Orleans system.

The effects produced by the load and the wind are such that the members of the arch may be regarded as bearing 1.27 tons per square inch under the ordinary load, 1.27 under the extra load, and 1.27 from the wind. The section of the number is therefore one-half greater than it would be if the wind were neglected. The trellis-work of the arch receives a strain of .63 ton per square inch under the permanent load, the same for the extra load, and 1.9 tons from the wind.

M. Boyer has calculated the deflection of the arch under the permanent load and under the extra load, and he determined the shortening of the rise at .63 inch for the first and 1.3 inches for the second. Under a change of temperature of 30° the rise varies 2 inches; consequently, under the simultaneous action of the extra load and the temperature the summit of the arch might descend 3.4 inches. The iron piers experience a similar depression, and the relative variation of level is less than ½ mm.

The Execution of the Work.—After the buildings for the accommodation of the workmen were complete, a service bridge was built at a level corresponding to the foundation of the chief pier. This bridge had a width of 14 feet 9 inches, and a height of 108 feet 3 inches above the waters of the Truyère. It cost £800. The head of the bridge was connected to the main highway by a road built upon the side of the ravine. When the foundations were complete and the piers built the girders were pushed forward into position, and then the preparations were made for the raising of the arch. Two principal scaffolds had been constructed before the foundations of the two abutment piers, just to the height of the pivots. Their upper parts were cut to a slope to receive the members of the intrados of Panels 1 and 2. Above these first pieces there were erected the uprights, the cross-ties, etc. The arch was stayed by means of supports secured a little above the pivots and the next pier at the height of its first stage, and the forward portion was held by steel cables extending to the summit of the pier. The arrangement made for the erection of the parts was as follows:

Upon the upper members of the arch there were placed horizontal timbers which formed the base of a frame similar to that of the rotary cranes used in railway stations for charging and discharging stone, and having its head slightly inclined toward the ravine. Two small platforms situated at other side received the workmen who worked at the winches. The parts of the arch were brought up by a waggon running on the service bridge below, and the crane chains, passing over pulleys attached to the upper cross-piece at variable points, raised the parts into the exact positions. The crane, fixed at its base to the extrados of the arch, and above to the upper girders, was advanced as the successive panels were erected. The projection at the head permitted it to hold the parts which were connected at the back to the part of the arch already constructed. Nets stretched upon wooden frames below the positions occupied by the workmen secured their safety under the dangerous conditions in which they worked.

Above the large piers of the central arch there were erected two wooden gantries which carried a steel-wire cable tramway spanning the distance of 580 feet, separating the piers. The cable carried two cages which served to raise small weights, while the shears were reserved for the large weights. By these means the arch gradually rose, always supported by the wire cables. The system of anchorage was as follows: (1) Cables (in number from 20 to 24) between each of the halves of the arch and the piers 4 and 5; (2) the lateral girders; (3) cables between the lateral girders and the lower part of the back of the abutments to the number of 28. The cables employed had a heart of hemp surrounded with eight strands, each of 19 wires of 2.4 mm. diameter.

The estimated cost of the viaduct was as follows:

Masonry of the viaducts and approaches	£15,601
Masonry of the foundation of the smaller piers	3,399
Masonry of the piers and abutments of the arch	8,188
Total	£27,188
Margin	2,812
Total	£30,000
Bars and plates for the girders and piers	£47,580
Bars and plates for arch	41,860
Castings	180
Machined castings	777
Cast steel	200
Lead	48
Total	£90,645
Margin	3,355
Total for the metallic portion	£94,000
Total for the work	£117,834
Margin	6,166
Total	£124,000
Mean cost per meter run:	
For the entire viaduct	£223,8
For the part with the girder	228.12

The idea of building a viaduct of this kind is due to M. Boyer, the engineer in charge of the survey, who saw that by its means the general construction of the line would be greatly facilitated, and his proposition was approved by M. Bauby, the engineer-in-chief, and General de Boisanger. The execution of the work was intrusted to M. G. Eiffel in a ministerial decree which stated that, as the bridge was of the same type which M. Eiffel had so successfully designed and erected over the Douro, it was evident that he was the most fitting person for the work, as he would be able to profit by the experience he had gained in the preceding venture. The execution of the work was undertaken under the direction of M. Bauby, at first, then under M. Lefranc, his successor. M. Boyer, although attached to the Railway Department in Paris, was the resident engineer.

The date of the decree was June 14, 1879. The arch was completed on the 26th of April, 1884, and the work was finished the same year, reflecting the greatest possible credit upon all concerned. The idea of building such an arch without any centering, supporting the two sides by means of elastic cables that responded to every change of temperature and weather, was a scheme of great boldness, and one that needed full success for its justification. By the skill of M. Eiffel this success was attained, and it remains a monument of what can be achieved by daring when it is accompanied by great constructive ability and comprehensive forethought. *Engineering* adds that they are indebted to the *Révue Générale des Chemins de Fer* for the above particulars.

SCIENCE AND MODERN DISCOVERY.

The present occupant of Sir Isaac Newton's Professorial Chair, at Cambridge University, Professor G. G. Stokes, F.R.S., who is also Secretary of the Royal Society of England, delivered a remarkable address at the annual meeting of the Victoria Institute, in London, towards the end of June. Sir H. Barkly, G.C.M.G., F.R.S., occupied the chair, and the audience, which included many members of both houses of Parliament, filled every part of the large hall. Professor Stokes gave an important account of the progress of physical science during the past quarter of a century, and, reviewing the results, specially noted that as scientific truth developed, so had men to give up the idea that there was any oppositson between the Book of Nature and the Book of Revelation. He said that for the last twenty years or so one of the most striking advances in science had been made in the application of the spectroscope, and in the information obtained with regard to the constitution of the heavenly bodies. The discovery that there were in these particular chemical elements, which were also present in our earth, exalted our idea of the universality of the laws of Nature, and there was nothing in that contrary to what he had learned in Revelation, unless we were to say as the heathen did that the God of the Hebrews was the God of the hills and not of the valleys. Entering with some particularity into the composition of the sun, the Professor said this gave an idea of an enormous temperature, since iron existed there in a state of vapour. This was utterly inconsistent with the possibility of the existence there of living beings at all approaching in character to those we have here. Are we then to regard this as a waste of materials? Might we not rather argue that as in animals we ascend by greater specialization, so we could consider the differentiation of office in different members of the solar system as marks of superiority, and could regard the sun as performing most important functions for that system? In fact, all life on our earth was ultimately derived from the radiation of solar heat. Referring to the doctrines of conservation of energy and of dissipation of energy, he pointed out at some length how the sun, so far as we could see, was not calculated for an eternal duration in the same state and performing the same functions as now. We must regard the Universe on a grand scale, and then there was progress. If we contemplated nothing but periodicity, perhaps we might rest content and think things would go on for ever as at present; but, looking on the state of the Universe on a grand scale as one of progress, this idea obliged us to refer to a First Cause. Professor Stokes concluded with recommending that the annual report of the Society, read by Captain Frank Petrie, the honorary secretary, be adopted. It showed that the number of home, American, and Colonial members had increased to upwards of eleven hundred, and that the Institute's object, in which scientific men whether in its ranks or not aided, was to promote scientific inquiry, and especially in cases where questions of science were held by those who advanced them to be subversive of religion. All its members and one-guinea associates received its transactions free, and twelve of its papers were now published in a People's Edition, which was to be had in many of the colonies and America. The address was delivered by Dr. J. Leslie Porter, President of Queen's College, Belfast, the subject being "Egypt: Historical and Geographical," a country with which he had been thirty years intimately acquainted. Having referred to the antiquity of Egyptian records, which in so many instances bore on the history of other ancient countries, he proceeded to describe the various changes through which that country had passed since its first colonization; and, touching on its physical geography, concluded by giving the main results of recent exploration. One or two special statements may be here recorded. Dr. Porter said. "Were the Nile, by some convulsion of Nature, or by some gigantic work of engineering skill,—neither of which is impossible,—turned out of its present channel away up to Khartoum, or at any other point above Wady Halfa, Egypt would soon become a desert." No tributary enters the Nile below Berber, that is to say for the last thousand miles of its course. "The arable land of Egypt is about equal in extent to Yorkshire." The White Nile, issuing from the lakes Albert and Victoria Nyanza, is broad and deep, never rises above a few feet, and supplies the permanent source of the river of Egypt. "The other tributaries produce the inundation." Of these the Atbara from the mountains of Abyssinia is the most fertilizing, as it brings down with it a quantity of soil. The deposit of this soil is slowly raising the bed of the river as well as extending on each side; for example, on the plain of Thebes the soil formed by deposits has in 3,500 years encroached upon the desert a third of a mile, "while the ruins of Hierapolis in the Delta, which once stood above reach of the inundation, are now buried in a mud deposit to a depth of nearly 7 feet." In conclusion, he referred to Egypt and its present condition, saying:—"The commerce from the upper tributaries of the Nile, and from the wide region of the Soudan, forms an essential factor in the prosperity and progress of Egypt." The Earl of Belmore and the Right Hon. A. S. Ayrton moved and seconded a vote of thanks, after which the company present assembled in the Museum, where refreshments were served.

A BIG ELECTRIC ORGAN.

The largest organ in the world, with the exception of the one at Riga, Russia, is in the Cathedral of the Incarnation at Garden City. Its capabilities were tested June 13th by George W. Morgan, who gave an interesting recital before a large number of ladies and gentlemen. The instrument, which was built by Mr. Hilborne L. Roosevelt, is distributed in four distinct and widely-separated localities of the cathedral, although the whole is under the control of one performer, through the agency of electric action. In an octagonal chamber, built for the purpose in the angle formed by the transept and chancel walls, is the largest portion of the instrument. The organ is here divided into floors, or stories, and in the basement are the engine, countershaft, etc. Above this, on a floor of brick and iron, are the bellows and the windchest, on which rest the 32-foot pipes. The great organ windchest, with that for the reeds and mixtures of the pedal organ, are on the next level, and then follows the swell organ, and, above all, the choir. Each of the three manual wind-chests is furnished with its own auxiliary reservoir, or regulator," where the wind is reduced to the pressure needed for that department.

In the tower at the western end of the cathedral is the most important division of the organ. In the room, which is 15 feet square, and is high enough to admit of one wind-chest being supported above another, are placed parts of the great, swell, and pedal organs and the whole of the solo organs, the second of these being above the first, the third at one side, and the fourth at the back. In the chapel beneath the cathedral is the third section which is provided with claviers of its own, so that it may be made independently available for chapel purposes. This comprises a part of the choir organ, divided here between the two manuals and two of the pedal stops. Its tone rises into the church through the different staircases, and the distance lends enchantment to the sound. The last part consists of the echo organ and one pedal stop, which is placed between the ceiling and the roof, above the intersection of the nave and transept. The mysterious source of the tone produces an interesting effect. The vox humana sounds are especially realistic.

Steam power is used in inflating the bellows. One engine is placed beneath the chancel division to supply it with compressed air, and another beneath the tower to operate the bellows of the chapel division, and the magneto machine, which generates the electricity. All the wires used in making the electric connections of the instrument stretched out in a continuous circuit would extend over distance of 21 miles. This summary will give an idea of the resources of the instrument:

	Stops	Pipes.		Stops	Pipes.
Great organ	31	2,406	Solo organ	7	427
Swell organ	27	1,942	Echo organ	7	382
Choir organ	23	1,444	Pedal organ	20	651
Total				115	7,252

There are 9 couplers, 11 mechanical accessories, 11 adjustable combination pedals, 9 vental pedals, and 3 miscellaneous pedals.

The recital given by Mr. Morgan brought out many of the fine qualities of this noble instrument, and the organist himself afterward praised it warmly.—*Chicago Journal of Commerce.*

MESSRS. Chas. Boeckh & Son, brush manufacturers, of Toronto, are building an extensive factory on Adelaide Street. The factory building alone will cost $12,000 and is to be fully equipped with the most improved machinery. The increased facilities this will give them will enable them to employ a large additional number of hands.

THE GARABIT VIADUCT.

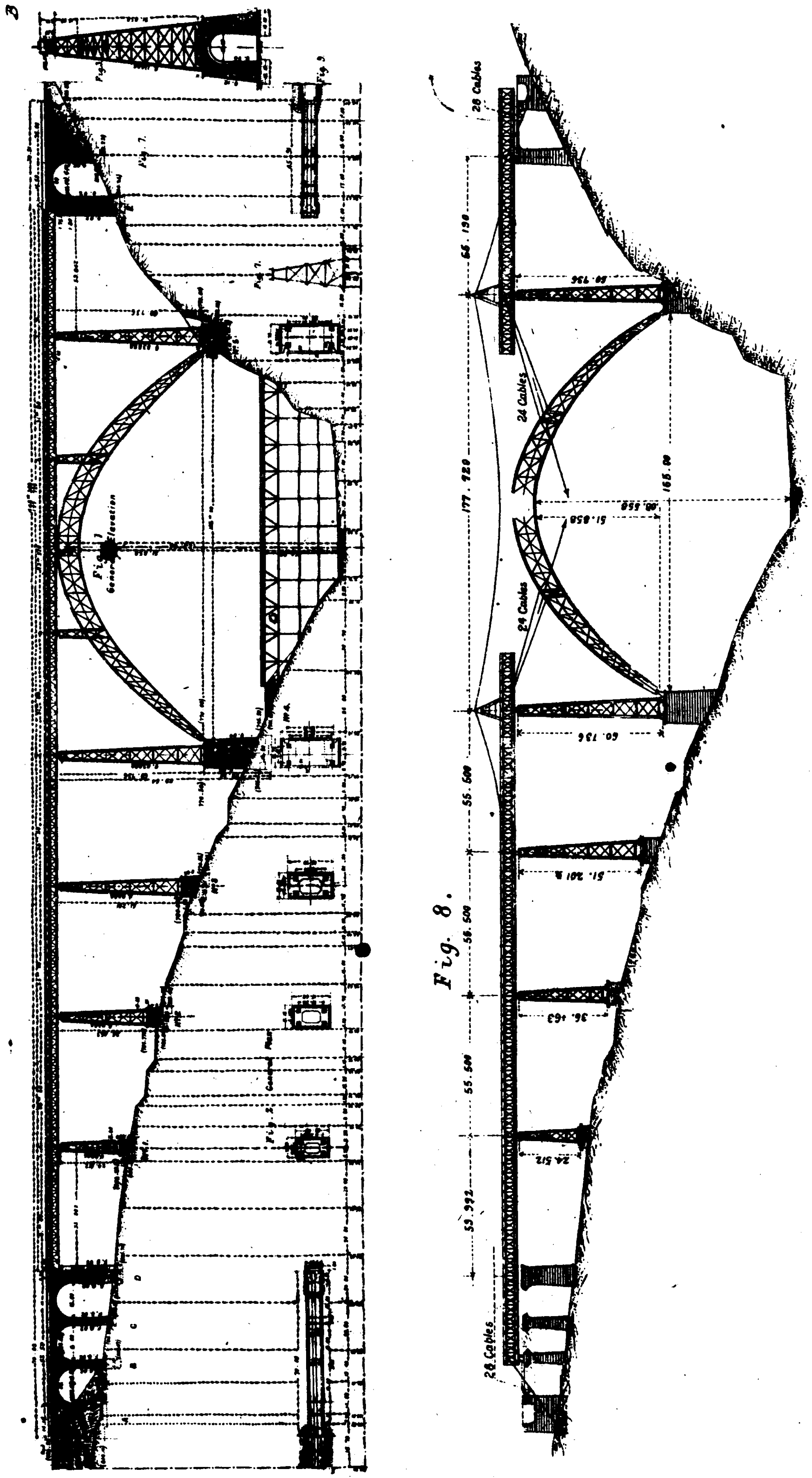
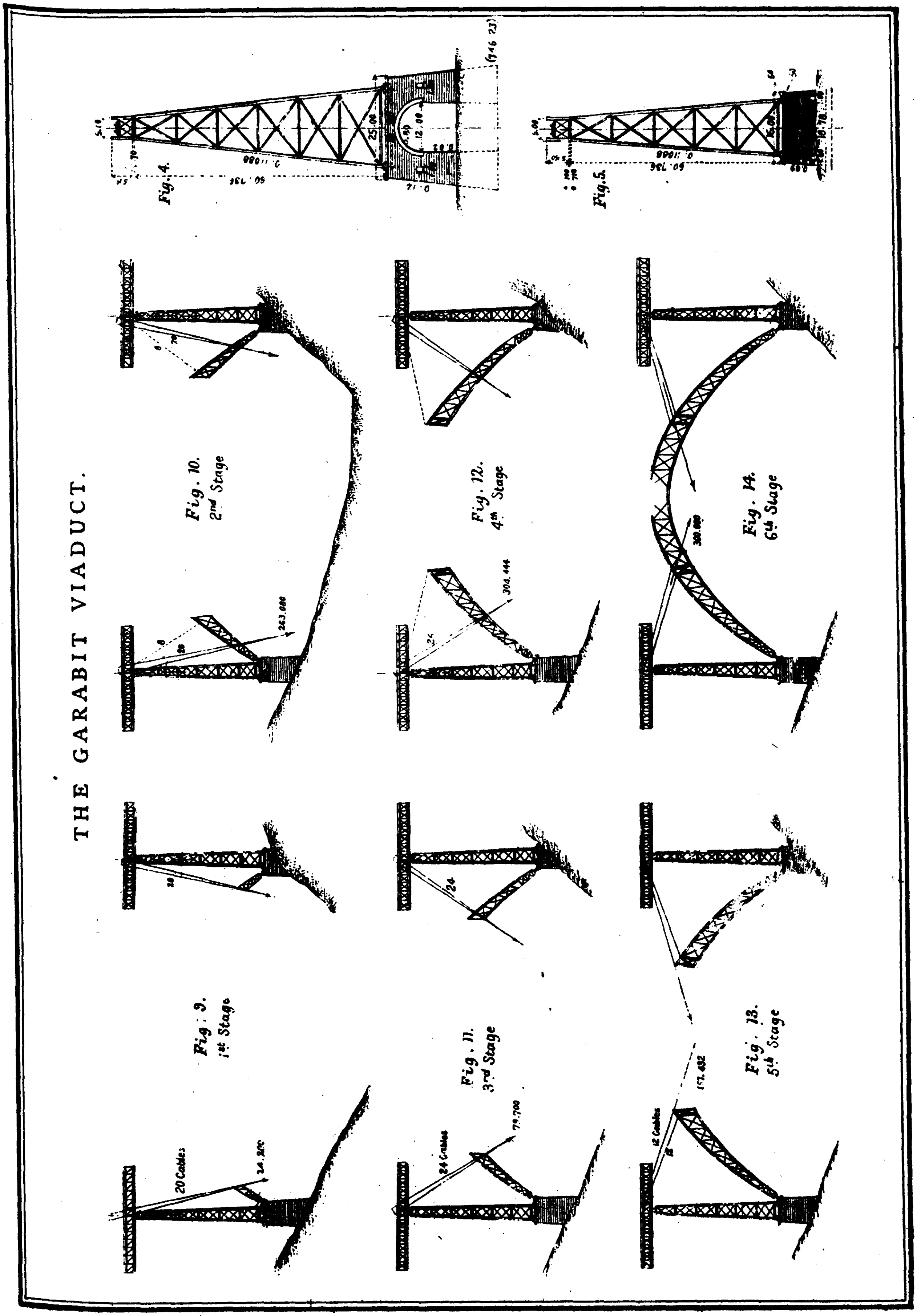


Fig. 8.


THE GARABIT VIADUCT.
Fig. 4.
Fig. 5.
Fig. 9. 1st Stage
20 Cables
Fig. 10. 2nd Stage
Fig. 11. 3rd Stage
24 Cables
Fig. 12. 4th Stage
Fig. 13. 5th Stage
12 Cables
Fig. 14. 6th Stage

AN ELECTRIC GUN.

Since the perfection of the breech-loading gun the aim of the mechanician has been to insure rapidity of fire, and magazines of various sizes and forms have been devised with a view of obtaining it. Experience in the field, however, has shown that these have a serious if not fatal defect. The cartridges, pressing, as they do, the one upon the primer of the other, are likely to explode prematurely, thus rendering the device especially impracticable as a military arm. A writer on this subject says:

"A French army cartridge, which is about the average weight of military cartridges in use, weighs more than 1 2·5 ounces. The weight of a column of five such cartridges would be 7 ounces, four-fifths of which weight would, in a tubular magazine, rest upon the point of the bullet of the last cartridge, and which bullet comes directly in contact with the primer of the cartridge in advance of it. All ordnance officers and ammunition manufacturers realize the difficulty experienced in preparing fulminate of mercury—used for primers—that will, in practical use, always have a uniform degree of sensitiveness. It can be made so sensitive that the slightest scratch will ignite it, and many fulminate mixers have lost their lives by a moment's inattention or relaxation of caution while compounding it. While it is generally possible to produce fulminate of nearly equal quality, still different batches do vary; and whether it be from difference in the quality or from the different position or placement of the fulminate in the primer as regards the cartridge anvil, or otherwise, still it is certainly true that cartridges are to be found in use that will explode with one-half the concussion ordinarily required. It is a fact that cartridges have exploded by dropping a few inches from the machine in which they are loaded into the receptacle below."

In order to prevent the cartridges from resting upon one another, a system has been devised of placing them side by side in a metallic case, which can be attached under the breech, and when emptied replaced by another, and so on. But the mechanism is intricate, and the parts awkward to handle.

Several attempts have been made to use electricity for firing the cartridges, and thus do away with fulminate of mercury altogether.

About two years ago Colonel Fosbery, Royal Engineers, exhibited in the Royal United Service Institution an electric gun which he had brought with him from Liege. The cartridges were of the ordinary kind, but contained no fulminate of mercury. Col. Fosbery carried in his pocket a small primary battery of about the size of a two ounce vial, which was connected with the gun by a fine wire. This fired the cartridge as fast as they could be placed in the breech. For obvious reasons this could be of little use outside of a laboratory or lecture room.

Several months ago an electric gun was sent by an arms company to Captain S. A. Day, Fifth Artillery, at Fort Hamilton, for trial in the field. Captain Day, an expert in small arms, has tested this gun under all conditions and found it admirably contrived to answer the purpose, not only of a sporting gun, but also of a military arm. The mechanism is simple, the parts few, and the electrical firing contact sure. The principle is applicable to any arm. A primary battery, of cylindrical form, about 8 in. long by 1 in width, is set in the stock of the gun and connected with the primer of the cartridge; contact being made and broken by pressing on and releasing a trigger of the usual form. When this system is used, there is no need of tumbler, hammer, mainspring, or any of the ordinary safety levers used in firing percussion.

There is an electric igniter or primer inserted in an ordinary metallic base shell, and this primer can be tested before loading the shell, whereas with percussion primers, to test is to explode. The change from the percussion fire to the electric is so easy that any intelligent person can make it.

The electric primers for the shells are easily made, too, and not easily destroyed by repeated firing. Captain Day says that the power of igniting charges of long proportions at any desired point along the central line, instead of at the base, as with percussion primers, or even at the wad as in the needle gun, gives the facility to burn the entire charge and under better conditions of using the expansive force. The exact point of ignition for best results should vary with dimensions and form of charge, but the power to determine at will the point at which ignition shall take place, and vary it is given by this method. With the uniform precision of an electric point, an exactitude of performance and an economy of producing given results are secured not heretofore possible with any percussion fire.

In the recent and final trial of this electric gun, the cartridges were loaded in the field in order to show how many shots could be fired from a single shell, or rather how many could be fired without renewing the primer. In testing this, Captain Day and the writer fired alternately and repeatedly; the latter firing as many as ten rounds from one shell before it became necessary to renew the igniter. The battery is said to be good for more than fourteen thousand rounds before becoming exhausted and requiring recharging and renewal of elements. At an absolute trial in the gun works, where men fired notch by notch for weeks, we have Captain Day's authority for saying that within a few hundred rounds of 15,000 were fired from the same gun and with the same battery.

Probably the most convenient form of gun that this electro-firing apparatus can be attached to is that type which has a tubular magazine, because, where no percussion is used, this seems by long odds to be the easiest handled, the weight being equally distributed, and because only the simplest mechanism is required to throw out the empty shell and send home the loaded one.

As a military arm the electric gun has great advantages. No magazine of cartridges primed with fulminate of mercury can withstand the ordeal of the manual of arms without imminent danger of premature explosion, and, as is well known, percussion cartridges rapidly deteriorate and become uncertain of fire when kept long in the field.—*Scientific American.*

CROPS AND RAILWAY TONNAGE.

A false view has been taken of the crop prospect for the coming year, and to read what the croakers say and to believe it all would lead one to think that we were in prospective starvation, while the railway had nothing to contemplate but a traffic so insignificant that it will not, according to these chronic croakers be worth considering. Now facts are in open contradiction to all these valid statements made by the gloomy viewers of the situation. Last year the wheat crop was the largest ever known. The amount likely to be exported is only of average quantity, while the surplus to be carried ever to supplement the yield of the present year is larger than usual. The wheat crop of 1882 has been estimated at 504,000,000 bushels, the exports of that year about 149,000,000 bushels of wheat and flour, while the domestic consumption and quantity used for seeding, 300,000,000 bushels, indicating a remainder of 55,000,000 bushels to be added to the reserves in country. In 1883 the crop was 420,000,000 bushels; add 55,000,000 bushels to the reserves by the excess of the preceeding crop, and we have a total of 475,000,000 bushels a supply. During the year the exports of wheat and flour equalled nearly 112,000,000 bushels; domestic consumption and seed requirements estimated at 325,000,000 bushels, making 437,000,000 disposed of leaving a surplus of 38,000,000 in excess of the returns of 1882.

The wheat crop of 1884 was about 512,000,000 bushels; adding the 38,000,000 mentioned, makes 550,000,000. The exports for the current year will be about 135,000,000 bushels, including flour; the domestic consumption and seeding rements 330,000,000 bushels making 465,000,000 bushels disposed of, which would leave 85,000,000 bushels of excess over the reduced reserves in 1882, and 47,000,000 bushels more in the supply than there was a year ago. In other words, the late crop of 512,000,000 bushels has supplied 165,000,000 for export and added 47,000,000 bushels to the reserves of the country, after meeting all the domestic requirements.

The incoming crop is estimated at 360,000,000 bushels; adding to the excess of 1884 makes a total of 445,000,000. It is also estimated that the domestic requirements of the coming year will reach 335,000,000 bushels, leaving for export about 110,000,000 bushels, no allowance being made for reserve to be carried over to the succeeding year. Thus, there is a prospect for abundance for domestic use, with at least 10,000,000 to spare. The yield in the leading wheat countries of Europe will, it is predicted, be below that of last year, and less than the average of the past five years. The prospect as regards spring wheat is highly promising, while the yield of corn will equal, if not excel, the yield of any former years. Now, what is all the croaking about? All these "scares" have more imagination than fact for ground-work, and this applies to the falling off of railway tonnage as well as to the crops.

Rates have been unprofitably low, but it is not admitted that the reduction in traffic charges were forced by the abundance to be moved or the low price of grain and provisions. The low rates of transportation are chargeable to other causes quite as likely to appear in seasons when prices for domestic products were unusually high. The abundance of last year's crop and the price at which they were marketed affected railway rates only in a moderate degree. The contest maintained among the trunk lines with which the volume of tonnage to be moved has but little to do, is chargeable with the low rates made and loss in earnings incurred. Those with a range of vision extending into the future profess to see ruin to the railways in the coming year because of a light yield of wheat. But with a wheat crop lengthened out by the surplus carried over from last year, according to the most unfavorable estimate, of over 100,000,000 bushels in excess of a full allowance for domestic consumption, it would seem that the railways are not in as much danger from reduced tonnage as from a spirit of discord that may be kept up among the trunk roads of the East and West. Harmony among the railways in sustaining fair rates of traffic would overcome the reduced tonnage of a lighter wheat crop for 1885, and restore earnings to a fair degree of profit.—*Chicago Journal of Commerce.*

GENERAL GRANT'S PREFACE.

[By Courtesy of Charles L. Webster & Co., publishers of the forthcoming book.]

"Man proposes and God disposes." There are but few important events in the affairs of men brought about by their own choice.

Although frequently urged by friends to write my memoirs I had determined never to do so, nor to write anything for publication. At the age of nearly 62 I received an injury from a fall, which confined me closely to the house while it did not apparently affect my general health. This made study a pleasant pastime. Shortly after, the rascality of a business partner developed itself by the announcement of a failure. This was followed soon after by universal depression of all securities, which seemed to threaten the extinction of a good part of the income still retained, and for which I am indebted to the kindly acts of friends. At this juncture the editor of the Century Magazine asked me to write a few articles for him. I consented for the money it gave me; for at that moment I was living upon borrowed money. The work I found congenial, and I determined to continue it. The event is an important one for me, for good or evil; I hope for the former.

In preparing these volumes for the public, I have entered upon the task with the sincere desire to avoid doing injustice to any one, whether on the National or Confederate side, other than the unavoidable injustice of not making mention often where special mention is due. There must be many errors of omission in this work, because the subject is too large to be treated of in two volumes in such way as to do justice to all the officers and men engaged. There were thousands of instances, during the rebellion, of individuals, company, regimental, and brigade deeds of heroism which deserve special mention and are not here alluded to. The troops engaged in them will have to look to the detailed reports of their individual commanders for the full history of those deeds.

The first volume, as well as a portion of the second, was written before I had reason to suppose I was in a critical condition of health. Later I was reduced almost to the point of death, and it became impossible for me to attend to anything for weeks. I have, however, regained, somewhat of my strength, and am able, often, to devote as many hours a day as a person should devote to such work. I would have more hope of satisfying the expectation of the public if I could have allowed myself more time. I have used my best efforts, with the aid of my eldest son, F. D. Grant, assisted by his brothers, to verify from the records every statement of fact given. The comments are my own, and show how I saw the matters treated of, whether others saw them in the same light or not.

With these remarks I present these volumes to the public, asking no favor, but hoping they will meet the approval of the reader.

U. S. GRANT.

Mount MacGregor, N.Y., July 1, 1885.—*N. Y. Tribune.*

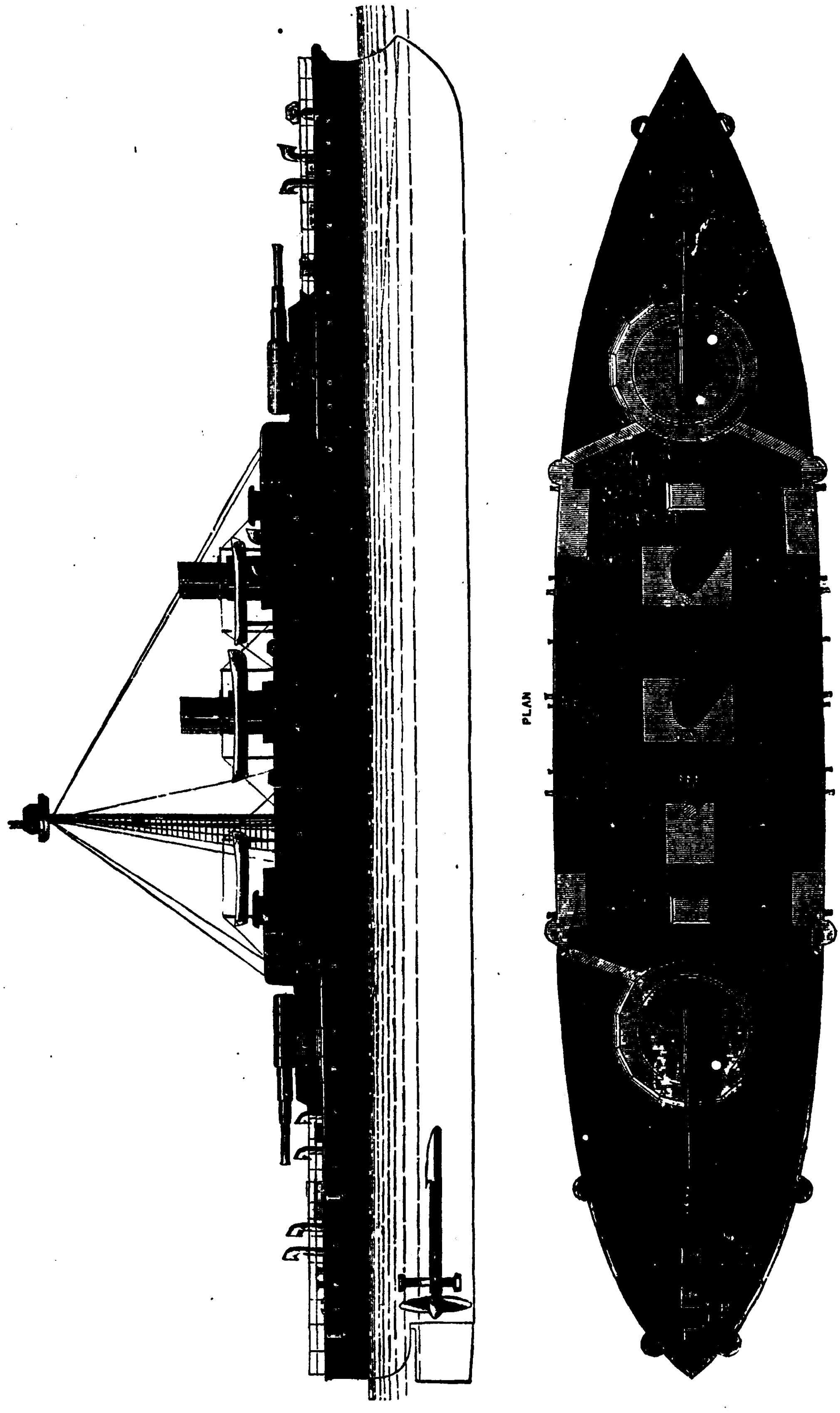
H. M. S. BENBOW.

The Benbow, built at the Thames Ironworks, Blackwall, and recently launched, is a ship to which special interest naturally attaches at the present time, because she is perhaps the most remarkable vessel of the new citadel type representing the ships termed the Admiral class, being all named after celebrated admirals—that is, the Howe, the Anson, the Collingwood, the Camperdown, the Rodney, and the Benbow. The Benbow differs from the others in carrying in each of her barbette towers one 110 ton breach loading gun instead of two smaller pieces. It is this fact that constitutes her most notable feature. The 110 ton breech loading gun ordered from Elswick is 43 ft. 6 in long; its caliber is 16.75 in. It fires a charge of 900 lb. and a projectile weighing 1,800 lb with a muzzle velocity of 2,020 ft. per second, giving a muzzle energy of 61,200 foot tons, with a calculated perforation of 30·5 in of wrought iron, and an energy per ton of gun of 513 tons. These figures will be found to imply that it will be the most powerful gun in the world at present, Krupp's 1.9 ton gun having only 46, 061 foot tons calculated muzzle energy. The Benbow is also inseresting as being built by contract, for at the present moment it is very important to learn the relative advantages and disadvantages of building by contract and in the royal shipyards. The Benbow is of the mastless type, having only a pole with a top for two machine guns. She has compound armor in a belt about 8 ft. wide and 18 in. maximum thickness along her water line amidships, with a 3 in. steel deck at the top of the armor, and a horizontal armored deck fore and aft of her citadal. She is 330 ft. long and 68·5 ft. wide. Her displacement will be over 10,000 tons, perhaps running up to 10,500 tons. She has 9,000 horse power, and her speed is hoped to be 16 knots. Her barbettes are protected by 14 in. of compound or steel faced armor built at an angle, as shown. Her armament is as follows:

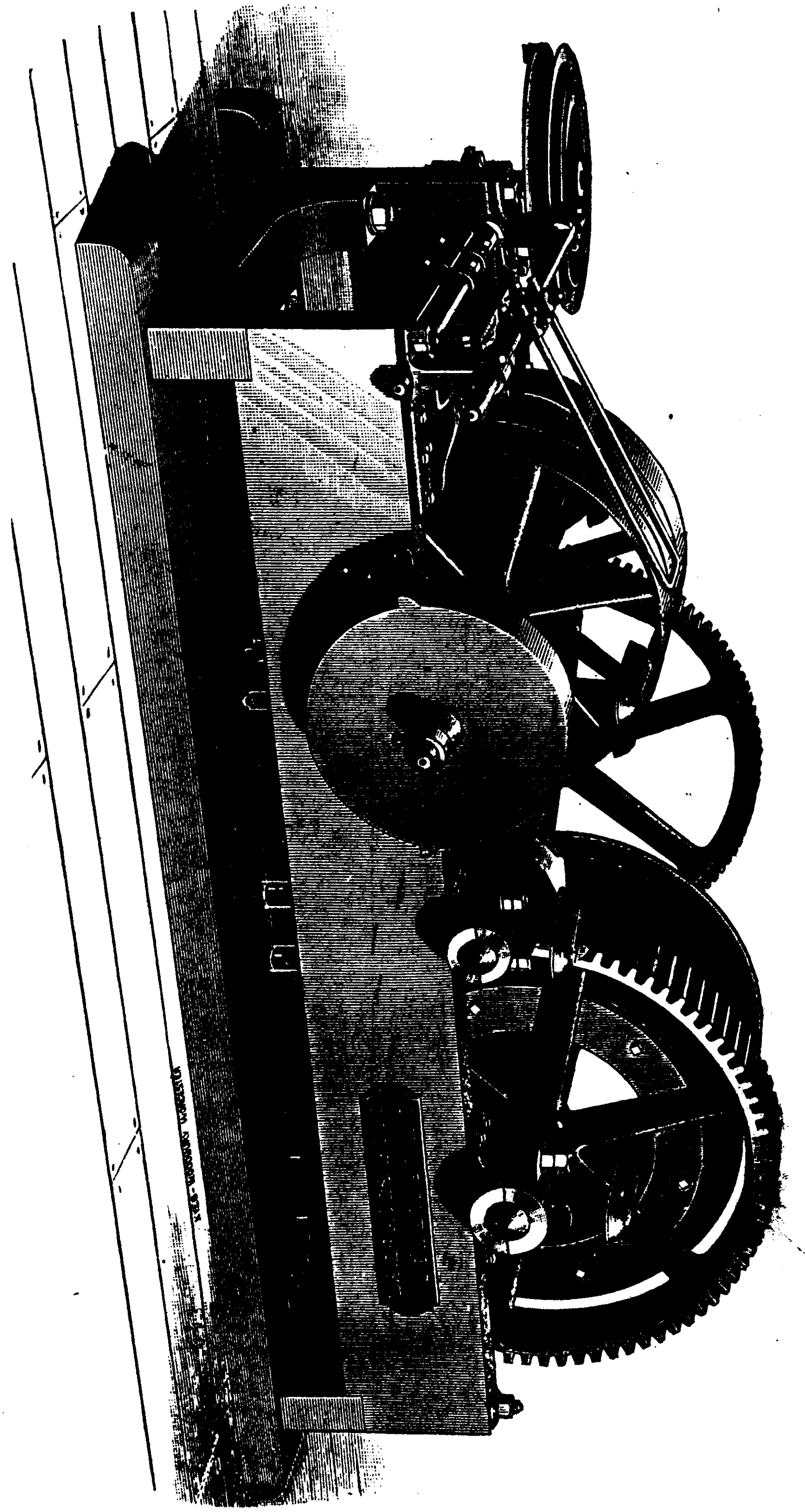
On her hurricane deck she carries eight quick-firing Hotchkiss 6 pounder guns and four Nordenfelt machine guns, probably four barreled 1 in. Nordenfelts in small projecting towers. On her battery deck are ten broad side 6 in. new type guns, those at the force and aft ends of the battery training round so as to fire if need be through ports made for firing directly fore or aft. There are also on this deck four quick-firing guns and six machine guns, four in towers and two carrying shields on their carriages. In her barbette towers are the two 110 ton guns. There are also four smaller five barralled Nordenfelt machine guns, 4·5 in bore. Her top is designed to carry two machine guns. Torpedoes can be discharged ahcau. astern, and abeam.

The guns on the barbette towers are of course much exposed, but the gun detachement is down below a steel circular 3 in. revolving deck. The gun is loaded by running back and lowering the breech. The type to which this vessel belongs is one which we need hardly say has been the subject of long and bitter attack by Sir Edward Reed. At present this line of criticism meets with the approval from some of the best known naval officers. On the other hand, others think it has been pushed to unreasonable lengths. Citadel ships leave their ends exposed at the water line. The French barbette class represented by the Admiral Duperre, have armor along their water line from end to end at the expense of exposing the ship in other places.

At Alexandria no shell that passed into the unarmored part of any of our vessels did serious damage, and until the introduction of quick-firing guns, few officers would we think, believe that ships could be destroyed by such fire. It is now urged that quick fire may very quickly riddle a vessel along her water line' and so cripple her that she may be rammed. Both classes of vessels may be capsized by destruction of unarmored parts, as has been shown at the Admiralty by model experiments. But the adversaries of the citadel type urge that water is liable to enter and interfere with speed. On the other hand, such a vessel as the Admiral Duperre has her men so entirely exposed that it may be questioned if she could keep a man at any of her guns under the fire of quick guns and machine guns. Some officers believe that the effect of quick fire is at present overrated. It appears probable that the construction of our ships may be so far effected by quick fire as to cause a thin belt of armor to be extended at the waterline to turn off the great mass of quick fire which may be assummed to fall an it more or less obliquely. As to ramming powers, the Benbow has a spur strengthened with a horizontal flange, and her bows are stiffened with her horizontal armor deck. With her twin screws she ought to be fairly handy.—*The Engineer.*



THE NEW BRITISH WAR STEAMER BENBOW.



SPUR GEAR WINDING MACHINE.

THE MAXIM MACHINE GUN.

Description of the Maxim Automatic Machine Gun.

BY MR. HIRAM S. MAXIM, OF LONDON.

Previous Machine Guns.—The first practical machine gun is believed by the writer to be that made by Dr. Gatling, an American inventor, by whom it was presented to the United States Government about 1863. In its earliest form it was not made for firing metallic cartridges, and was constructed with a series of steel sections, which, after having been previously loaded by hand, were one after another brought up to the breech of the barrel and pressed firmly against it at the instant of firing. None of the Gattling guns however appear to have been actually used in the field before the close of the American war in 1865. The next machine gun of any note was that of Hotchkiss, another American inventor, who took it to France, where he established a large factory, and has supplied his guns to nearly all the principal governments in the world. This gun was followed by the Nordenfelt and the Gardner.

All four of these machine guns depend upon hand power for performing the various operations of loading, firing, and extracting the empty shells. Three of them are worked by a crank, while the Nordenfelt gun is worked by means of a lever, like an ordinary pump. As considerable force is required for working either the crank or the lever, the gun has to be mounted on a very firm stand or base, in order that it may not be rendered unsteady by the motion given to the handle. This necessity precludes the possibility of turning these guns with any degree of freedom ; excepting the Hotchkiss gun, which is essentially a slow-firing gun, firing only about forty shots per minute, and is the only one that can be moved freely while firing.

These guns are each provided with a magazine of ammunition. The Hotchkiss magazine holds about a dozen cartridges ; and the quick-firing Gattling, the Nordenfelt, and the Gardner, have each a magazine holding about a hundred. The magazine is placed on the top of the gun, and with any great rapidity of firing, has of course to be replenished very often ; for which purpose two men, at least, are required, who are compelled to expose themselves above the gun, both the magazine and the men presenting a target to the enemy's fire.

The workmanship of all four of these guns is exquisite. Their weak point does not lie here, but arises from another cause which would be very difficult to remedy in them. It is said by some military men that no machine gun has ever been brought into action which has not become "jammed" at the critical moment. Even if that be not strictly true, still the liability to accident from this cause is very great. A certain percentage of all cartridges fail to explode promptly at the instant of being struck ; to use the technical expression, they "hang fire." Suppose that, while the handle of the gun is being worked at its highest speed, one of these sluggish cartridges happens to enter the barrel. It is struck ; and instantly, before it explodes, the breech is opened, and the cartridge begins to be withdrawn again out of the barrel. At this instant the explosion takes place, breaks the shell in two, drives the front half forward into the barrel, and blows the rear half out of the breech, and sometimes blows up the magazine. At any rate, it always drives the forward end of the cartridge firmly into the chamber of the barrel ; and if the magazine does not explode, the next rotation of the crank drives a loaded cartridge into this chamber ; the gun then becomes blocked or jammed, and is of no further use.

Maxim Automatic Gun.—It is many years since the writer conceived the idea of making a gun in which the recoil should be utilised for loading and firing ; but it was not until 1883 that he had any time to devote to this problem. Before commencing experiments he considered carefully the different methods which might be employed for working an automatic gun by means of power derived from the burning powder. In those which he afterwards experimented upon, the power required was derived in the six following ways : (1) Power derived from the gases escaping from the muzzle of the gun, either by utilizing their pressure directly, or by employing them as an ejector to produce a vacuum in a chamber near the muzzle of the gun ; (2) power derived from the recoil of the entire gun ; (3) power derived from the recoil of the barrel, the breech-block, and the lock ; (4) power derived from a backward motion of the cartridge in the chamber at the instant of exploding ; (5) power derived from only a portion of the cartridge moving backwards ; (6) power derived from the elongation of the cartridge at the instant of exploding.

Experimental Apparatus.—The apparatus is now exhibited that was used for conducting experiments on a gun in which the power was derived according to the third of the methods—namely, from the recoil of the barrel, the breech-block, and the lock As the writer was the first to make a gun of this kind, he had no data whatever to go upon, and had therefore to contrive some kind of device for ascertaining both the quantity and the character of the power to be dealt with. This apparatus consists of two parallel steel bars, clamped into supports, and having the barrel and the breech-block mounted between them. The whole is so constructed that all of the parts are adjustable. The distance through which the barrel recoils before the breech-block becomes detached from it, is adjustable ; the further distance that the barrel travels backwards, after it becomes detached from the block, is also adjustable ; the travel given to the striker is adjustable ; the angle at which the crank stands at the instant of explosion is adjustable ; the amount of weight in the rotating parts and their distance from the centre of rotation are also adjustable.

This experimental apparatus was made as far as possible of soft steel and brass, in order that the action of the gunpowder might be observed upon the various parts. If any part showed signs of yielding under the strain, it was obvious that this part required strengthening in the gun ultimately to be made. The apparatus has already fired about a thousand cartridges, and at the present time is still in condition to be fired. With one hand on the muzzle the barrel can be pushed back with sufficient force to perform the whole cycle of operations for firing, the push of the hand taking the place of the recoil of the barrel. In this way it has been found that a pressure of about 60 lb. travelling through a distance of ⅞ in. is the power required for working the gun, which is very much less than the actual power derived from the recoil, as determined approximately by the writer in experiments with a Winchester rifle of the "express" pattern.

First Gun.—Having in this way determined the character and quantity of the power to be dealt with, and having ascertained the time required for the gas to escape from the barrel, as well as the strength required for the several parts, and the distance through which they had to travel, the writer proceeded to make his first gun, the construction of which is shown in the accompanying engravings.

The barrel A, Figs. 1 and 2, is encased throughout the greater portion of its length within a water jacket, which projects from the front end of the casing that incloses the machinery. Its backward motion, produced by the recoil of a shot just fired, is, at first opposed by a pair of flat springs, one at each side, which have to be forced apart by toggle struts T T recessed into the sides of the barrel, as shown in the plan, Fig. 1, and in Figs. 9 to 11. As soon as these struts have passed the centre, the springs close together again, and thereby aid the further backward travel of the barrel. During the first half of the ⅞ in. backward travel of the barrel it carries the breech-block B with it at the same speed, the two being secured fast together by the locking catch C, Fig. 2, which is held firmly down under the crossbar D. But when the barrel has moved backwards through 7-16th in. the catch is free from under the crossbar, and is lifted by a projection on its front end coming in contact with the face of the crossbar, thereby releasing the breech-block from the barrel. At the same instant a straight lever L centred upon the barrel (Figs. 1, 9, 10, and 11) encounters with one of its arms a stop S fixed in the casing, while its other arm bears against the toe of a sliding rod R, the rear end of which bears against the breech-block. Both the stop S and the toe of the rod R are made with long bearing faces slightly curved, as shown in Figs. 9 to 11 ; and as the slightly curved arms of the lever L roll over them, the respective leverages change very rapidly in relation to each other, and becomes inverted with the result of imparting a rapidly accelerated motion to the breech-block Consequently while the barrel travels through the remaining 7-16th in. of its backward motion, the breech block is driven backwards with sufficient force to carry the crank K over the back centre (Figs. 1 and 2) ; the radius of the crank is 3 in. and the connecting-rod G, from the breech-block, is 6 in. long, The action of the lever L in accelerating the breech-block has also the converse effect of simultaneously retarding the backward travel of the barrel ; and all the backward motions cease at the instant of the crank passing the back centre. With freshly loaded cartridges the momentum given to the crank and its attachments is found sufficient to drive the breech-block forwards again into its firing position and to fire the next shot.

But with old and weaker cartridges the gun is found to work with greater certainty if a strong helical spring P is used (Fig. 1) to assist in drawing the breech-block forwards again into its firing position after the crank has passed the back centre. Consequently all guns made after the very first experimental gun are now provided with this spring.

Immediately upon the breech-block quitting the barrel, the tail of the extractor E (Fig. 2), which is a forked lever centred upon the barrel, comes against a stop fixed in its path; and the forked end of the lever, which takes hold of the cartridge rim or flange at each side, withdraws the empty cartridge shell about ¼ in. out of the barrel. Its extraction is then completed by a hook I attached to the same crosshead as the breech-block. The hook runs underneath a pair of long fixed springs F, by which it is pressed down upon the cartridge so as to keep a secure hold while extracting it; but at each end the springs are curved slightly upwards, in order to reduce the pressure upon the hook in its foremost position, where it has to lift for catching hold of the cartridge flange, as well as in its hindmost position, where it has to be lifted again by the fixed crossbar J (Fig. 1) for releasing its hold of the cartridge. In this way the empty cartridge is drawn back into one of the grooves or pockets in the rim of the magazine of feeding cylinder M which is mounted upon an axis immediately beneath and parallel with the line of travel of the breech-block.

The magazine M (Figs. 4 to 7) is rotated intermittently by an arrangement of spiral ratchet-wheel and pawl, which is somewhat similar to the arrangement commonly employed in rock-drills for rotating the drill automatically between each blow; the motion of the breech-block in the last part of its backward travel, when the empty cartridge is entirely drawn out of the barrel, rotates the cylinder M through half the pitch or distance to the next groove or pocket, which has already been charged with a fresh cartridge; and the first of the forward travel rotates it through the remaining half, bringing the fresh cartridge into the exact line of the barrel before the front end of the cartrid e has reached the rear end of the barrel. The grooves or pockets in the magazine are charged, one at a time, in each backstroke, from a belt of cartridges that passes over a flanged wheel W (Figs. 1 and 7), which is situated in front of the magazine M, and is geared to it. The flanged wheel W has recesses in each flange for the ends of the cartridges to lie in. A hook or extractor H carried on the crosshead of the breech-block, catches a cartridge in the bacwkard travel of the breech-block, and draws it out of the belt into one of the pockets on the underside of the magazine M, where it remains while carried upwards step by step to the barrel by the intermittent rotation of the magazine. The empty belt passes out through an opening in the left-hand side of the gun casing; and through another opening on the same side the empty cartridges drop out, one by one, from the pockets of the magazine as it rotates. During the backward travel of the breech-block a hinged cover plate N (Figs. 1 and 4) is thrown across laterally over the magazine by the pressure of a coiled spring, in order to prevent any risk of the cartridge being jerked upwards out of the magazine.

As the crank approaches the back centre, towards the end of the backward travel of the breech-block the tail of the cocking lever O, Fig. 2, which is pivoted upon the crosshead, comes against a fixed stud; in the remainder of the backward travel the cocking lever then compresses the main spring, which is a helical spring coiled round the striking pin; and a suitable catch or sear Q, also hinged upon the crosshead, finally catches the nose of the cocking lever, and holds the striker cocked in readiness for firing the next shot.

The second half of the cycle of operations comprises those which are effected by the forward travel of the breech-block with its connections; and consists in pushing the fresh cartridge home into the barrel, locking the breech-piece, and releasing the sear Q for firing the shot. As soon as the crank has passed the back centre, it begins to push the breech-block forwards, with the fresh cartridge in front of it; and through the lever L centred upon the barrel, Fig. 1, the quick travel of the breech-block imparts a slow forward travel to the barrel, sufficient to carry it forwards until the toggle struts T T pass the centre, and the flat side springs are then in a position to urge it forwards to the end of its travel with the breech-block lock fast against it. In this final travel of 7-16th in. under the action of the side springs, the sear Q coming into contact with a cam U releases the striker, which fires the cartridge. The cam is connected with an ordinary cataract or hydraulic buffer V, of which the by-pass is throttled by an adjustable plug, Fig. 13; a hand-lever on the plug regulates the rate of firing so as to deliver any number of shots from two or three per minute up to as many as 600 under favourable conditions. The handle on the cataract plug serves as a trigger for firing the gun by hand; for if the by-pass be opened while the gun is loaded, the explosion follows instantly; and if it be entirely closed, the gun though loaded cannot be fired at all.

The crankshaft K is fitted with a handle Z outside the casing and opposite to the crank, Fig. 1, by which the gun is worked by hand at starting, until the first shot has been fired; the recoil then comes into action for continuing the firing automatically.

The gun is 4 ft. 9 in. long all over, from the muzzle to the rear of the casing that contains the firing mechanism. It stands about 3 ft. high upon its tripod. The belt supplying the cartridges is made of two lengths of canvas, rivetted together at regular intervals with brass eyelets and strips, so as to form a succession of loops, into each of which a cartridge is inserted by hand. When any belt is running out, a fresh one is hooked on to its tail end, without causing any delay to the continuous firing of the gun. By means of a simple appliance attached to the muzzle of the gun, the smoke can be deflected in any direction desired, sideways or upwards, so as to give the gunner at all times a clear view of his aim. A gun of rifle calibre can also be made practically noiseless. The simple water jacket encasing the barrel of the gun is found to answer very well for preventing excessive heating of the barrel, as the amount of heat required to evaporate water is so very great.

Working of Gun.—The gun is mounted upon a tripod, which is a very convenient stand for exhibiting its working. The tripod of course is not a necessary part of the gun, the mounting of which depends altogether upon whether it is wanted in the field or on shipboard. The crank handle projecting at the rear from the right-hand side of the gun, is necessary in order to work the crank for bringing the first cartridge into the barrel of the gun; also for removing from the barrel any cartridge which may have failed to explode. The cartridges for supplying the gun are placed in a box beneath, which may be made large enough to contain almost any number. In a light field carriage about 2,000 would be a fair supply; the box here shown holds 333, or one-sixth of that supply.

In turning the crank handle forwards and backwards the feeding wheel or magazine is moved forwards one tooth at each turn; so that when the end of a belt of cartridges is introduced into the feed chamber, one cartridge is drawn in at each turn of the crank handle. Seven turns will draw seven cartridges out of the belt, and there will then be six cartridges in the magazine of the gun, and one in the barrel. On pulling the trigger, the cartridge in the barrel will explode, and its empty shell will be expelled from the breech of the barrel, which will instantly receive a fresh cartridge from the magazine; and the magazine in its turn will be supplied with another cartridge from the belt of cartridges.

When a cartridge enters the barrel, and the breech block presses it firmly home, the block closes the breech of the barrel securely, the two being firmly locked together during the explosion of the cartridge; and the breech cannot be opened again until the barrel, together with all its attachments, which participate with it in the recoil, has moved backwards through 7-16th in., being half of its total travel of 7-8th in. By the time they have moved back through this distance, 7-8th in., the shot is already some distance out of the barrel, and the pressure of the gases is so far reduced that it is quite safe, to open the breech. As the barrel recoils further, it becomes detached from the other moving parts; and while it is stopping, the breech-block with its attachments is sent rapidly backwards to a still greater distance. This further backward movement removes the empty shell from the barrel and cocks the hammer; and then the return or forward travel of the breech-block pushes a fresh cartridge into the barrel, closes the breech, and pulls the trigger.

Seven cartridges have been drawn from the belt into the magazine of the gun, there are now six of them in the magazine, and one in the barrel. The regulating lever of the trigger has been set forwards into such a position as will cause the gun to fire very slow.

In this slow firing the whole of the various operations take place very rapidly, with the single exception of finally pulling the trigger for firing the shot. The speed of firing or rapidity of pulling the trigger is regulated by a piston working in the controlling cylinder or cataract, which has an adjustable by-pass from one end to the other (Fig. 3); the area of this pas-

THE MAXIM MACHINE GUN.

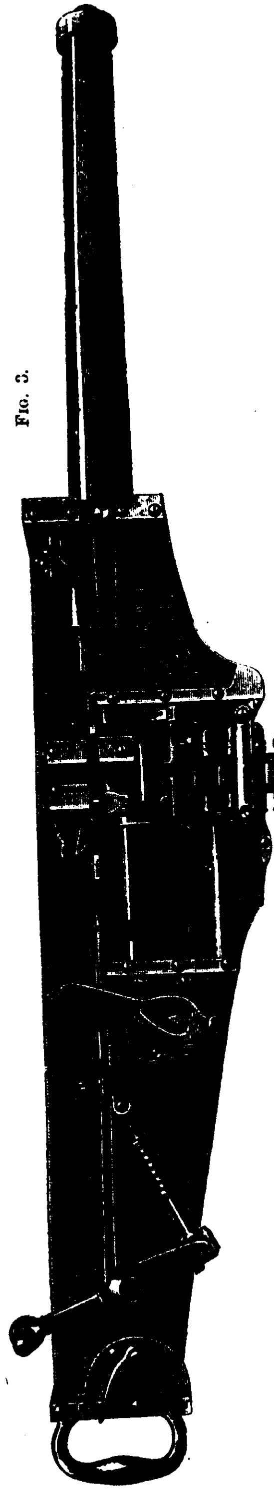


Fig. 3.

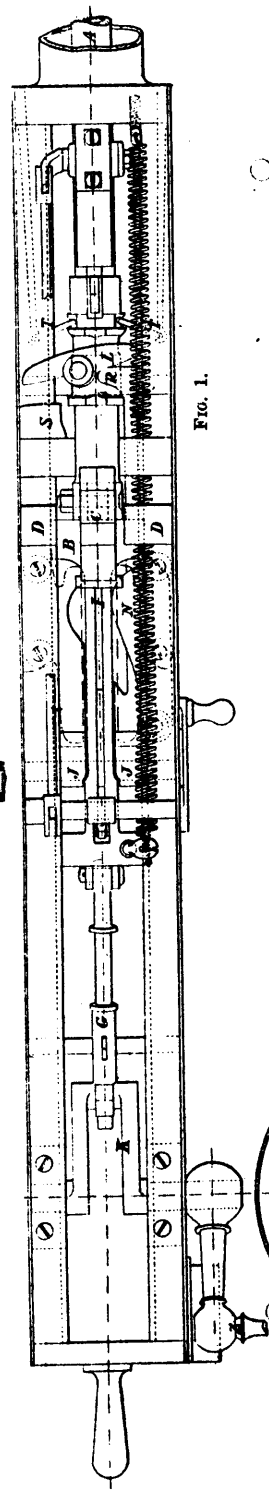


Fig. 1.

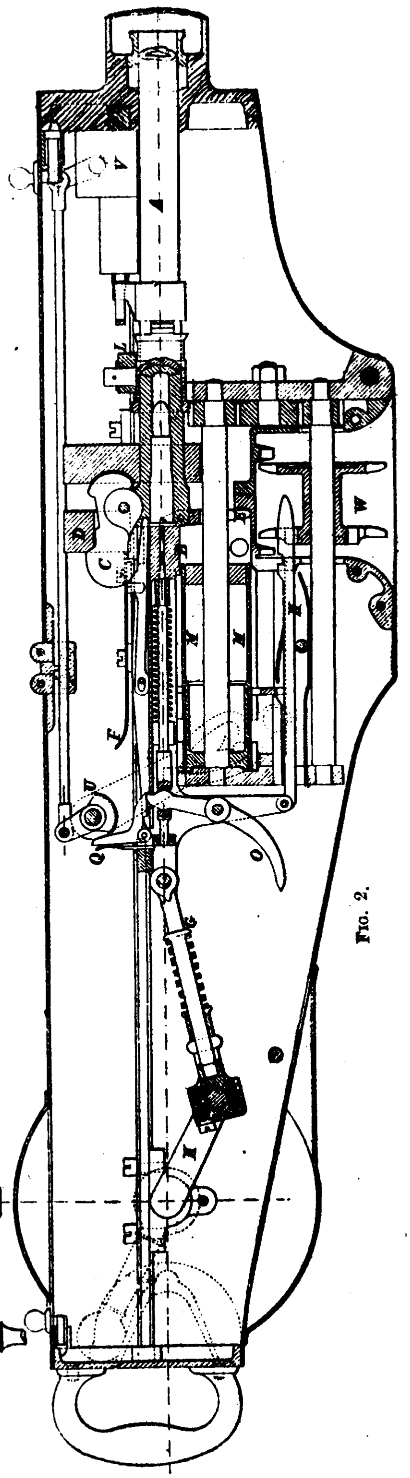
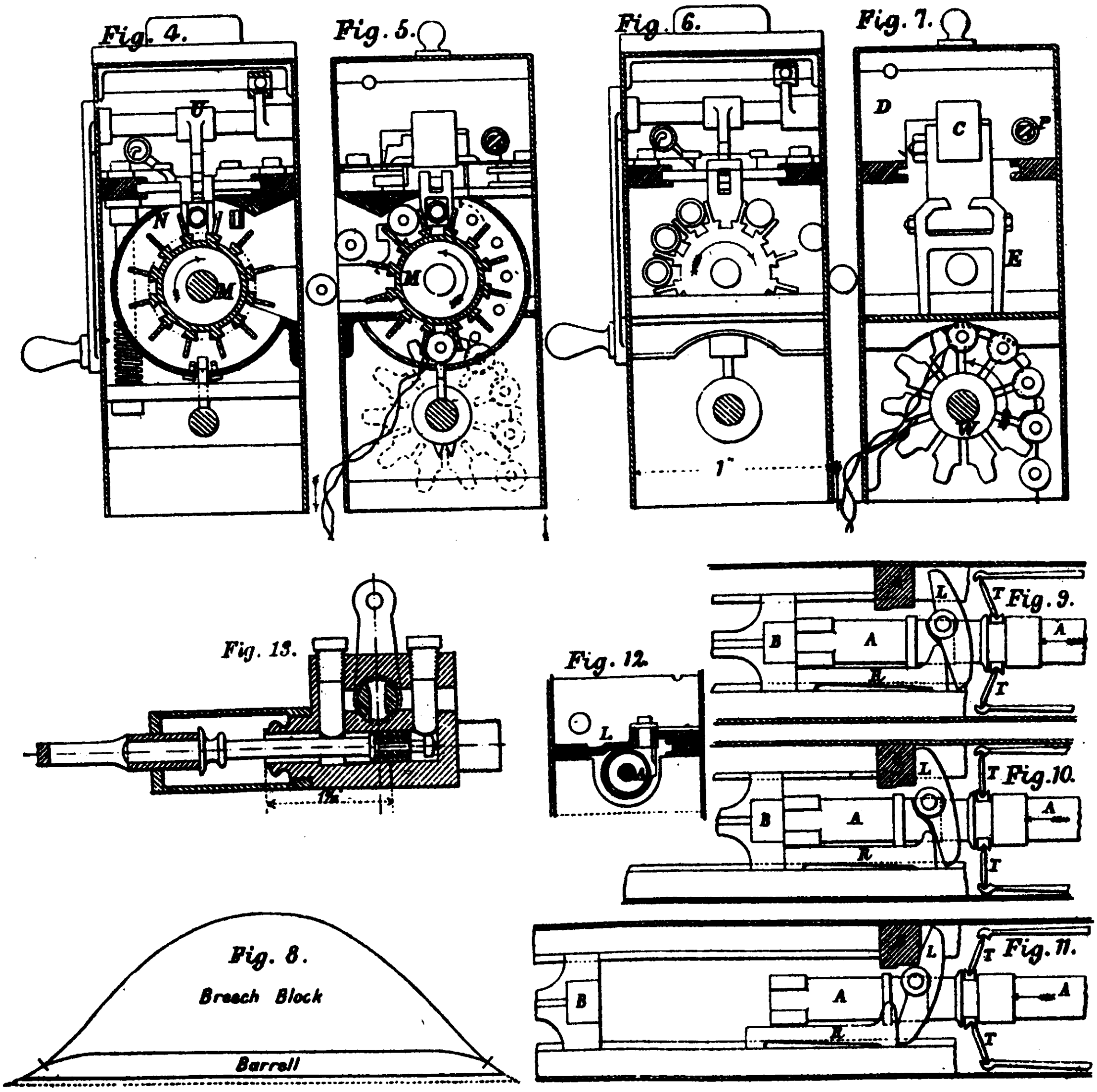


Fig. 2.



THE MAXIM MACHINE GUN.

sage way is regulated by a cock, and the cock is attached to the trigger lever. When the seven cartridges were fired very slowly, it was because the trigger lever was pulled back only far enough to open the cock very slightly. If the lever be pulled further back, the speed of firing will be greater; while if it be pulled completely back against its stop, the whole seven cartridges will be fired in less than one second of time.

When the barrel with its attachments has recoiled through half its travel, and has thus reached the point at which the breech-block becomes detached from it, the remaining half of its travel has then to be occupied in bringing the barrel itself to rest, while at the same time withdrawing the breech-block rapidly from it through a much longer range of backward travel. This is accomplished by the single lever L, Fig. 1, so contrived as to afford a great range of variation in its effective leverage. The breech-block is then by driven rapidly backwards at the expense of stopping the barrel completely. Upon the return or forward movement of the block, the impact which would be expected from its closing against the end of the barrel is prevented by this same lever arrangement, whereby the barrel is caused to be already moving forward in the same direction as the block before they come in contact, thus preventing any destructive hammering between them.

In Fig. 8 is shown a diagram of the relative movements of the barrel and of the breech-block, set out upon a base-line which represents the length of the circular path described by the crank. The lower area shows the short travel of the barrel; and the upper area shows where the breech-block parts company with the barrel, and how it then continues its much longer travel while the barrel is stationary, and how it afterwards overtakes and rejoins the barrel in the return or forward travel. Below the actual base-line is added also a dotted line, for indicating what would have been the virtual base-line, had the crank been arranged to make a complete revolution, instead of which it is a fundamental feature of this gun that the cranks stops short on each side of its front centre, and rotates forwards and backwards alternately through somewhat less than a whole circle.

On introducing a belt of cartridges into the gun, and turning the crank handle, the cartridges are drawn in one by one, until the magazine is full, that is, until it is filled round half its circumference up to the barrel, and empty round the other half; and the empty part of the belt hangs out from the opposite side of the gun. On pulling the trigger by hand, the first one of these cartridges is fired; and the gun will then supply itself from the belt and continue firing automatically as long as there are any cartridges in the belt. The firing can be stopped after only a single cartridge has been fired, or after two, three, or any other number up to a whole volley has been fired, and the gun can be made to fire either slow or with great rapidity. It is the first shot alone that requires to be fired by hand, after which the firing goes on automatically until stopped.

Hang Fire.—Suppose that any of the cartridges supplied to the gun should hang fire. At the instant of the cartridge being struck the breech is closed, and there is no power to open it automatically except the power locked up in the cartridge itself. This power does not develop itself until the cartridge itself explodes; consequently the breech does not open until after it has exploded, and the cartridge cannot be withdrawn in the act of exploding, as it can in other guns. Thus the serious trouble occurring with all other machine guns in cases of hang fire cannot here occur, being rendered impossible by the very principle upon which the gun is constructed.

The case of a cartridge entering the barrel and failing to go off at all may be exemplified by placing in the magazine of the gun two good cartridges, then a bad one, and then two good ones. As soon as the first cartridge is in the barrel and has been fired by pulling the trigger by hand, the gun will fire the second cartridge automatically, and will attempt to fire the third or bad cartridge, but will fail. The bad cartridge has then to be removed from the barrel by working the crank handle by hand; the fourth cartridge has, like the first, to be fired by hand; after which the gun will fire the fifth automatically. The whole operation of passing the bad cartridge will occupy about half a second.

Hence, if a cartridge hangs fire, the gun waits for it; if it fails to go off at all, it must be removed by hand, which is done in about half a second.

Adjustment.—As the gun requires no external power for working it, being wholly self-contained, it may of course be turned freely in any direction while firing. For target practice, and for accurate shooting at long range, it is convenient to train it with screws, as in the case of other machine guns; and suitable adjusting screws are accordingly provided.

ENGLISH CENTRIFUGAL PUMPS.

So long as English and American mechanical methods vary so materially, it is interesting and instructive to compare the practice of the two countries, as it may bear upon any particular machine; and the centrifugal pump, so highly developed and esteemed by our "kin across the seas," is probably one of the best type to study. To an English engineer (the late John G. Appold) we are indebted for the centrifugal pump. After spending a fortune in perfecting it, he gave the world the benefit of the labors of the best years of his life. From a crude water fan, returning only 12 per cent. of effective work for power expended, he developed a machine capable, under certain conditions, of increasing this result to more than 75 per cent, of effective work. Since Appold's death in 1865, some of the ablest engineers have given their attention to this type of pump, and the same scientific study bestowed with us on the direct acting or duplex pump has in England been devoted to the centrifugal.

These pumps are beautiful in design, and are models of strength and simplicity.

The bearings are long, and fitted with gun-metal boxes with self-oiling arrangements, balanced pistons, with spindles of steel large and perfectly true, and the details of construction generally such as we put on a high-speed steam engine. The curvatures of shell or piston, and the shape and size of water passages, are carefully studied and varied to suit the work to be done, all being based upon scientific research and practical experience. The means of priming used by English builders are neat and effective; some have the steam jet, others employ a little air exhauster driven from pump-shaft, and contained within pump. Foot valves are rarely used, but a flap valve on delivery pipe is preferred, whenever possible. The result of all this care and experience is a machine which for certain duties is unsurpassed, and is available for many uses for which we now think the steam pump necessary. In efficiency and economy nothing can compare with the centrifugal where large amounts of water are to be raised to a slight height and in a short period of time—the more so as dirty or gritty liquids are equally well handled.

Single pumps capable of raising eighteen to twenty-five thousand gallons per minute, from five to ten feet, are frequently built. These giants among pumps stand from eight to twelve feet high and have discharge outlets of from thirty to forty inches diameter. The present English practice, however, favors a number of smaller pumps arranged to be driven together, rather than one very large machine. The usual pump is that driven by a belt, but numerous styles are built, in which one or more pumps are driven directly by high-speed engines attached to the spindle of the piston; this design is largely used for circulating and belge pumps for steamships, as well as for drainage and wrecking pumps. As bilge and circulating pumps for surface condensers, the English centrifugals are firmly established in favor, and will be found on most of the new Atlantic fast ships, as well as on many others built by the great shipbuilding firms on the Clyde.

Compared with the best English makers, American centrifugals will be found wanting in all points in design, construction, and workmanship; and in variety of style and arrangements for various uses we are far behind the English practice. The field in America for the centrifutal type of pump is broad, and as yet hardly occupied, and we wait the builder who will intelligently study and carefully construct centrifugals which shall embody the best that English experience has established, with the addition of American ideas and adaptability.—*J. H. Howell, Engr's Club, Phila.*

A forge hammer hes been invented in England which is driven by gas instead of steam.

Not 10 years have elapsed since the first paper mill was started in Japan, with the latest appliances of European and American machinery, and now we are told that there are a dozen mills in operation in that country, several of them making good dividends. It may be put down to the credit of Japan that she was a few hundred years in advance of the United States in making paper from wood fibre.

FOSSIL ELEPHANTS IN CALIFORNIA.

That both mastodons and mammoths once existed in California there is no doubt, since several finds of their bones in a fossilized condition have been made. No complete skeleton has been exhumed which could be set up in a museum for exhibition, owing to the fact that in most cases the bones have been more or less scattered, portions have been missing, or else what have been found soon crumbled when exposed to atmospheric influences. A deposit of bones of a mammoth has lately been opened in Yolo county, and the remains have been carefully removed and brought to San Francisco, where they have been placed in the museum of the California Academy of Sciences. Mr. C. D. Gibbes, by authority of the Academy, and in its behalf, visited the deposit last week.

The situation is in the Sacramento Valley, about 12 miles from the foothills of the Coast range, 60 miles from San Francisco in an air line, and six or seven miles from Dixon, Yolo county. It is on the ranch of Hecht Bros., and opposite that of Montgomery S. Currey. The bone deposit is on the dry bed of the creek on the north side of a shallow stream about 40 or 50 feet wide, flowing through the centre of the creek bed, which is about 150 to 200 feet wide.

In his report to the Academy, Mr. Gibbes states that Mr. Hecht discovered the bones two years since on a point of land in the bend of the creek that had been carried away in the great flood three years since, sweeping off two or three acres to a depth of 20 feet. Some of the large bones Mr. Geo. W. Pierce had taken out and given away to Mr. J. B. Hollingsworth, of Woodland. Mr. Gibbes reports that the bones are not in the bluff bank but are resting on a blue clay or mud, under a yellow clay, 30 feet from the present stream, which was once the margin of the north bank, and are 70 feet from the bluff on the present left, or north bank of the creek. The bones are about three feet above the level of the stream, and the bluff bank 20 or more feet above the bones. This being the deepest part of the bend makes it 100 feet of earth, over 20 feet in depth, that was cut off and carried away by the flood.

Fifteen or sixteen feet in depth from the surface the soil is a sandy loam, then a yellow clay seven or eight feet thick, resting on a blue mud or clay. Most of the yellow clay was carried off by the flood, leaving about 12 or 15 inches above the bones, but cut in small channels or grooves by the water, and in one of these channels the bones were exposed. There was a grove of large oaks on the surface above the bones before the high water referred to, and the north bank is still lined with large oaks above and below.

The yellow clay is intersected by a complete network of hard seams of a white calcareous deposit, and in some places a solid mass 10 or 15 feet in diameter, resembling a honeycomb, as if a pool of water had evaporated, leaving these specimens. At the first view over the ground it had the appearance of numerous bleached ribs, and other bones imbedded in the clay, and these seams made it difficult in excavating to distinguish between the bones and this calcareous deposit.

The impressions of the large bones taken out by Mr. Pierce still remained on the blue clay, and Mr. Gibbes commenced work at the upper end of the humerus, near the shoulder, as it was desired to obtain the jaw, or at least a tooth. The work proceeded slowly, as they had to dig with a knife carefully all around each bone to loosen it from the tenacious mud and clay in which it was imbedded; yet even with the greatest care, many of the bones broke. Several fragments of ribs and other bones were uncovered, some imbedded under and across others. It became evident, from the result of digging, that the head had been above the level of the other bones, and had been washed away in the upper portion of the clay bank. It may yet be found further down stream. As far as can be judged, Mr. Gibbes thinks the animal must have been lying on its right side, with its head up stream. The elevation above sea level is between 45 and 50 feet. One of the bones found by Mr. Pierce is a humerus 2 2 feet in length, and the other a femur, 3.2 feet long. No teeth were found, so it could not be stated whether the bones were those of a mastodon or a mammoth. Mr. Gibbes is inclined to think it was a mastodon. A large number of the bones are now at the Academy museum. While on his way back to this city, he stopped at Martinez, as requested by Prof. Davidson, President of the Academy, to examine certain large teeth which had been found there. What had been supposed to be three large teeth of a mastodon, found by Mr. Martin Woolbert, proved to be a portion of the tooth of a mammoth, split in three pieces, and not whole teeth. Mr. Gibbes also examined th tooth found by a son of Mr. Jones, which is in a better state of preservation. Both were found near each other on the beach below high tide, near Mr. Woolbert's, a mile east of Martinez. Mr. Gibbes visited the spot, and though the tide was partly up, they dug under the sand and found yellow clay on blue mud. One of the teeth, supposed by Mr. Gibbes to be that of the Elephas Americanus, has been presented to the Academy.—*Ex.*

HYDRAULIC DREDGER.

The following are the general dimensions of the vessel:

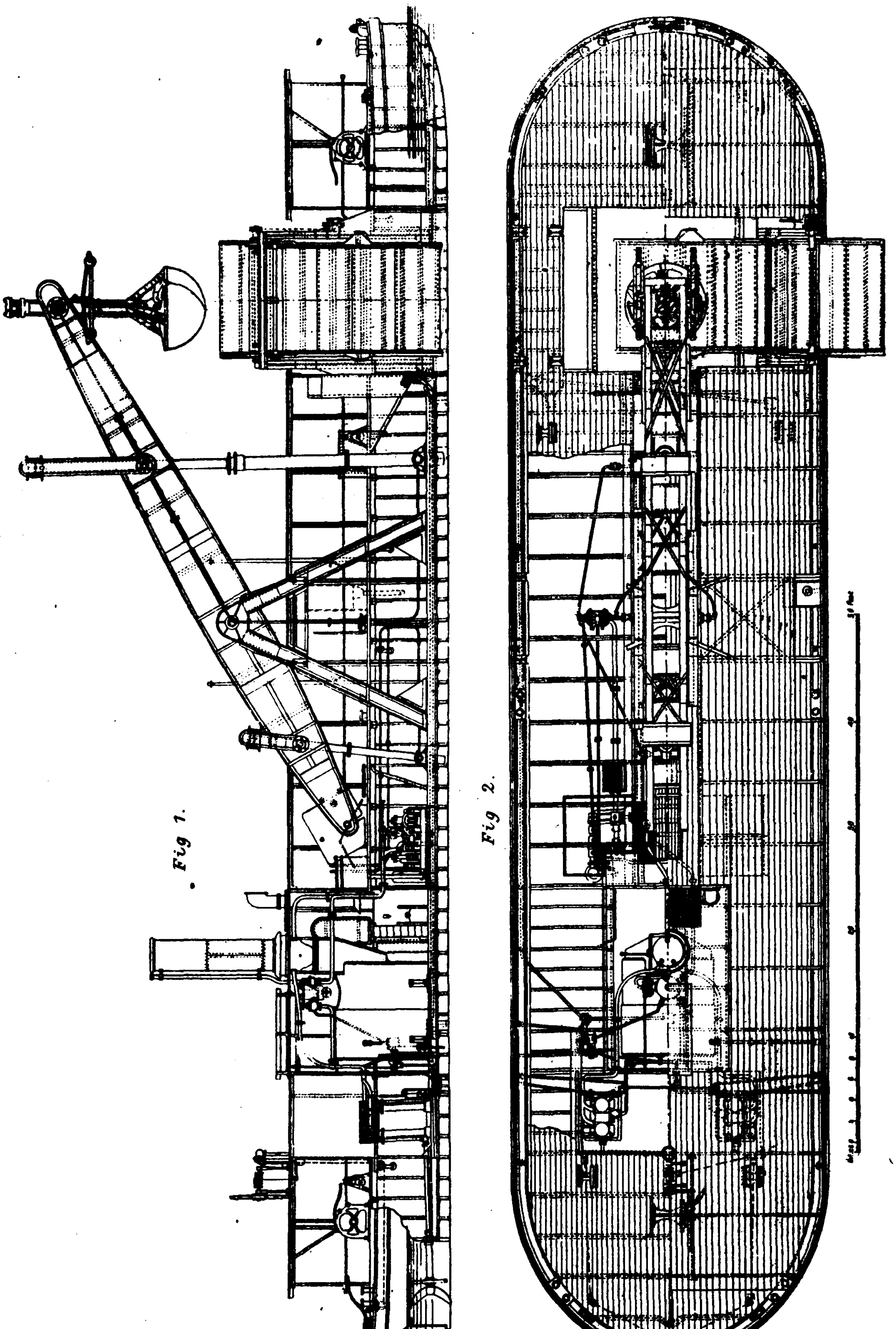
	ft.
Length between perpendiculars	126
Breadth of beam	30
Depth moulded	7
Draught of water (mean)	3

It has one excavator working through a well, with shoots so arranged as to discharge over either side as required. It will work to a depth of 15 ft., and will raise 250 tons an hour. The excavator is of the "grab" type, and is mounted at the end of a rocking beam, by which it is alternately depressed to take up a load of spoil, and raised to deliver it on to the shoots, which carry it into the hopper alongside. The beam is worked by two hydraulic cylinders, and the excavator itself is also opened and closed by two rams doubled together by side rods, so that they move in unison. The lower and larger ram is connected by rods to the three segmental scoops, and serves to draw them together, a pressure of 30 tons being available for the purpose. The smaller ram opens the excavator when it is raised. All the rams are controlled by slide valves placed admidships, so that one man can regulate the whole of the motions without leaving his station. The hull is of iron, and the well through which the excavator passes measures 17 ft. by 14 ft. at the end, and is 5 ft. wide for the remainder of its length to allow the beam, on which the excavator is mounted, to dip. The hull is clinker built, the frames being of angle iron $3\frac{3}{4}$ in. by $\frac{3}{8}$ in., spaced 2 ft. apart. The floor-plates are 12 in. deep and $\frac{5}{16}$ in. thick and the deck beams 8 in. by $\frac{3}{8}$ in., with angle-irons $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{3}{8}$ in., spaced every alternate frame in the main portion of the vessel, and 4 in. by $2\frac{1}{2}$ in. by $\frac{3}{8}$ in. at the well sides. A stringer plate 18 in. wide by $\frac{3}{8}$ in thick is carried all round the vessel, the plates being double rivetted and placed on the top of the beams and gunwale iron. The keelsons are of open box section, formed with angle-irons 3 in. by 3 in., and with plates 12 in. deep by $\frac{3}{8}$ in. thick. A teak fender extends all round the vessel above the water line; it is 7 in. thick by 14 in. deep, and is attached to angle-irons 3 in. by 3 in. by $\frac{3}{8}$ in. deep, placed at each side of it. There are six cast iron mooring bitts bolted to the deck beams, and at the bow and stern there are knight-heads of oak, fitted with cast-iron hawse-pipes for the mooring chain and with fair leaders. All the iron in the hull and framing is of best Staffordshire quality, and the bolts and rivets of S. C. crown, or Staffordshire L.W.R.O.

The propelling engines for the twin screws have cylinders $13\frac{1}{4}$ in. in diameter by 15 in. stroke. The boiler is of steel 8 ft. 6 in. in diameter by 9 ft. 6 in long, and works up to 80 lb. per square inch. The pumping engines are of the direct-acting differential type with cylinders 17 in. in diameter by 24 in. stroke, the pumps being $3\frac{3}{4}$ in. in diameter. They are capable of supplying 38 cubic feet of water per minute and of maintaining a constant pressure of 1000 lb. per square inch. The rams for raising and lowering the beam are placed as shown in Fig. 1, and oscillate in bearings firmly bolted to a wrought-iron framing fixed to the floor-plates and to the main keelsons. The lifting ram has a diameter of 10 ft. 8 in. The lowering ram is 6 in. in diameter and 13 ft. 9 in. stroke. The excavator is 8 ft. in diameter, and the blades are three in number. They are made of steel and are worked by two hydraulic presses suspended by a universal joint to the beam. This latter is of $\frac{3}{8}$ in. plate, and carries a 15 ton balanceweight of cast iron at the after end. It is mounted on A frames of wrought iron.

Both the vessel and machinery were shipped in pieces, and have now been erected at their destination. A model, differing but little from the dredger shown in our illustration, is to be seen at the Inventions Exhibition.

HYDRAULIC DREDGER FOR BURMAH (BRUCE AND BATHO'S SYSTEM.)



HYDRAULIC DREDGER.

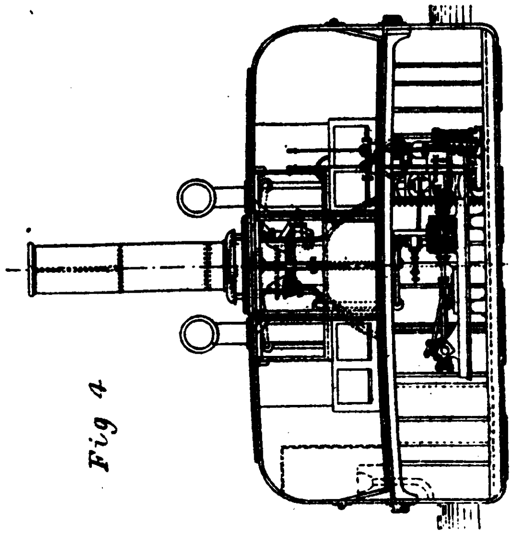


Fig 4

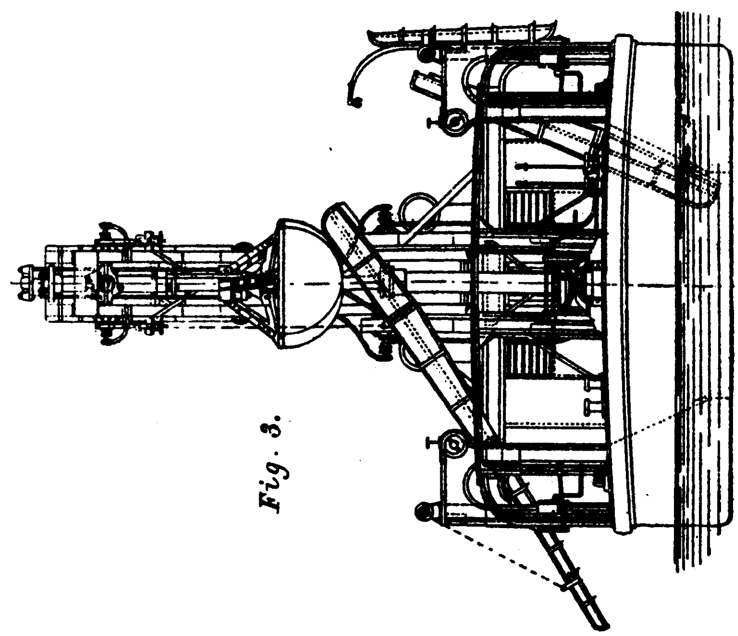


Fig. 3.

THE STATION "B" CHIMNEY OF THE NEW YORK STEAM COMPANY.

In response to a recent request by the Secretary of the American Society of Civil Engineers, several interesting papers on chimney construction have been contributed, among them one by Mr. Chas. E. Emery, giving details of the chimney constructed under his direction at Station B of the New York Steam Co. From this paper we extract the following :—

The chimney may be called a "creature of circumstances," from the fact that it was necessary to erect boilers of 16,000 horse-power on an irregularly-shaped plot 75 feet in width, and on the average less than 120 feet deep, and the chimneys were necessarily shaped to suit the space available. To obtain proper floor-room the boilers were arranged in four tiers, each tier in a separate story 20 feet high, besides which the plans provide for a fifth story for coal storage and a basement for miscellaneous uses. Each floor is arranged for 15 boilers of 250 horse-power each, which are placed in two rows to face a central fireroom. There are two chimneys, one located between the boilers on each side of the fireroom as near the center of the building as the shape of the plot permitted. Fig. 1 is a plan view of one story of the building, and includes a horizontal section at a lower elevation through the vault under the sidewalk on Greenwich street ; A A are the chimneys ; B B the elevators ; Y Y vertical steam drums ; D D steam pipes to street ; E E bases of columns of the elevated railroad in street ; F F is the fireroom, and G a circular staircase. The location of boilers are numbered from 1 to 16. At the left are shown the floor beams in position, and on the right the side walls and steam drums C C of some of the boilers are represented. Fig. 2 shows on the right a vertical transverse section of the building, with a boiler in position on one floor, and at the left a transverse vertical section of one chimney. Fig. 3 shows a longitudinal section of the same chimney.

The whole capacity of the building not being needed at first, the walls were only carried up to an elevation of 88 ft. 8 in. and a temporary roof applied, so that an present there are available only three stories for boilers and one above for coal storage. The south chimney has been practically completed. The north one is extended through the temporary roof and covered, but it is connected with the other by a sheet-iron casing at the level of the openings O O. There are now in place 35 boilers, aggregating 8750 horse-power. The coal is brought from the dock in carts and wagons, and dumped from the rear street into small cars in the basement of the rear buildings. These cars are run back to the elevators, lifted to the top of the main building, run out on tracks over coal bins and dumped, the coal descending by gravity through shutes in front of each alternate column, and flowing out as needed on the several fireroom floors, close alongside the fronts of the boilers. The ashes pass from the ash-pans down shutes in front of intermediate columns to cars in the basement. These cars are hoisted on the elevator to the roof of the rear building, run out on tracks to the front of the building, and the ashes dumped into a shute, from which they are loaded into cars on the street below. The boilers are of the sectional type, manufactured by the Babcock & Wilcox Company.

From lack of room, a well-established rule was necessarily disregarded, and the lower portions of the chimneys, instead of being independent, were made part of the building, the section of each being rectangular and corresponding closely to the floor space occupied by one of the boilers. Within the building the outside of the chimney walls are vertical, the offsets, due to reducing the thickness of walls upward, being inside the flue. Above the roof the inside of flue is parallel, and the walls are decreased on the outside, each offset being marked by a belt of granite blocks forming a water table. The lining extends only to the roof line, and is put in sections, supported on the internal offsets. The lower part of each chimney, above the footings, is 32 feet long outside and 13 feet wide. The flue at the top is 27 feet 10 inches long and 8 feet 4 inches wide. The south chimney is topped out at a height of 220 feet above high water, or 221 feet above its foundation. The top of chimney is therefore 201 feet above the grates of the lower tier of boilers, but only 141 feet above the grates of the upper tier of boilers.

The foundations of the walls of the building are at the elevation of mean highwater, and the chimney and column foundations 1 foot below. The foundations are of concrete laid directly on the sand of the old beach, which formerly extended to this point. The sand was for the greater part quite fine, but there were pockets of sharp gravel containing at some points small stone. The foundations were below the spring line, and the sand, being thoroughly saturated with water, would flow when disturbed or undermined. The walls of most of the buildings in the vicinity were laid on longitudinal timbers, located at or near the line of high water, and showed no cracks or signs of settlement. The chimney and boiler-house were, however, to be exceptionally heavy ; so it was thought desirable before beginning work to test the bearing power of the sand, preliminary to which a test pit was sunk until the water became troublesome, when an iron tube was started down with a view to detecting any covered mud or other want of homogeneity due to the shifting of the river bank. All preliminary work was, however, promptly stopped by the management, the statement of possible difficulties being considered valueless as against the opinion of builders and others that a good foundation could be obtained without piling at that location. The bases of the foundations could not be spread so as to reduce the pressure on the sand below 4 tons per square foot for the finished structure, and, before one-third of this pressure was reached, it became evident that the wet sand was compressible, and limited settlements took place which were not entirely uniform, as the chimney foundation received its full load before that caused by the boilers was received on the foundations of columns and walls. Eventually some narrow vertical cracks appeared, which relieved the strains, apparently without any material injury to the structure.

The concrete foundation under walls of building is 9 feet wide and 2 to 4 feet thick ; under the chimney, 22 feet wide and 4 feet thick, and under the two rows of columns, 18½ feet wide and 3 feet thick. The two chimney foundations are joined by a brick invert. Concrete at the elevation of that under the side walls was first extended over the entire area of the building, and an additional layer, 1 foot thick, applied afterward, the surface of which forms the basement floor. The walls are racked out at the bases to a width of 8 feet. The enlarged base of chimney is 20 feet wide. The walls of chimney, just above the footings, are 3 feet thick at the rear, 3 feet 8 inches on the sides, and 5 feet on the front (toward the other chimney). The walls decrease, as shown on plan, to 20 inches thick at the top of chimney. An archery, A, is provided through the base of each chimney as a means of communication between different parts of the basement. The opening B is provided to clean the interior of chimney. On each floor and at each side of chimney, at rear of boilers, are provided the openings C C C C, shaped to connect the horizontal flues from boilers, the openings being strengthened by complete blind arches, *d d d d*, above the partial arches at tops of flue openings. The openings O O O O are designed for the application of economizers in the future, the gases to be brought out of the lower ones and returned to chimney through the upper ones. The upper part of chimney is stayed at *f f f* by iron rods passing through struts of pipe. A fixed iron ladder is attached to the interior face of chimney, and connected at top with points and at bottom with cable to form a lightning protector. It was designed to make the top of the chimney with a projecting platform and iron reticulated balustrade, as shown by design at upper part of Fig. 2, in which case the chimney would have been 232 feet above high water. It was hoped that by painting the balustrade prominently it would give the effect of a capital to the shaft without the weight of actual surface projections. For various reasons, however, the top was finished with a granite coping at the elevation of 220 feet above high water, as previously stated, a simple footboard being provided about the chimney, as shown, with an iron hand-rail secured in coping stones.

Although the chimney appears slender the narrow way, it is supported by the walls to the elevation of openings O O, and above that point it is calculated to have ample weight to resist the overturning moment caused by a wind pressure of 50 pounds square foot on the area of one flat side. Mr. Emery acknowledges the valuable services of Mr. H. W. Brinckerhoff, M. Am. Soc. C.E., assistant engineer in immediate charge of the work during design and construction, and at a later date of those of Mr. Thos. E. Brown, Jr., M. Am. Coc. B.E., who was associated with Mr. Brinckerhoff. These designs have accomplished their purpose for the particular conditions encountered, but the necessity of putting the plant on such limited space has largely increased the cost of the work and caused continual embarassment in the details of the internal arrangements. The other stations being located where land is less valuable, larger plots have been obtained and different designs throughout can be employed.—*Ex.*

THE FORTH BRIDGE WORKS.

We believe that any information concerning the Forth Bridge will be interesting, and we therefore reprint the following from the London *Times :*

The extreme mildness of the past winter, together with the almost total absence of heavy gales has made it possible to carry on the work without serious interruption. Consequently the progress made has been great. At both of the shoreward ends the approach piers have been completed with one exception on the south side, up to the level at which they receive the girders. That, however, gives no idea of the height to which they will ultimately be carried. They are now only 18 feet 6 inches above high water, and the solid masonry has still to be carried up 125 feet higher. But already the work of placing the girders in position has been begun, and the superstructure of the bridge begins to show. On the Queensferry side the girders have been completed over three spans, and with the fourth and fifth spans some progress has been made. On the Fife side this part of the work is still further advanced, the girders on which the permanent way will rest having been laid down over nearly the whole of the approach piers. This is a feature of the work which puzzles the unskilled observer. One would naturally expect that no attempt would be made to place the girders which are to carry the railroad until the piers on which they are to rest had been built up to their full height. That, however, is only the non-professional view. In practice the engineers prefer to put together the steel bridge (for every part of the metal work is of steel) at low elevation, and then to raise the completed structure foot by foot by hydraulic power, building up at the same time foot by foot the granite masonry of the piers on which it rests.

As regards the progress of the construction of the piers, No. 1 pier of the southern group of four is completed, and ready to receive the plate-bed of the cantilever. Pier No. 2 is far advanced. Nothing is now seen of the caissons of these piers the upper parts of them having been removed. Some idea of the mass of masonry in these granite piers may be gathered from the fact that they are, as has been said, 70 feet in diameter, and that the base of their foundation is 73 feet below high water. The caisson for pier No. 3, however, has suffered shipreck. After it had been floated out and safely lowered in its position, it unaccountably canted over, suffered damage in the accident, and is now half filled with water. Its recovery will be a work of some difficulty, and will involve the contractors in great expense, though there need be no doubt of the ultimate success of the operation. For pier No. 4 the caisson is in position, and has been sunk to its final level, the air chamber (the bottom of which is 90 feet below high water) having been filled up and sealed some weeks ago.

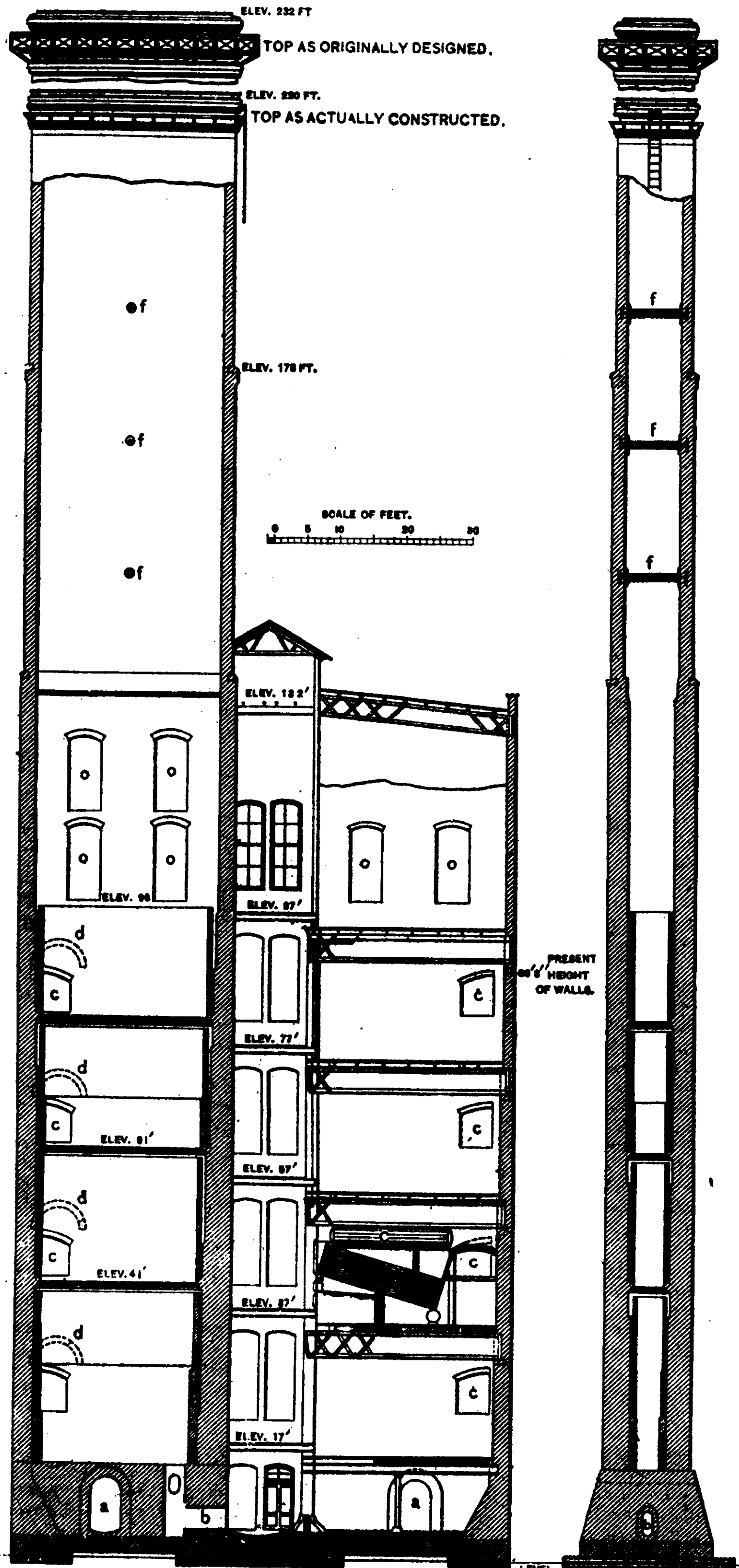
The second group of four piers is at the island of Inchgarvie in mid-stream, partly on the island and partly on the shelving rock to the south of it. Two of these piers (Nos. 7 and 8) are completed, and for the other two the foundations are being prepared. That is a work of no small difficulty, owing to the abrupt slope of the sea bottom. The caisson must rest on a fairly level bed, and this is being artificially obtained by lowering into the sea many thousands of bags of sand. The caisson of pier No. 6 is ready, and is now moored at the end of the temporary staging on the south side awaiting (No. 5), and the last of the whole, is now being constructed close to the Queensferry shore. The third and last group of four piers is that on the northern or Fife shore. Three of these are completed, and have received their lower plate-beds, on which the cantilever will rest. The fourth pier (No. 10), which is protected towards the sea by a coffer-dam, is far advanced towards completion. It thus appears that of the twelve piers which are to form the foundation of the three cantilevers six are finished, two are far advanced, and three are making good progress, while only one is in a position to cause anxiety or delay.

Undoubtedly the most difficult and most anxious part of the undertaking is the founding and building of the piers.

The cantilever principle has been adopted by Mr. Fowler, the designer and engineer of the bridge, as the best means of spanning the two wide channels of deep water north and south of the island of Inchgarvie, each forming a span of 1,700 feet. According to Mr. Fowler's design, each of the three cantilevers rests on a group of four piers, the central one being on the island of Inchgarvie, or, to be quite accurate, partly on the shelving rock to the south of it. We have thus to account for twelve piers, forming the bases of three cantilevers. It is satisfactory to note that with this delicate and trying part of the work remarkable progress has been made. In order to estimate truly the nature of the operation we must try to realize what it involves.

Each pier is built up within a circular water-tight iron caisson—resembling a vast cauldron or an inverted gasometer—from 90 feet to 120 feet in height, according to the depth of water, and 70 feet in diameter, which is floated out to its position and sunk in the bed of the estuary. The pier, however, cannot rest on the surface of the sea bottom. Its foundations must be sunk and rooted in the subsoil, precisely as in the case of a pier or of any other building on dry land. To effect this the caisson must first be sunk to the required depth, the *maximum* being 48 feet, and the foundation must then be built inside of it. It is accomplished in the following way. The door of the caisson is 75 feet above its lower rim. There is thus formed in its lower part a chamber 70 feet in diameter and 7 feet high. This chamber is air-tight and is, in fact a huge diving bell, within which the workmen carry on the work of excavation ; and as they excavate the caisson sinks foot by foot into the bed of the channel. The chamber is kept constantly filled with compressed air, which serves at once to exclude the water and to enable the men to breath freely and it is amply lighted with electric lights. The only means of communicating with the chamber is by three air-tight iron shafts or hollow columns, rising from the floor of the caisson to the top of it, by one of which the men descend and ascend, while by the others the soil which they dig out is carried away. The arrangements by which the men are enabled to enter and leave the shaft without allowing the compressed air to escape are very simple, though it is difficult to make it intelligible without the use of diagrams. The head of the shaft is surrounded by an outer chamber, also air-tight. When the men have entered this outer chamber the door is closed, and then it also is filled with compressed air of the same density as that within the shaft. The door of the inner chamber forming the head of the shaft is then easily opened, and the men descend by iron steps within the tube. When the caisson has been sunk to the requisite depth, the air-chamber is completely filled with concrete and is sealed. On this concrete bed the floor of the caisson rests, and, then, the shafts having been removed, the work of building the pier, with granite blocks on the outside, and freestone and concrete in the interior, is carried on within the caisson under the open sky, in the same way as within an ordinary coffer-dam. The work of excavating the subsoil within the compressed air-chamber is carried on chiefly by Italians, who have had experience in that kind of labor in connection with the St. Gothard tunnel and other similar works.

One gets the best idea of the extent of the temporary works by going over the workshops and drilling roads on the top of the hill above South Queensferry. Several new workshops have been recently added, including a vast moulding shop, with blackboard floor, on which the several parts of the structure are laid down in life size. The most interesting part of the work is seen on the drilling roads, where the cantilevers are being put together and built up precisely as they will be on the top of the piers. After being fitted together here they will be taken to pieces again and transported piecemeal to their places in the bridge with a view to which each plate, truss and diaphragm is carefully marked and numbered. In examining these structures one gets a vivid idea, though still a very partial one, of the vast dimensions which the completed structure will assume. The shortest of the steel cylinders, 12 feet in diameter, which will stretch from pier to pier, are 145 feet in length, while the two longest—those on the Inchgarvie piers—measure 260 feet. At the extremities of these huge cylinders, where the arms are thrown upwards and outwards, so as to form the spring of the arches of the bridge—which are not, in fact, true arches—and where, consequently, the strain will be the greatest, the tubes are strengthened by the insertion into their interior of a complicated system of diaphragms and trusses, which is apt to bewilder the non-professional eye. The drilling engines are marvels of ingenuity and exactness. They completely surround the cylinders, so that the operation of drilling is carried on at many points at the same time. This work is carried on, of course, in the open air, and it presents an interesting and lively scene. In the covered workshops the scene is still more animated. These shops are beehives of industry, in which all kinds of operations are carried on at the same time, with the



Figs. 2 and 3.—Vertical Sections of Building and Chimney.

CHIMNEY OF STATION "B" OF THE NEW YORK STEAM COMPANY.

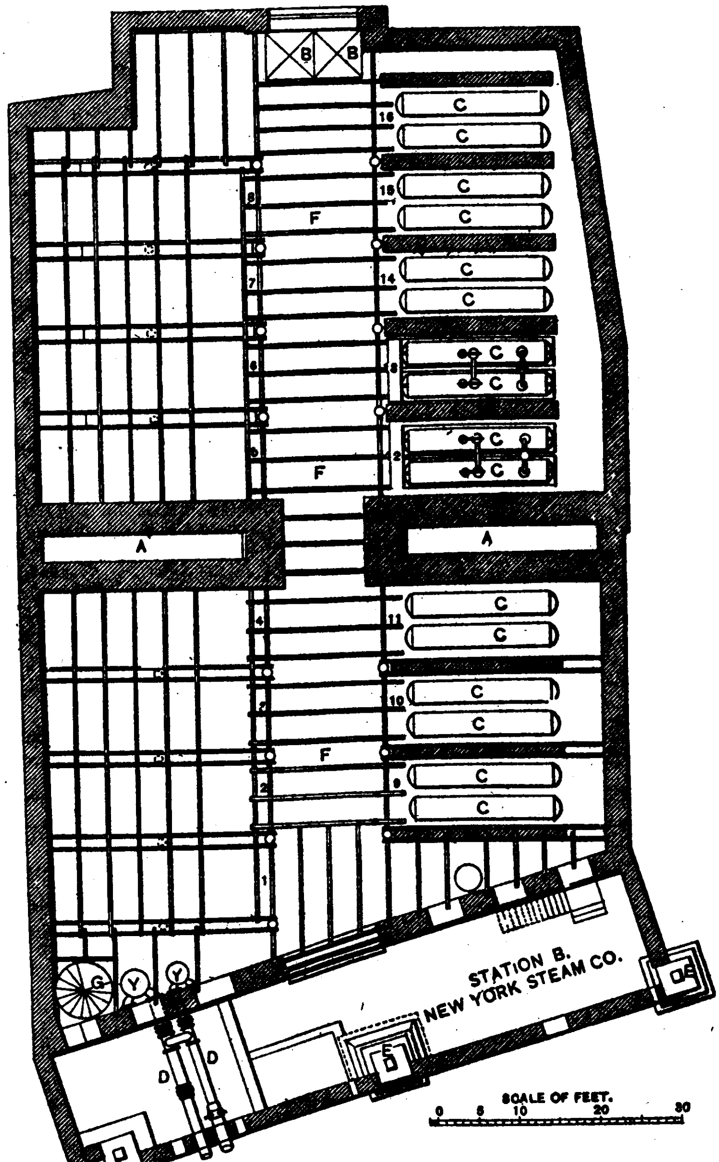


Fig. 1.—Plan of One Story of Station, Including a Section Through the Vault Under the Sidewalk.

CHIMNEY OF STATION "B" OF THE NEW YORK STEAM COMPANY.

varied din of hammers beating, engines puffing, wheels whirring, and drills booming, so that "the air is filled with noises" of a very different kind from those that beset the ears of Caliban on his enchanted island. Plates of iron half an inch thick are punched as deftly as if they were sheets of cardboard. Plates of solid steel are planed as easily as if they were planks of wood. Everything is done with mathematical precision, yet with a speed that is marvellous.

It may be useful to repeat here some particulars regarding the statistics of the great undertaking. The total length of the bridge is 8,091 feet, or upwards of a mile and a half. The length of the main portion, from cantilever pier to cantilever pier, is 5,342 feet. The two main spans, north and south of Inchgarvie, are 1,710 feet each. In the approach viaducts there are fifteen spans—ten on the south side and five on the north—of which thirteen are spans of 168 feet each, the other two, next to the cantilever piers, being of 179 feet. The height of the rails above high water will be 150 feet. The breadth of each cantilever at base is 120 feet, at top 35 feet, and at the extremities 35 feet. The height of the cantilever columns is 350 feet. The number of men employed on the works is about 2,000. The estimated cost of the whole undertaking is £1,600,000. The work has now been in progress for two years and a half. It is expected to occupy another five years at least.—*Am. Eng.*

THE MESSAGÉRIES MARITIMES.

Although this great French steam shipping concern, in common with other important maritime enterprises, is not so prosperous now as it was a few years since, it was still enabled to give its shareholders a return upon their capital for 1884 at the rate of 5 per cent per annum. At the close of last year, the value of the company's fleet was returned at £4,769,825, showing an increase of £178,724 upon the corresponding total at the close of 1883. This increase was the result of the building of additional ships required to insure the satisfactory working of the company's varied services, and especially the due execution of the postal service undertaken between Marseilles, the Australian continent, and New Caledonia. The Yarra, a first-class steamer, built for the Australian line, was launched and equipped in the course of last year, and two cargo boats, the Cordouan and Medoc, were also placed last year upon the list of ships in service. The Arethuse was equipped last year with a new engine, and is now employed upon the Saigon line. The Arethuse completes the list of ships engaged in the company's Cochin-China local service, the working of which was conceded to the undertaking in 1881 for a term of nine years. The vessels just mentioned, and sundry works executed to other ships still in the company's yards, represented a total capital outlay for 1884, of £260,435, which was reduced, however, by £81,711 written off capital in respect of the Euphrate and the Emirne, the hulls of which were recently sold in order to be broken up. We have stated that the whole outlay of capital made to the close of last year upon the company's fleet was £4,769,825; but we should add of this sum £2,649,317 had at the same date been written off out of revenue, so that the company's ships stood in the books December 31, 1884, for £2,160,-508 and no more. The Council of Administration systematically writes 5 per cent year by year off the first cost of all vessels owned by the company, and in this way what we may term the sinking fund allocation was provided last year to the extent of £184,256, less £81,711 representing the value of the Euphrate and the Emirne, which, as we have just stated, have been sold in order that they may be broken up. The value of the stores in hand at the company's various working centres at the close of last year was £515,691, showing an increase of £9.024 as compared with the corresponding total at the close of 1882. The value of the tools, furniture, apparatus, and premises owned by the company at the close of 1884, was estimated at £638,-783, showing an increase of £7,813, as compared with the corresponding total for 1883. The insurance fund, formed by the company stood at the close of 1884 at nearly £320,000. No serious disaster was sustained by the company's fleet in 1884, but the insurance fund had to make good certain damages sustained in connection with the wreck of the Gironde upon the Brazilian coast in the course of 1883. In addition to the insurance fund, the company has also systematically formed what is termed a statutory reserve fund, that is, a fund formed by a deduction of 5 per cent from the profits of each year. At the close of 1884 the statutory reserve fund stood at £204,574.

The company had to contend last year with certain special difficulties, its interests having been prejudiced by the continuation of hostilities between France and China, and by quarantine impediments arising out of the choleraic epidemic at Marseilles and Toulon. It was hoped at first that this epidemic would be of comparatively little importance, but the disease unhappily spread to Italy, Egypt, and Algeria; and until the close of December business was profoundly troubled in the Mediterranean and Black Seas. The evil influence of the epidemic was even felt as remotely as Australia, the Mauritius and Rio de Janeiro. In consequence of these difficulties, the company's service was suspended during six months in the Black Sea, while as from August, the port of Shanghai was also closed to the company's vessels in consequence of the uncertain state of political affairs in the extreme East. The aggregate distance run by the company's vesels last year was 696,987 marine leagues as compared with 686,115 marine leagues in 1883. The increase of 10,872 marine leagues was to a great extent accounted for by the complete execution of thirteen voyages in connection with the Australian postal service, while in 1883 the corresponding number of voyages was only eleven. Notwithstanding the inconvenience occasioned by quarentine difficulties, the postal service undertaken by the company was regularly carried on last year—at any rate upon the more important lines. The average speed attained by the company's steamers last year was 11.73 knots per hour upon the Australian line 12.25 knots per hour upon the Brazilian and La Plata line, and 12.15 knots per hour upon the China line. The number of vessels employed in running the 696,987 marine leagues traversed last year, was 56, giving an average of 12,530 marine leagues per ship. The French Minister of Marine and the Colonies has applied to the company to unite its Australian line with the French establishment in Madagascar and the Mozambique Canal, by means of a French line to Saint Denis, Reunion, and Mosambique. A contract has been signed for the establishment of the proposed new service, which will involve an annual run of 14,456 marine leagues; the remuneration accorded to the company is £1 per marine league. A new line is also proposed to be established in connection with the Cochin China service, it being intended to run a small steamer between Saigon and Manilla. This new service will involve an annual run of 7,878 marine leagues, and the remuneration accorded to the company is 16s. 10d. per marine league. In consequence of these new services the annual obligatory distance to be traversed by the company's steamers will, in future, be 573,758 marine leagues. The company carried last year 83,721 passengers, 394,647 tons of goods and specie, and securities to the value of £5,609,675. The receipts of every description on revenue account last year were £1,994,257. The working expenses, including sinking fund and insurance allocations, were £1,841,619, leaving a surplus of £152,638. Of this amount, £25,413 was absorbed by obligation interest, leaving a balance of £127,125 available for dividend upon the share capital, less 5 per cent to be carried to the statutory reserve fund. This latter allocation amounted for 1884 to £6,361 A dividend at the rate of 5 per cent upon the share capital absorbed £120,000, leaving a final balance of £864 to be carried to the credit of 1885, which, it is to be hoped, will be a year of fewer difficulties and more profitable results.—*Eng.*

PUPILAGE.

With the proposed extension and improvement of the educational work of the Architectural Association, the question of pupilage may not inappropriately be taken into consideration. The system of pupilage is not likely to become extinct yet a while, nor is it desirable in our opinion that it should. No student's education can be complete in the right sense without an office training, but as matters stand at present this training is in most cases very much of a farcial kind. And we question whether in more than a very few instances is there anything like that true relationship of master and pupil which ought to obtain. What we want from the profession is more of that correspondence of sympathy between master and pupil which used to exist in the painters' studies of former times. But how to obtain it? Well, it is difficult to see how such a relationship can be brought about under the present system of premiums and paid assistants. The pupil is generally regarded as a superior kind of office boy, and is left almost entirely to the care and attention of a clerk in charge, whose educating influence may be good enough of its kind but yet does not exercise that precise influence for the benefit of which the premium is paid. Just as a carpenter or mason is unlikely to obtain full experience and ability without the regular routine of the workshop, so the architectural student will be ill-fitted for his future practice if his training does not include some experience of office life and of the business relationships between architect, client and builder.

But there will be a great difference between the progress of a pupil who passes through his office experience when he is uninstructed in the bare elements of professional knowledge, and that one who has, before his pupilage, begins, acquired some elementary theoretical knowledge of his profession, and also, perhaps, of some of the trades it employs. If a newcomer to the study of architectural practice goes into a carpenter's or a mason's shop, and combines that with some systematic study of professional subjects at University College and at the Royal Academy, he will be filling his time to a solid advantage and will lay a foundation on which he may build with certainty of good result. He will with this foundation be of some service as a pupil and give his master asssistance worth having, such as may afford some return for the educating influence the latter can bestow. In such a system the cost of a premium would be devoted to the direct and certain education in college and in shop, and then when the pupil comes to the architect's office he is in a position to afford genuine assistance, instead of being regarded pretty much as an interloper, whose sole value to the office lies in the premium paid on his behalf.

It is, we think, open to serious question whether such a preliminary stage such as we have suggested would not operate far more to the benefit of architect and pupil alike than the present system of taking a boy direct from the restraints of school to the freer life of an office, where his labor is often of a voluntary kind, and in a very indirect way conducive to his own benefit. It is not very likely that a pupil can put forth his best efforts when he is engaged all day in a sort of office drudgery ; he cannot, after a day so spent, feel the attendance at classes in the evening anything but irksome. A medical man once said to us that no student should begin the actual hard study of his profession till he was over twenty years of age, when his capacity for understanding the higher branches of knowledge would be fully developed. Before that age he thought there was a tendency to "cram." We believe there is much truth in this And if architectural pupils were thoroughly grounded in purely elementary work, practical and theoretical, before being sent into an architect's office, they would then be able to learn much more quickly and thoroughly the practical details of their profession than they otherwise would do ; they would also have a more ready understanding, and both they and their masters would be the gainers.

Pupilage we have said cannot be dispensed with. It must, however, be placed on an altogether different footing if it is to be of any real educational value. We have tried the old system long enough, and it has failed completely and ignominiously as most who have experienced it know to their cost. To whom then must we look for the imitation of a more rational system ? We have, we are happy to know, conscientious men in the profession who can and do recognize the responsibility which the taking of a premiated pupil throws upon them. But what of the great number who take premiums and turn loose into the profession a lot of raw, ignorant youths, who, if they have not brains and strength of will sufficient to overcome all obstacles, simply go to swell the ranks of those who claim a rank and title to which they have no manner of right ?

This is a question that we feel has not been fairly answered. It may be left to the individual members to solve it in their own practice, but if individual effort could have found a more excellent way, we are sure it would have been done so long ago. We were much struck with some remarks of Professor Roger Smith not long ago, when speaking on this subject, and thought then that if every architect could be induced to think as he did about this question of pupilage, there would practically be no fear of incapable or ill-trained men entering the profession. We are persuaded that some better-defined and more united course of action is needed to reform this one of the most crying evils in the system of architectural education, as it at present exists. Cannot our architectural societies, metropolitan and provincial, take up the subject and develope some scheme of reform ? In their unity on this, as in other important details of professional practice, depends the real strength and life of the profession. Let them at least agree upon certain essential qualifications in candidates for pupilage, requiring, for instance that pupils should be liberally educated, or that they should possess special faculties and capacities for overcoming pecuniary difficulties, that they should in fact be naturally inclined and specially educated for entering upon their apprenticeship. Upon this and other points connected with this subject, it is absolutely necessary we should be all agreed if we are to effect any reasonable measure of reform.—*British Architect.*

A CHAT ABOUT MODELLING.

"Mr. Hems," I inquired one day of the well-known Exeter sculptor, Harry Hems, whose studio in fair Devon's ancient capital, I happened to be visiting, "If I were a student of yours, what would be the first most important thing for me to learn ? Is there any real artistic help that a master, like yourself, can give his pupil, or is it, after all, the better for a young beginner to take council only by experience, teaching himself as he goes along ?"

As I said this, I gazed around me and noted the peculiar features of the *atelier* I stood in. See, there are no windows ; the light is entirely obtained from the roof, and so nothing but a soft north light falls upon the work the sculptor and his assistants are so earnestly engaged upon. All around and upon the walls are grouped models of commissions already completed; life-sized saints, virgins, bishops, and martyrs are there in mute array by the score. In this corner are the pointing machines by whose help the superfluous material is knocked off the huge blocks of stone or marble ere they come into the sculptor's hands. Tram lines and turn tables are laid on the floor in every direction, and from the roof are suspended ingenious appliances by which big blocks, weighing tons in weight, are picked up and placed with ease in their respective positions. In one corner is a deep pit where a dozen or so tons of modelling clay is kept moist, ready for use ; on the bankers are some colossal statues which will one day adorn the high altar screens at St. Albans' ancient abbey ; and, by my side, the moving mind of all this work, is Harry Hems himself ; an immense and most ferocious-looking bull dog (who he affectionately addresses as "Bob," but of whose movements I am somewhat suspicious) being his close attendant. By no means affecting the ideal artistic cut, Mr. Hems is a medium-sized, somewhat sturdy man, of between 40 and fifty years of age, who delights in being mistaken for the man, rather than the master, of the place he owns, and seems so quietly to rule. Yet if all accounts be true, Mr. Harry Hems is not always so quiet as he generally seems to be, and tales are told that when he is in his "tantrums" (as an artificer confidentially expressed it to me) "the devil himself couldn't hold him !"

But I had well-nigh forgotten that I had asked Mr. Hems his opinion as to whether practical training was really of service to the would-be student in sculpture, and that he is politely waiting, with a good-natured and open smile upon his face, to answer me.

"Undoubtedly," replied the sculptor, "a young artist can be saved a world of unnecessary, and oftentime disheartening trouble, by a few useful, practical hints from a teacher at the outset. For example, in setting up the clay for the statue he intends to model, considerable difficulty and delay, yea, much vexatious loss of time, will be incurred if primary rules are not followed. In the first place the clay must be well tempered."

"What description of clay is it ?" I asked. "It is pipe clay," was the sculptor's prompt reply. "You may buy it at any pipe-makers in the kingdom for a shilling a ball ; a ball being about the size of a man's head. That is the retail price and mode of procuring it ; but we sculptors, schools of art masters, and others, who use large quantities, of course get it direct from the clay pits. These are situated in the immediate neighbourhood of Kingsteignton, near Newton Abbott, on the borders of Dartmoor; Modelling clay is believed by geologists to be simply nothing more or less than disintegrated and decomposed granite. There are several hundred men constantly engaged in the avocation of digging the clay, of which upwards of 80,000 tons are sent away by ship or rail every year. It lays in beds, from 20 ft. to 80 ft. deep, and varies somewhat in quality ; that best suited for modelling being most free from grit, and able to take a good polish, besides being both tough and plastic when in a damp state, though not too brittle when hard. The cost of the clay wholesale is a guinea a ton, a 'tally' of 70 balls going to the ton. The rate of carriage from Newton Abbott to London by water is 5s. per ton, and £1 a ton per rail. Messrs. Whiteway and Mortimer ; Messrs. Brown, Goddard, and Hatherly ; Messrs. Watts, Blake, Bearne, and Co., are perhaps the best known among the clay merchants ;

and all of these supply a good article." "And what," we ask' "should the student first do, after getting his clay all 'knocked up' and ready for working?" "You must prepare a vertebra, as it were, to support your figure," replied Mr. Hems. "On the wooden stand that forms the base, erect an upright rod or pole long enough to reach to the neck of the figure, and fasten it securely in a perpendicular position. The upper end must be directly under the pit of the throat, or else the body will not stand well. Put some cross pieces near the pelvis to support the clay, and see that the clay is thick enough. If it is not, it will have a tendency to roll down; into the wood, too, drive a number of small nails, knocking them, however, only an inch in; they will thus stick out and all add to support the clay when it is put on. For the bent arm and leg use pieces of ordinary lead gas-piping, which will bend easily and can be readily adjusted at the proper angle after being covered with clay. Iron pipe does not do, it is liable to oxidize, and besides would be more or less brittle and unmanageable! Over all the skeleton thus made, put on the clay, remembering that the nearer the frame-work the stiffer the clay must be; this will make the figure more compact. Thus you will gradually build up the body, putting on large strips of clay around the waist, the head, feet, legs, and so on. Mind and keep all the main parts of the figure at about the same stage of completion, so that you may judge intelligently of their relation the one to the other. It won't do, for instance, to half finish the head before beginning the bust; for afterwards, when the torso was done, the head might require considerable alteration. No matter how the figure is to be draped, always model it in the nude first, so as to feel the masses and the movement of the figure."

"That," said he, continuing and warming in his conversation with all the enthusiasm which is so characteristic of the true artist, "that, you see, will be a statue of St. Benedict. The worthy saint in question lived so long ago as the sixth century, and founded the celebrated order of monks known to this day as the Benedictines. Here are the actual robes (*i. e.*, the self-same kind of costume) that St. Benedict himself wore. I have borrowed them of my good friend Father Hamilton, O.S.B., at Buckfast Abbey, where a community of Benedictines now live. They wear precisely similar vestments to those their founder himself wore, and for several hours every day, I have this man," pointing to a noble-looking grey-bearded old fellow hard by, "dressed therein; he stands as a model to be worked from. So you see the folds of drapery, although strictly Gothic, are withal soft and natural. As for tools, almost anything will do to make modelling tools out of; for instance, you may take ——"

But here an interruption came in the shape of a messenger with a telegram which called for the immediate presence of Mr. Hems elsewhere, and hastily begging to be excused, he left with a cheerful promise to give me an hour at an early day, when I mean to pay another visit to the studio of the "Luckie Horseshoe."—By an Art Lover, in *The Stonemason.*

THE DOLPHIN'S DEFECTS.

In view of recent developments in connection with the Dolphin, the following statement, made by Chief Engineer B. F. Isherwood somewhat over a year ago, is interesting:

"The Dolphin is not available for any military use, being merely a steam yacht, designed apparently only for the use of an admiral commanding a squadron, her elegant and spacious accommodations and high speed rendering her convenient for such purpose. She does not, therefore, fall into the category of a naval cruiser at all, and the only question in relation to her is whether so expensive a vessel to make and maintain, and so useless a one, is desirable in a navy that is destitute of fighting ships. As the appropriations for naval vessels are likely to be very limited, and asthe cruisers now belonging to the navy or likely to belong toit in the near future are very few, therecan be no doubt that no more yachts of the Dolphin type, or, indeed, of any type, should be constructed for many years to come, if ever. The money should be wholly expended for useful vessels of war, the common wealth not requiring the appendage of luxurious yachts for its squadrons. A properly built cruiser of the smaller class, with such speed as it ought to have, will perform all the services that could be rendered by a yacht, besides being always available for military uses. Imagine a squadron restricted from motives of economy to two or three fighting vessels, as our squadron will be, yet with the wholly useless addition of a magnificent steam yacht, costing to make and maintain as much as a small cruiser, and merely for the personal use of the admiral commanding.

"The boilers of the Dolphin are largely above the water level. Her engine extends to a considerable height above even her spar deck, and not a single shot could be fired at her that would not destroy the machinery sufficiently to immediatety put the vessel *hors de combat.* To speak of arming such a sheet-iron vessel, with her machinery all exposed, or of expecting any military service from her, is utterly absurd, though such statements may disguise her character. This type of vessel was proposed to the first Advisory Board, of which the writer was a member, and the proposition was voted down almost unanimously, as appears in the unpublished minutes of the proceedings of that board. No vessel should be built for the navy unlesss she be for her dimensions an efficient vessel for war purposes, and vessels of all dimensions can be so built.

"The contract price for building the Dolphin, but not for equipping her, which is additional, is $315,000; adding for the equipment. her cost in round numbers will be about $400, 000. Her length between perpendiculars is 240 feet; her breath is 30 feet; her mean draft of water is 14½ feet; her displacement is 1485 tons, and her estimated speed is 15 geographical or about 17¼ statute miles per hour. These are the dimensions, the speed and the cost of a third-class cruiser. They are cited to show that the terms expensive and magnificent applied to her as a yacht are not exagerations.

"The desighns of the Dolphin are claimed by the present or second Advisory Board. The machinery is simply that of most coasting screw steamers, and is probably a duplicate, or nearly so of machinery built by the contractor, Mr. John Roach, for such a vessel. It will unquestionably function well, and is admirably adapted for coasting steamers, but is entirely out of place in any vessels intended for war service unless they be armored. The entire designs of the hull and machinery are understood to be made at the contractor's works, only the general idea being given by the board, which certainly furnished no working drawings. In fact, the contract for this vessel especially stipulates that:

"'*Fifth*—It is hereby agreed by the contractors that such plans as it may be necessary to prepare during the progress of the work shall be submitted to the Naval Advisory Board for approval before the material is ordered or the work commenced.'

"From which it is evident that the board furnished at most only a very general idea, the real designs or working drawings being afterward made by the contractor from time to time as the work progressed. Of course, neither the weights, the details of mechanism on which so much depends, both of the cost and the efficiency, nor the character of the work, can be known until all the working drawings are completed; consequently, the greater part of what is predicted of the vessel by the board can have no real basis—in fact, is mere assumption."

Miscellaneous Notes.

On Wednesday the total number of visitors to the International Inventions Exhibition reached one million in 45 days, being an average of 2,000 a day more than last year.

Boiler Explosion.—Last Monday a steam boiler exploded in the wool-scouring establishment of M. de Coster, at Turcoing. Seventeen persons were killed and forty injured.

An improved system of building jetties has lately been devised in America. The entire jetty, except the sills and mats, is made of metal and stone, the only wood being the sills, which are completely embedded in mud, so no part of the structure can be injured by the teredo, and the metal plates are coated with paint to prevent their oxidation, the whole making a form of jetty adapted for use in deep water, or where the current is very strong, and great strength is required.

Mr. Gladstone has carefully estimated that the production of wealth in Great Britain, since the opening of this country and up to the year 1870, equals the aggregate that had been acquired during the entire time from the landing of Julius Cæsar, fifty-five years before the birth of Christ, up to 1800. Furthermore, that the wealth produced since 1850 has been equal to all that was made the fifty years preceding; yet there are more poor people and fewer rich than ever before.