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On: 01 February 2015, At: 13:07
Publisher: Routledge
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Number: 1072954 Registered office: Mortimer House,
37-41 Mortimer Street, London W1T 3JH, UK



Royal United Services Institution. Journal

Publication details, including
instructions for authors and
subscription information:
[http://www.tandfonline.com/
loi/rusi19](http://www.tandfonline.com/loi/rusi19)

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Published online: 11 Sep 2009.

To cite this article: John Dixon Esq., C.E. (1877) On the
Arrangements Made for the Removal and for the Transport to
England of Cleopatra's Needle, Royal United Services Institution.
Journal, 21:93, 1111-1131, DOI: [10.1080/03071847709434521](http://dx.doi.org/10.1080/03071847709434521)

To link to this article: [http://
dx.doi.org/10.1080/03071847709434521](http://dx.doi.org/10.1080/03071847709434521)

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SPECIAL LECTURE.

Friday, November 16, 1877.

ADMIRAL SIR ERASMUS OMMANNEY, C.B., F.R.S., in the Chair.

ON THE ARRANGEMENTS MADE FOR THE REMOVAL AND FOR THE TRANSPORT TO ENGLAND OF CLEOPATRA'S NEEDLE.

By JOHN DIXON, Esq., C.E.

THE CHAIRMAN: Ladies and Gentlemen, I have to mention to you that the Council had selected General Sir James Alexander for the honour of filling the chair to-day. I regret, however, to say that the gallant General is confined to his house in Scotland by illness. Perhaps you are not all aware that it is to Sir James Alexander that the merit is due of taking the initiative in active measures with regard to transferring the Cleopatra needle to England. As the General is unable to be present, he has transmitted a brief statement with regard to the steps that have been taken, which, with your permission, I will read:—

“Having been asked to take the chair at the meeting of the Royal United Service Institution, on the 16th of November, I regret much my inability to do so owing to an unexpected attack of illness. I was particularly anxious to hear a very interesting and instructive lecture by Mr. John Dixon, C.E., on the construction of the iron vessel, in which he placed the Obelisk of Alexandria for transport to England, because I have been connected with this movement and in the manner which I beg now to explain as briefly as possible.

“In the year 1867 I was present at the great Exhibition in Paris, and whilst admiring the Obelisk of Luxor at the Place de la Concorde, I was told that the British nation had as good an obelisk lying neglected in the sand at Alexandria, and which had been presented to Britain in 1820 by Mahomed Ali Pasha in recognition of the valuable services rendered to Egypt in the beginning of the century, under the leadership of the heroes Nelson and Abercromby, but that as the gift did not seem to be appreciated, the foreigner on whose ground it lay proposed to break it up for building materials!

“This naturally led me, at once, to resolve to endeavour to save us from this national disgrace, respecting as I did the memory of the above illustrious men, and proud of the achievements of our fleet and army in the East. I collected as much information as possible regarding the prostrate Obelisk of Alexandria. It seems the French intended removing both the upright and the prostrate obelisk, “Cleopatra's Needles,” for the former was found, after the Battle of Alexandria, with a cable round it, and the latter had been excavated all round, and its hieroglyphics copied, as may be seen in the great work by Champollion the younger, in the British Museum.

"I next endeavoured to direct public attention to the prostrate obelisk by reading papers before the Royal Society of Edinburgh, the British Association, &c., and published a plan in *The Engineer* for transporting it to England. Engineer eminence took up the matter, among others Mr. Dixon, Mr. Bateman, Mr. Lor Clarke, &c. Introduced to the then Chancellor of the Exchequer, the Right Hon. able Mr. Lowe, I laid before him plans and estimates, aided in this by Mr. Gar Mr. Hill, and Mr. Essie of London; but the time did not seem favourably engaging in the enterprise, and it was hinted that possibly the obelisk was mutilated and was now under the sea-wall, and that the Khedive might not allow it to be moved: I therefore determined to go to Egypt and ascertain the actual condition of the obelisk, and if found entire, endeavour to get his Highness's consent to its removal.

"The Earl of Derby, the Foreign Secretary, was so obliging as to give me an introduction to the Consul-General in Egypt, Her Majesty's Agent, General Stanton, C.B. He presented me to the Khedive at a special audience. I explained what was desired, and showed plans for the removal of the obelisk. His Highness then granted full powers for its removal, and his Chief of Harbours and Lightships, Admiral McKillop Pasha, said that every aid would be afforded at the docks of Alexandria.

"At Alexandria I became acquainted with Mr. Waynman Dixon, the brother of Mr. John Dixon, and on my expressing a desire to have the obelisk uncovered and examined (it was invisible under three feet of sand, and no building was over it), Mr. Dixon had it quickly uncovered, and it was found in good condition, and I found it was the twin of the upright obelisk. Mr. Waynman then gave me the 'Dixon' for encasing the monolith in iron and having it towed to England.

"I then returned home, and at some expenditure of time and money, went on to the agitation for the removal of the national trophy to England. I had interviews in high quarters, and tried to obtain Government funds to ship and transport the obelisk from its inglorious bed by the sea-shore, where it was treated with no respect. I had much intercourse with Mr. John Dixon, who was most zealous and anxious to engage in the work. I was about to endeavour to obtain a charter for the city, when after a conference with Professor Erasmus Wilson, F.R.S., giving full explanations to him of the state of the case, he nobly and patriotically said, 'there was no occasion to apply to the Government, nor to go into the city for subscriptions, he would undertake the whole himself and wanted no partner in the work.' Mr. Dixon's plan of the iron caisson and others—an ingenious one!—Messrs. King, engineers, London, was to place the monolith in a hopper barge, which is used for dredging, and, with a steam-engine in the stern of the barge, convey the obelisk to the Thames.

"Professor Wilson communicated with Mr. Dixon, made arrangements with him for shipping the obelisk at Alexandria, bringing it to the Thames, and placing it on a suitable site (I had got one in 1872 from the Metropolitan Board of Works, the Thames Embankment) and though a great misfortune befel the 'Cleopatra' in the Bay of Biscay, where it was cast off from the towing ship 'Olga' by a hurricane, and accompanied with a melancholy loss of life, we believe that Mr. Wilson, with his energy and ability will overcome present difficulties at Ferrol, where the obelisk lies, and we shall yet see the venerable trophy ornamenting the Metropolis.

"It only remains to notice that in 1801 Lord Cavan, commanding a regiment of guards in Egypt, made every effort to ship the prostrate obelisk. My uncle, Major Bryce, then a senior Officer of Engineers (afterwards Sir Alexander Bryce, Inspector-General of Fortifications), constructed a jetty to roll the obelisk towards deep water, but the sea carried the jetty away, and the army, finding the attempt to secure the obelisk was then unavoidably though reluctantly abandoned."

¹ Its historical and archaeological interest is very ably shown in Professor Wilson's popular pamphlet, published by Messrs. Brain and Co., and entitled "Our Egyptian Obelisk, Cleopatra's Needle," and also in his larger work, just published by the same firm. The Institution is indebted to Professor Wilson for the engraving of the obelisk at the head of this article.—ED.

If Thothmes III was satisfied with the skill of his engineers in the transport of this obelisk down the Nile from As-suan, how greatly astonished must the Pharoah of the present day have been to observe the skill and ingenuity of Mr. Dixon, who enveloped this obelisk with an iron casing, which served to float it from the beach of Alexandria and carry it into the Atlantic. I consider the "Cleopatra" was ably designed for the object. We must all sympathise with Mr. Dixon in the accident which occurred to the vessel off Cape Ortegal, which, in my opinion, may be attributed to the shifting of the ballast; that she did not founder in the storm after she was abandoned by the "Olga" is due to the foresight of Mr. Dixon, by his mode of tubular construction. We must now wish him the fullest measure of success on its final voyage to the Thames.

The erection of this interesting record of antiquity in our metropolis occurs at a period to which posterity will refer as remarkable in our connection with Egypt and Africa. If this obelisk is to be regarded as a trophy to the victors under Nelson and Abercromby, it comes to our shores just when British enterprise, through the intrepidity of our heroic travellers, has completed the discovery of the mighty Lake system in Equatorial Africa; the sources of the mysterious Nile of the ancient Egyptians have been revealed; the mighty Congo has been traced; and the heart of Africa is being opened up to the blessings of civilization. Our influence with the Pharoah of the present day is predominant. We have a deep interest in the internal condition and further development of the fertility of Egypt. His Highness the Khedive now seeks for British councillors. Following on the achievements of Sir Samuel Baker, he has selected Colonel Gordon to rule over the Soudan, and to bring his recently-acquired territories (which extend to the Equator) under subjection; and, above all, he has plenary powers to exterminate the odious slave trade. I now beg leave to introduce to you Mr. John Dixon.

Mr. DIXON: Sir Erasmus Ommanney, Ladies and Gentlemen: The Council of the Royal United Service Institution being good enough to ask me to address you on a subject of which I may be presumed to have some slight knowledge, I accede with pleasure to that suggestion. My only difficulty is to know, not what to say, but what not to say. I shall, however, trust to your indulgence, endeavouring not to exceed a reasonable time, and to dwell in greatest detail on those points which will most interest a scientific institution like this. In the first place, as this is the first public occasion since we obtained possession of the obelisk, on which I have had the opportunity of speaking, I think it is but meet that we should accord to His Highness the Khedive of Egypt our warm thanks for the gracious liberality with which he placed the obelisk at our disposal, and received all our suggestions, and for the very warm sympathy and interest which he has evinced in the removal of this obelisk. It was the earnest desire of his illustrious grandfather, the great Mehemet Ali, to see this obelisk removed to England. Mehemet Ali, remembering the exertions made by the British Army in 1801, at the close of one of the most brilliant cam-

paigns that it had ever fought, to bring this obelisk home with as a monument of their success, endeavoured to get the Egyptian nation to accept it and remove it. They neither accepted it nor removed it. Our thanks are also due to Mr. John Fowler, the engineering engineer; and especially are they due to the Hon. Crespigny V. Her Majesty's Consul-General in Egypt, a member of one of the Services, for the interest he has taken in our enterprise, and for the assistance he has given us. Whilst recording our thanks to those who have assisted us, I must not forget to include that courteous and gentleman, Signor Demetrio, on whose land the obelisk lay. He has given us every assistance. He has expended a very considerable amount of money in helping us, when he might have been an awkward impediment in the way, notwithstanding the goodwill of the Khedive.

Now, sir, what is this monument that we are trying to get to London? It is the oldest monument now in Europe or Asia. It records upon its face the history of its birth and parentage. It is therefore, to be an interesting monument.

Seven hundred miles up the Nile, the country is crossed by a ridge of granite, possessing peculiar consistency,—exceptionally free from flaws and cracks. It is there that the Nile bursts through it in the cataracts, and it is from this ridge of granite that all the obelisks with the name, that the world possesses have been carved. Above Assuan the quarries in this region, there now rests a monster obelisk, which, had it been finished, would have vied with the old Flaminian, or the Lateran. Two of its sides are squared, and the grooves are cut in which the wedges were to have been inserted to separate it from its natural bed. This obelisk would have been about 120 feet long and 11 feet square. Now, for many years I have taken an interest in the old monuments of Egypt; and circumstances did occur which enabled me to visit that land some years ago. I looked at the position in which this Alexandrian obelisk—which we may call ours—was lying: I thought it was a pity that so interesting a relic of an olden time should be so interesting a record of the genius and engineering skill of the Egyptians who could quarry such blocks of stone, could move them with such labour from place to place, set them up and take them down as they should be lost to posterity—for the handling of such pieces of granite as any of these obelisks, is no child's play, to say the least. Our obelisk has a weight of about 200 tons. I therefore, as I say, thought myself, that this piece of stone ought to be preserved to England, and that I should like, at some future day, to see it set up in the heart of modern engineering, in this our city of Westminster.

If such be its merits as an engineering monument, what shall we say of its interest as an historical monument? We have recently had such full descriptions of its history in the journals, that I need not detain a scientific gathering like this by dilating upon matters which you are as familiar as myself; but I will claim a minute only just to bring to your minds a few of the principal dates connected with its history, because the question may be asked—nay, it has frequently been asked,—“What is the use of this battered old sto-

"Why should we take all this trouble about it?" As if every national monument of such a people as the ancient Egyptians were not of priceless worth, especially a grand, historical, and even chronological landmark, like this colossal monolith! We do not live for the day alone, but as beings gifted with large discourse, we look before and after. What is it that is one of the strongest incentives to duty, that "stirs the imagination and nerves the will of the members of those distinguished services I have the honour of addressing, but the impulse to write on to-day's page of history, names comparable to those with which its earlier records glisten?" Hence we want a past to look back to, as we hope ourselves to make a glorious past for future generations to emulate. "The child," says Wilhelm von Humboldt, in a striking passage quoted in his illustrious brother's "Cosmos," "longs to pass the hills or the seas which embrace his narrow home; yet, when his eager steps have borne him beyond those limits, he pines, like the plant, for his native soil; and it is by this touching and beautiful attribute of man—this longing for that which is unknown, and this fond remembrance of that which is lost—that he is spared from an exclusive attachment to the present." Gentlemen, the best answer to a question hardly needing or deserving any reply is a slight sketch of this obelisk's history.

Fifteen hundred and fifteen years before Christ, on the 7th of May, the greatest monarch of his time, Thothmes III, ascended the throne of the Pharaohs. To celebrate a grand recurring festival, which fell but once in thirty years, having caused this stone to be quarried at Syene, he set it up, with its fellow obelisk, in his imperial city of On, as the crowning triumph of the day, on the 28th of August, B.C. 1502. Curiously enough, it was almost exactly thirty-three centuries before the battle of Alexandria. Two or three hundred years glided by, and then came Ramses II, the great Sesostri of the Greek and Roman historians, who did him homage as the mightiest of Egyptian heroes and conquerors. Sesostri could think of no more honoured place than these obelisks at On for recording, in the same mysterious hieroglyphic character which the genius of Champollion first taught modern Egyptologists, like my friends Dr. Birch and Mr. Basil Cooper, to decipher, the glories of his reign. Heliopolis, or On, was the only university of the world. To that university-city came Joseph, and thither he brought his brethren; thither, too, he brought his father Jacob. It was the imperial city of Lower Egypt. After Joseph, Moses was sent thither, the adopted son of the Pharaohs, to learn all the wisdom and science of the Egyptians. After him Euclid, Eudoxus, Pythagoras, Plato, Herodotus, and a host of others, whose names are illustrious in ancient history, came thither to study. Twelve centuries from Sesostri saw something of the decadence and the fall of On; and so we come, after passing by such names as Cambyeses, the great Persian conqueror, to the time of the famous Queen of Egypt, Cleopatra, with whose history the name of this obelisk is so intimately associated. Forty or fifty years before Christ, she tempted the great Julius Cæsar, and afterwards Mark Antony, to visit Egypt, and she, no doubt, initiated the removal of these two obelisks from On to decorate the temple of her deified lover, Cæsar, which she founded

in the then great metropolis of Egypt—the Greek city of Alexandria to which had been transferred, in all probability, the libraries, professors, the learning, and the wisdom that had been accumulated and concentrated at Heliopolis. The battle of Actium cut her reign and her life; and it was not known until my brother made some excavations which he made in the course of our removal of our English obelisk, had the good fortune to discover one of the bronze crabs which the Romans had put under the corners standing one to support it, and found an inscription on the large of one of the crabs, that, in the eighth year of Augustus (B.C. 23), Barbarus, the Prefect of Egypt, caused these obelisks to be erected by Pontius the architect. One of my good friends, writing me, has adduced a course of argument, which, to him, makes it clear, that the Pontius who erected these obelisks at Alexandria was the grandfather of the Governor of Judea, the celebrated Pontius Pilate. Whether it be so or not, I do not know; but one thing strikes me in considering the grandeur of the great Cleopatra's and especially her fine buildings, viz., the truth of a reflection made in a work on obelisks by Mr. W. R. Cooper. He observes that when the reins of supreme power have been held in the hands of a woman it has, in all periods of history, been exercised with singularly with singular discretion, and has been marked by works of singular magnificence.

I have now brought you down to about the time of Christ when this obelisk was set up in Alexandria. How it came to be taken down we have no record; and we must pass on over eighteen centuries to arrive at the time when history again enables us to refer to the vicissitudes which have befallen it. Two obelisks were placed at the entrance of the great temple of the Cæsars, to denote the Water Gate. One of them is still standing on a base, the top of which you see before you; it is a counterpart of the base on which the dummy obelisk I have erected on St. Stephen's Green is placed. You therefore see, that that base is no suggestion of any man's architect's brain: it is a copy of the old bases on which the obelisks stood at Alexandria; and, in all probability, the original bases themselves were moved to Alexandria at the time the pair of obelisks were carried thither from Heliopolis. Whether that be so or no, they stood; and for eighteen centuries we know little of their history. Probably the obelisk, which is now our own, was thrown down for the sake of abstracting the four bronzes which had been placed under the corners to support it, for why the corners are rounded off, as you see them at present, I cannot otherwise imagine. It is, however, probable that nearly all the obelisks of Egypt have their corners so rounded, and these bronzes were placed there to support it. I think it is likely that to that cause we may attribute its overthrow. At any rate, nothing was heard of it until 1801, when the Army and Navy of England endeavoured to remove this obelisk as a trophy of their victories. They were stopped in that endeavour, and the matter was then allowed to drop. In 1871 I happened to visit Egypt. I went to the spot where this obelisk lay: I considered its size, I regretted

in all its bearings, and I considered it was a pity it should be allowed to go to destruction, for I felt we were not wholly a people who solely regarded the monetary view of a thing, but that we had some feeling and some aspirations above that. I said to myself, "I think the time will come when we shall see this obelisk in England." I worked on, assisted by my brother and other friends from time to time. We inspired paragraphs in the papers. We took other quiet means of moving in the pursuit of our object, and so we went on until, in 1875, I had the pleasure of making the acquaintance of the distinguished General, whose ill-health, I regret, has prevented him from filling the chair to-day. General Alexander told me what he had done. I found he had obtained a great deal of information. We combined our forces and worked on together, until at last we found ourselves in this position, that we had prepared perfect plans for moving the obelisk. Everything was arranged, but there was still wanting the one essential in all operations of this character—those sinews of war which are absolutely indispensable. It was then that my distinguished friend, Professor Erasmus Wilson, magnanimously stepped in; and to him, and to him alone, if ever this obelisk shall reach—as I trust it may—the shores of England, when it shall be erected here, the thanks of the English nation will be directly due for that monument which they will then possess.

Such being the history of the obelisk, I think no one can say that it is not desirable that it should be preserved from destruction. It is the greatest monument of Egypt's greatest princes, the most interesting record of Egypt's interesting history. As such, I hope that the time may not be far distant when we may see it presented to the English nation as its heirloom for ever, and to the city of London. No doubt difficulties have surrounded us: we have some still to get over; but, in saying that, our thanks are due the more to every one who has hitherto so cordially assisted in the enterprise. I will also say that I do not believe the very good-natured Glasgow gentlemen, in whose hands, owing to our disaster, the obelisk at present lies, will be wanting or will be any exception to the rule.

We may now pass, I think, to the subject of more scientific interest—the removal and erection of these obelisks; and the first question that naturally arises is, How did the old Egyptians do such work? Well, notwithstanding all their bas-reliefs and all their monuments, we have no decisive record of how they moved an obelisk. Obelisks of colossal size, even with the Egyptians, were not very common. They can almost be counted on one's fingers; and we cannot find any record of the mode in which they were erected. The distinguished Director of Art at South Kensington gave us a vivid picture a few years ago, in a painting exhibited at the Royal Academy, of the method of moving one of the great Assyrian bulls, and that was simply by sheer brute force. But in the erection of these obelisks I believe that the Egyptians exercised a little more skill. Egypt is a land where sand is not scarce, and I have long thought that the use of sand would be found possibly to be the simplest and most efficient way of erecting or lowering these monuments. My friend, Mr. Baker, to whose kind

assistance throughout the whole of this work any engineering success—should success ultimately be obtained—will most mainly be due, was talking to me the other day, when he happened to mention the curious fact of the enormous weight that a simple packing case filled with sand will support, and of the pressure that must be brought to bear upon it before it will burst. It struck me that a very simple solution of the problem before us may be arrived at from that little fact. Instead of raising a big mound of sand round the entire obelisk, the building of two slight walls on either side and the filling in of the interstices with sand would almost suffice to do the whole thing. For you will see as the obelisk begins to rise from the horizontal, so rapidly does the weight which you have to handle diminish, that after you get it to about that position, say about sixty degrees, you will not have more than a third or one-fourth of the whole weight to operate upon in order to haul it by ropes over to the vertical. I think very likely some such plan as that was adopted, because we do know that the ancient Egyptians always resorted to the simplest and most primitive way of achieving their objects. Well, then, after the Egyptians came the Romans. The Romans had to operate in a different country, and adopted different means, because successful engineering simply means the employment and adaptation of the materials which are most readily at hand. What might be good in Egypt would not be good on St. Stephen's Green; what might be good here would not be good in Rome. The Romans had the Apennines at their back; they had great forests of timber, and they erected their obelisks by the free use of that material. I have here through the kindness of Professor Donaldson, who has taken a great interest in our work, a very interesting old engraving of the plan of erecting the old obelisk of the Vatican by the architect Fontana, in 1586, and you will be able to trace it without any elaborate engineering explanation. They built round it a pile of timber higher than the obelisk which they had to lift. They lifted it by blocks, ropes, and tackles, by the employment of the joint labours of 1,500 men and 140 horses, into its place in about a month. Then the French improved upon that. The French plan of erecting their obelisk in 1836 was not materially different from Fontana's; but they did considerably economise material. They did not build the staging above the obelisk, so that they could get hold of it with ropes and hang it from the top; but they ingeniously devised some shear legs that would rise and fall as the obelisk ascended. Practically, however, it was the same system as that adopted by the old Romans. Since 1836, considerable changes have taken place. Various mechanical contrivances have been invented, and new materials produced for our use, and it would not do for us at the present time to remove our obelisk by plans which sufficed even forty years ago. We must resort to something different, and not only must we do so, but we have no reason to adhere to the old plans; for we have now facilities in the utilisation of iron and mechanical tools which, even forty years ago, were unknown. Therefore, when this obelisk had to be moved, I looked upon the site on which it lay, and saw it reposing behind an old quay wall at Alexandria.

The waters of the Mediterranean washed the foot of that wall; but the depth at which a ship competent to carry such a stone could approach, was far distant. How to get the vessel to the obelisk, or the obelisk to the vessel, was therefore the question. The bed of the sea was sand; but under that sand, at a depth of a few feet, lay a bed of stone, and engineers in the present company will readily understand that to dredge the sand in the face of the strong side current was difficult with the rock underneath, and to blast the rock with the sand above it was equally difficult. It would have been a costly process; and then, even if the canal had been made, what was the ship that we were to get into it, in order to carry the obelisk? We were on an exposed coast with a heavy sea. We had a strong set of the current carrying in the sand; and we had also the fact that although our obelisk only weighed about 200 tons, as you may readily understand, a vessel able to carry 200 tons in one solid piece, would require to be a big ship. It would require her to be peculiarly strengthened, and we should at once get into very great expense. Also, we should get into great expense if we had tried to remove it through Alexandria. We could not have carried it through its narrow and tortuous streets without the expenditure of a fabulous amount of money in straightening the route; therefore, it was clear something different would have to be resorted to. It at once occurred to my brother and myself, that the simplest plan would be to let the obelisk lie where it was, and to build round it a cylindrical vessel in which we could enclose it, and which cylindrical vessel should have sufficient strength to stand rolling over the sea-bed until it reached a depth of water sufficient to float it. This seemed practicable and simple; and ultimately, after considering the whole question, we determined that that was in fact the only way in which, at any moderate cost, this obelisk could be put afloat. The crude ideas of the initiation of any undertaking are, of course, capable of material improvement, and the plans which we formed at the beginning of our labours were considerably different in many minor respects from those which were ultimately carried out; but in the main point the idea was the same. We knew that we had to enclose this stone in a vessel that should be strong enough to resist rolling on the dry land, and strong enough to resist pitching when it should be afloat at sea. That required a considerable amount of calculation, but I took my tried friend Baker into my confidence, and we found that there would be no insuperable difficulty in carrying it out. We found that, perched up on the top of a wave, we should not have, under any circumstances, more than $\frac{1}{10}$ inch of deflection in the length of the vessel which we designed. We knew by calculation that we should not have more than $\frac{1}{4}$ ton per square inch of section of strain on the iron of that vessel at any point under the most adverse circumstances, and the investigations of the eminent chief engineer of Lloyd's have shown clearly that many of our ordinary and best known ships are exposed to strains of ten times that amount. Therefore, we came to the conclusion, that in trusting this old monument to such a vessel, we were not running any risks, or trying any novel experiment and endangering its stability,

and we felt that if this vessel should not have more than $\frac{1}{10}$ inch deflection while she was supported amidships, perhaps on the top of a wave, or lying in the hollow with her ends supported, no more than that could, by any possibility, be brought to bear on the stone which was to be her cargo. However, we provided not for $\frac{1}{10}$ inch but for nearly 4 inches of possible deflection, and gave the vessel an elastic cushion, which, under all circumstances, we felt might confidently be relied upon. Although the vessel is not home, yet she has survived rougher usage than in all human probability she can experience again, and we think that that experience may be applied to as some proof of the correctness of our calculations. The vessel was made 15 feet in diameter and 93 feet long, which we found of sufficient size to ensure the necessary buoyancy and the necessary flotation. We divided it into ten watertight compartments, and in this model you will see that the stone as it passes through each of the diaphragms, is supported by a wooden wedging and packing, which gives the necessary elasticity, so that if the centre of the ship is bent or struck, it might deflect to the extent of three to four inches before any unreasonable strain was brought upon the stone. Each of the nine bulkheads is made watertight, and between the bulkheads we have got two frames carried right round to ensure the stiffness of the plating. Now it must be perfectly apparent to any one that a tubular form gives the greatest strength, and that by adopting that form and avoiding all straight surfaces in the parts upon which a strain could come, we were making the greatest economy of materials. The vessel was placed round the Needle; for all we did was to let the old stone lie. We did not attempt to disturb it, except that as it was lying quite parallel with the sea, we brought the end of it round and lifted it up on some wood, and cleared away the sand. We then set to work, and put these diaphragms round it, and after we had fixed a few of the centre ones we riveted to their periphery the iron shell of the vessel. As we went on towards each end building up this great round rolling-pin we cleared away those chocks which supported it, and moved them back to the part which was finished. So, by degrees we proceeded, until at last we had a round iron structure somewhat like an enormous boiler, with the ends sloped off, lying before us. We had then no cabins or masts upon it; but we had this to contend with that for the sake of the future requirements of the vessel we had the stone four inches out of the centre. Instead of building the vessel exactly round the centre of the stone we had built the vessel four inches above the centre of the stone. The top plating of the vessel is also not so thick as the bottom plating; consequently it will be at once apparent that we had this difficulty to provide against, that as it was rolled down the sloping sea beach into the water, we had fear, as soon as over the heavy part got over the perpendicular, a great lurch forward, which would have been inconvenient. We therefore made a recess in the round skin, where the cabin was afterwards to be built, just sufficient to hold the necessary quantity of old rails packed close in that recess, to counter balance this inequality. These old rails would afterwards, when she came to be afloat, and they were tra-

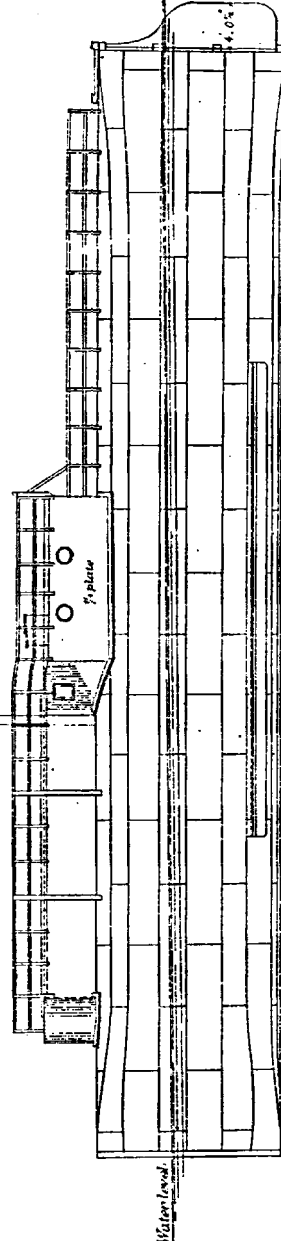
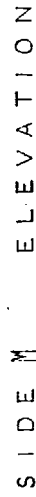
ferred to the bottom of the ship, serve as the ballast to keep her permanently and safely in the position which we desired. The launch was successfully carried out. Some little difficulties, as always is the case in these matters, did occur. We had foreign workmen to contend with, with whom we could not converse as readily and as intelligibly as I can talk to you, and it did, I will not hesitate to say, so happen that although we had provided ten watertight compartments, and made them perfectly watertight, yet one little circumstance neutralised all our care. We had arranged that any compartment might be pierced by any of the stones lying on the beach over which we had to roll it, we had removed a great many of the largest stones, though no doubt there were stones almost covered with mud and sand which we could not see, and which when the weight of the vessel came upon them would be left standing up. We foresaw that, and we put round the cylinder on the two points where it was likely to take the greatest weight, a skin of timber. But we were not to get off scot free; and within about twenty yards of the point where the vessel was to have floated—after rolling it, I should think more than 200 yards—a stone pierced the hull just past the end of this timber, and filled the compartment with water. Now I shall never be hard, and never be severe, on any naval captains, or anyone else after what occurred. There were six or seven of us, with every inducement to pay every attention to that vessel. There was Mr. Waynman Dixon in actual charge of the operations, the others looking on. We had provided bulkheads, we had provided watertight doors through them, and we had so carefully managed that the man whose duty it was to close these doors had forgotten to do so, and all were left open! There is nothing like confession, because it may induce other people under similar circumstances to avoid such mistakes; but so it was. Therefore as soon as ever a hole was made in this end compartment, the whole ship filled, and we had a water-logged vessel lying within two feet of flotation, carrying 300 or 400 tons of dead weight in 9 feet or 10 feet of water, to operate upon. However, there is an old saying that Providence helps those that help themselves. We fortunately did not encounter any rough weather, and the measures which we took for getting her into deep water were very soon successful; but this little misfortune and consequent delay, prevented His Highness the Khedive of Egypt from being present at the final floating out of dock, which he had heartily hoped to witness.

Such being a general description of the vessel, and of the operations which we conducted, I may now be pardoned if I draw attention to a few of the more scientific questions which arise, and to be clear on these I have taken the precaution to put them into writing.

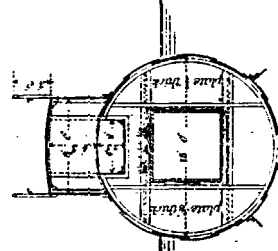
It will be seen that a circular form of ship was suggested; or it might almost be said dictated, by the plan of building and launching determined upon as the cheapest and best under the peculiar circumstances of the case. It can easily be shown that, apart from the latter considerations, the circular form offered many advantages.

In the first place, weight for weight, no other form of ship could compete with the tubular one as regards strength and stiffness; the latter an especially important desideratum when the load is a monolith,

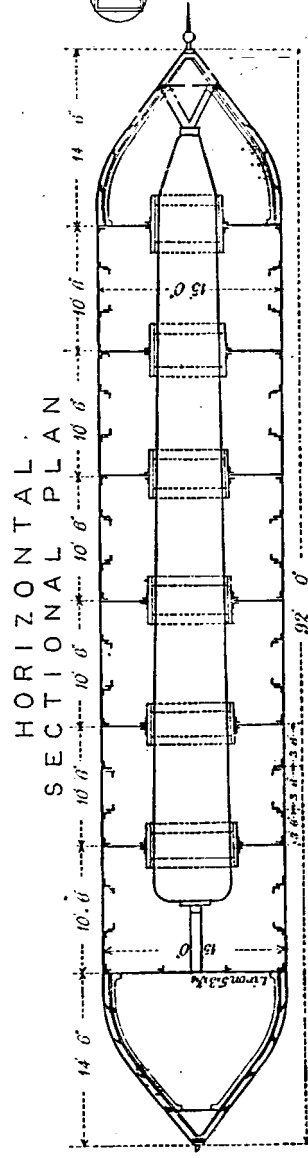
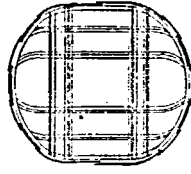
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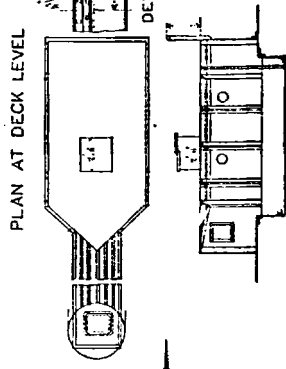
CROSS SECTION THROUGH CABIN



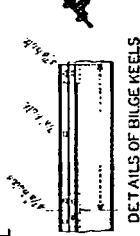
SECTION AT A.B.



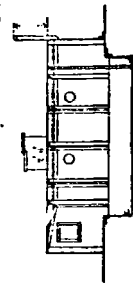
HORIZONTAL SECTIONAL PLAN



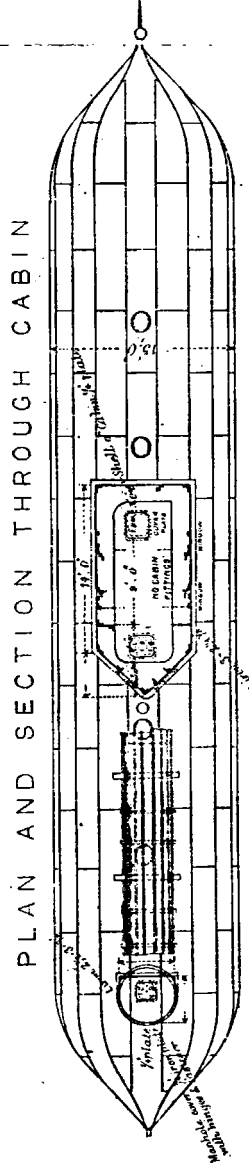
PLAN AT DECK LEVEL



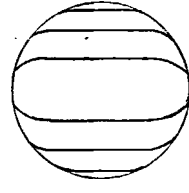
DETAILS OF BILGE KEELS



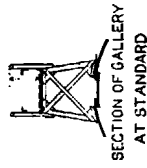
LONGITUDINAL SECTION OF CABIN



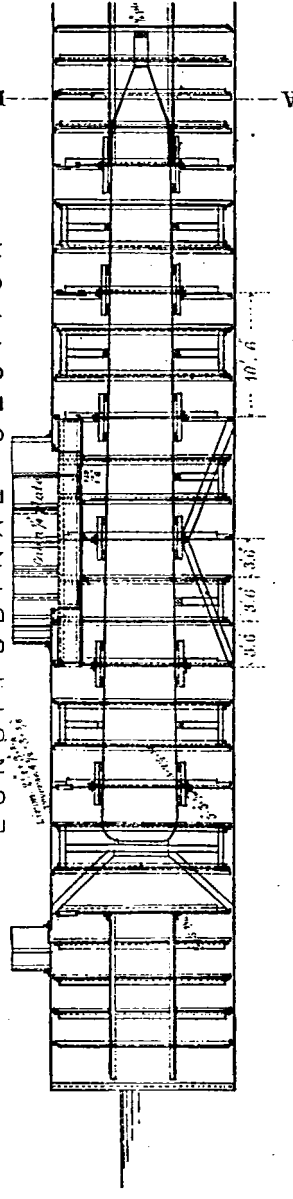
PLAN AND SECTION THROUGH CABIN



LINES AT BOW AND STERN



SECTION OF GALLERY
AT STANDARD



LONGITUDINAL SECTION



GENERAL SECTION
OF GALILEY

as in the present instance. The plates being everywhere curved consequently well adapted to resist fluid pressure, we were enabled to dispense with one-half the number of frames prescribed by L. rules, and to lighten the construction in other respects. Indeed, from an engineering point of view, the advantages of the tubular construction are self-evident: it is only when we look at the matter from a sailor's point of view that the necessity of a most careful and scientific investigation of the whole question becomes apparent.

We had no direct experience to guide us as to the probable behavior of our little ship. It was necessary to rely upon theory, and we have proved our guide to be thoroughly trustworthy. It may be interesting to refer briefly to some of our conclusions.

The question of rolling was obviously the all-important one in the present case. A circular ship must evidently be the easiest to roll in water as on land under the influence of an applied force. Our circular vessel, unloaded and unballasted, could be turned round and round in the water, like a treadmill, and the only resistance to the movement would be the "skin resistance" of the iron plates and the so-called "keel resistance" of the pinched-in ends, which would absorb a small amount of force in churning up the water fore and aft. A square rectangular cross section—a square tube in short—similarly unloaded and unballasted could not have been so rotated, because of its instability of form. Again, suppose we put an equal quantity of ballast in the two ships, heel them over forcibly to a given angle and let them go simultaneously, which would come to rest the quickest? Obviously the square ship, for it could not roll without displacing large volumes of water at each oscillation. A great wedge of water would have to be displaced on the depressed side and a corresponding vacuum, in which the water must rush, would be formed on the other side, and waves would be generated, which would absorb power and gradually extinguish the movement of the ship. There would be nothing of the kind with the circular ship.

The principles of mechanics show that the circular ship would not roll true, generate some waves by reason of a slight lateral movement of the axis of the cylinder, but the waves would be relatively insignificant in size and absorb but little power. The circular ship would, therefore, be practically dependent upon skin-friction to bring it to a stop of rest, and this retardation is of course shared in alike by the circular or any other form of ship. In one sense of the word, then, a circular ship may be said to be the worst for rolling which could be devised, because she would be easily started and not readily stopped. Is it in this sense of the word that we are concerned? We are not interested in knowing how quickly or how deeply we could roll our ship, by marching crew from side to side on her deck or by pulling her from the shore. What we want to know is how much the waves will roll her if we abandon her to them, and let them do the worst, and that is a very different thing. Looked at from this point of view, the circular is the very best instead of the very worst for rolling, but to make this clear it will be necessary to say a few words about waves.

When water is at rest the different particles are acted upon by gravity alone, and as they are affected equally, the surface of the water is necessarily horizontal. When waves are formed, the different particles are affected by gravity as before, but combined in this case with the centrifugal force due to the circular movement of the particles in the wave, and the surface of the wave assumes a position at right angles to the resultant of the weight and centrifugal force. If the particles of water at the surface of a wave are in equilibrium when standing at a slope instead of horizontal, as in still water, so will any body floating on the surface of the wave be in equilibrium. For instance, a man standing on a raft floating on the surface of the waves would not have to find his "sea legs," or maintain a vertical position by bending his knees alternately as the raft tilted to the one side or the other, he would simply stand square to the raft at all times; and so when on the slope of the wave he would be inclined inwards just as is a rider in a circus, and for similar reasons. If the man held a plumb-bob in his hand it would not hang vertically but at right angles to the surface of the wave, and from the operation of the same forces every ship which tends to stand vertical in still water tends with equal force to stand perpendicular to the "effective wave slope" in disturbed water. It is necessary to draw a distinction here between the "effective wave slope" and the "surface slope," because the ship, unlike the raft, is affected by the deeper layers of water.

It is quite unnecessary to involve ourselves in the difficult and obscure theory of the reaction of the particles in a wave. It is sufficient for our purpose to know that it has been clearly established, by the profound investigations of Rankine, Froude, and others, that the same attributes which tend to keep a ship steadily vertical in still water will tend to throw her forcibly out of the vertical on a wave slope. In other words, a very stiff ship will be a very bad roller. This theoretical truth has been but too frequently exemplified in practice. The early ironclads, both of England and France, were enormously stiff, and, as a consequence, rolled perhaps 60° and made 12 or 13 rolls a minute, whilst our modern and relatively unstable ships would, under the same circumstances, roll but one-third as fast and one-third as deeply. We may take it then as proved, that an unstable ship is, in virtue of its instability, steady amongst waves, and we might reasonably conclude, as we did, that our cylindrical ship would, from its exceptionally unstable form, roll to an exceptionally small extent, unless we spoilt her by over ballasting or a bad distribution of the weights.

Suppose that our tubular ship was of uniform thickness, and that the Needle was placed exactly in the centre, she would then have no stability, but neither would she be affected by the waves, which would simply move her up and down gently as they rolled under her. She might turn round a few times daily, as a general resultant of the action of the wave particles and the skin-friction, but she would not roll at all in the usually accepted sense of the word. But, as we intended to put a cabin on the top of the cylinder, it was obviously essential to keep her right-side-up, and the important question was,

what was the happy medium, in the way of stability, which w make the ship stiff enough to stand up against a gale and yet leave crank enough to roll little, if any, amongst the waves.

After a careful consideration of the question in all its bearing was decided to give the ship a metacentric height of 9 or 10 in or, in other words, to fix the centre of gravity at that distance b the centre of the cylinder. It is hardly necessary to remark, tha stability so provided is exceptionally small, and that some exce authorities thought we were taking a rather bold step in so limi it. Experience has, however, fully justified the course we adop The obelisk was placed about 4" below the centre of the cylinder, when the latter was towed round from the old site of the obelis Alexandria harbour, the stability was wholly dependent upon position of the obelisk and upon the little extra weight in the bot plates of the cylinder. There was no ballast whatever in the s and her metacentric height could hardly have exceeded 4 inches the top of the cylinder was covered with Maltese and Arabs, sat quietly on the iron skin, with nothing to save them if the v had made a roll, which she never did to the smallest extent, tho the beam-sea was so heavy that the tugs accompanying her r sponsions under.

When the "Cleopatra" left Alexandria for her homeward voyage had 20 tons of iron ballast on board, and her metacentric heigh what is the same thing in this case, the distance of the cent gravity below the axis of the cylinder, was 9 inches. Her total placement was about 290 tons, and the radius of gyration was 4.75 f These elements are all that are required to enable us to form estimate of the "period of the ship" or the number of second which she would make a roll from starboard to port and back ag The "period" of a ship is a very important factor in her sea-g qualities, and it is always ascertained for every ship in our own foreign navies. A slow-rolling ship is not only a more comfort ship, but also a safer one, as she is less likely to suffer from accumulated rolling which occurs when a vessel is amongst wave the same period as herself.

There is an obvious analogy between the rolling of a ship and swinging of a pendulum; all we want to know is the length of pendulum. It might at first appear that the lower the centre of gravity below the axis of our cylindrical ship, the longer would be pendulum, and the slower the oscillation of the ship, but exactly converse is the truth. The number of double rolls a ship makes i minute is directly proportional to the square root of the metacen height, so that, if we doubled our stability by lowering the centre gravity, our ship would roll $\sqrt{2}$, or 1.4 times as fast as before. number of rolls is again inversely proportional to the radius of gy tion. The length of the pendulum which would oscillate in the s time as a ship rolls in still water is simply obtainable by squaring radius of gyration and dividing the product by the metacentric heig In our case it is 4.75 feet square divided by .75 feet = 30 feet. N a pendulum 30 feet long makes a double oscillation in $\frac{1}{6}$ secon

and we therefore may conclude that the unresisted rolling of the "Cleopatra" would be performed at the same rate.

The addition of bilge-keels and the skin-friction causes some water to accompany the rolling ship, and so, in effect, adds to the moment of inertia and increases the period of the ship. It may be added that 6 seconds is an exceptionally good period for a ship of the size of the "Cleopatra." Very few gun-boats roll so slowly, and many of the earlier ironclads, in our own and foreign navies, rolled faster.

Our investigations led us, therefore, to anticipate that the "Cleopatra" would, from her unstable form and high centre of gravity, roll but little when amongst the waves; and that if she were started rolling by the wind, or otherwise, she would roll easily and slowly. Events have justified these conclusions.

As regards pitching, greater difficulties presented themselves. We could not stow our cargo as we liked, or, in the interests of the comfort of the crew and ease of stowage, we should have broken the needle in two and stowed the two halves side by side in the centre of the ship. However, we were compelled to carry the obelisk intact, and to put up with the resultant pitching and discomfort. In order to ease the ship as much as possible in lifting to the waves, the obelisk was stowed thick end foremost, so as to take advantage of the law, that dynamical forces vary as the square of the velocity, and not as the velocity simply. To illustrate the effect of this, imagine the needle-ship, when resting in smooth water, to be seized by the stem and lifted up by a force sufficient to impart to the bows a velocity of say one foot per second, and suppose, farther, the stern to be similarly lifted up, then, upon a comparison of the intensity of the two forces required to impart the given velocity, it would be found that it was about seven per cent. easier to lift the bow of our ship than to lift the stern. It is not unreasonable to assume that easiness of pitching would, other things being the same, be proportional to the ease with which the bows rise to the waves; and that by stowing the obelisk as we did, an appreciable advantage was obtained.

It is only fair to remark that, in consequence of a slight leakage at stem and stern, a considerable quantity of concrete was unfortunately filled into the extreme compartments of the ship in Egypt. This un contemplated modification of the design, of course, added seriously to the severity of the pitching. It was equivalent in effect to hanging the best bower anchor of one of our largest ironclads over the bows of our little ship, and a similar anchor over her stern, and probably if those who had charge of the ballasting had seen the weight in that form they would have found some means of getting rid of it.

The form of bow obtained by "pinching in" a ship a circular cross section is obviously not the most favourable as regards pitching, because the lifting force is less than in a bow with vertical sides, and the water acts on the back of the cylinder and weighs it down. To remedy these defects as far as possible, the bow was made as full as was consistent with a reasonable expenditure of power in towing, and a turret was placed on it to split the seas and throw the water off the forward end of the ship. Captain Carter reports that the desired ends

were achieved, as the ship, after plunging into a wave, rose at and shook the water off her back "like a duck."

The preceding brief review of the considerations which led to design of the needle-ship will, it is hoped, afford a sufficient justification of the perfect confidence with which we entrusted the valuable and irreplaceable cargo to her. Had the ballast not shifted, she, humanly speaking, have been certain to do the work with safety and dispatch. Unhappily, the tendency of the ballast to break loose was under-estimated by those who stowed it, and perhaps not unnaturally so; for M. Bertin, the great French authority on rolling, has shown that, in order to keep matter in place in rolling, we must reckon efforts at least equal to two-thirds of the weight for the hull, and four-thirds for the masts, even in still water; and of course at sea the stress will be far greater. It is more a matter of regret than surprise, therefore, to find that the ballast broke loose in the fearful wave encountered in the Bay of Biscay.

I may perhaps simply illustrate the few remarks I have made by a diagram which I have prepared here. I said that standing on a wave, lying on the slope of a wave a man would not require to shift his legs, but he would simply stand at perfect ease, and for this reason. Suppose I have a trough half filled with water up to that level. On the top I have two supports, one carrying a ball suspended in one position, the other carrying a ball suspended in this position. I take that trough in my hand, and I give to it practically the centrifugal force which the particles of a wave possess: what occurs? You will see at once that the water will fill itself up at the far end of the trough, somewhat in the position I have shown here. You will also see quite clearly that that weight will swing itself into that position owing to the result of the same centrifugal force. When the water is in that form, or when the part of a wave surface is created, the body which is floating on it is influenced by the centrifugal force, and stands still perpendicular to it, just as it did when it was vertical on the surface and the water was horizontal. But mark this. There the weight is suspended by a thread. What is the result instead of being suspended by a thread which can swing out and be suspended by the centre, or an equal weight placed upon it? If you put two equal weights on the end of this stick and send it round as fast as ever I choose, it will be perfectly apparent to you that the vertical position of the stick will remain the same; it would never be changed. The case would be very different if I had the weight suspended from the bottom, and took hold of the stick at the top. There it would swing out in proportion to the centrifugal force; so that in this position I have endeavoured to show the effect of the position the body assumes on the surface of a wave; and if you will regard the centre of buoyancy of a vessel, or rather as her metacentre, and regard this as the centre of gravity of the weight of that vessel, you will find as those two centres approach each other, or get into equilibrium, the vessel has a tendency to become stable, or rather to stand steady in the position in which it was. It has no tendency to be that position disturbed; but in this case where there is a great

ence between the metacentre and the centre of gravity, there the slightest force brought to bear, at once tends to throw out the centre of gravity beyond the metacentre, and to pitch the vessel. But it must be perfectly apparent to you all, that in still water this weight which is hanging over the centre will have a far greater tendency to keep in that position than the weight which is supported on its centre. Very little will make this swing, as a very little would make our ship roll in still water. It requires a great deal of force comparatively to make this move, and hence you have the difference between the two points, and have a low metacentric height and great steadiness, and great metacentric height and great stiffness. Stiffness and steadiness are in contrast the one with the other.

The Needle-ship at present rests at Ferrol. I do not know when she may be here, but I think you may reasonably look to her appearing in England. When she does arrive alongside the Thames Embankment, the circular form of our ship holds us in good stead, the same as it did at the Alexandrian end. We shall float it at high tide on to a stage, let it rest on the stage, strip off all its excrescences, and then we have nothing but a round cylinder that we can roll, as we did before, wherever we may land it, and we can get it to the site upon which it is to be erected. Now imagine that the obelisk is on that site. I am going to explain to you, if I can, the plan we purpose adopting for erecting the monument. We shall have the obelisk, we will imagine, lying on the ground. We will strip the remaining skin of the cylinder from it, and we shall proceed to put round it a jacket in iron somewhat similar to this. We shall have the means of lacing these stays so tight, that when the time comes that we have to turn it, endways, and hold it upright, it will grip the stone with sufficient force to prevent its slipping out. We then simply bring into use the most primitive contrivances possible; for they are often the best. We simply put a small hydraulic jack, a thing any two of us could lift, under one end, and we lay a number of timbers across the ground, and then we lift the other end, and do the same. Then we lay some longitudinally, again some across, lifting the stone each time, and so we go on, as you see, gradually rising, until at last we get into a pile of timber something like the model which I have before me, but, I may say, not so close a pile as this model shows. The timber is not damaged; we do not have to cut it. We simply use it for piling, and consequently it will be a very inexpensive process, as well as a very safe and simple one. We raise by that means the stone and its jacket up to the height we require. We have adapted this jacket to the centre of gravity, so that there is a little preponderance at the heavy end. We get it up to about this height, and then you will see in a moment the object of this framework, which is meant to represent two iron girders. If we had a stack of timber, and the Needle lying on it with these trunnions at the side, it could roll round; but it would catch the pedestal as it swung. It requires therefore to be raised a few inches clear, or, what is the same thing, we must have the means of lowering it after it has swung into its vertical position. To get that, we purpose using an iron frame. We shall simply take the ordinary iron girders, rest them

on the wood at one end, and under the other end, we shall put the same hydraulic jacks that we have used throughout for lifting. We shall, when all is arranged, find ourselves with an object before something like a monster cannon on its carriage. We, having nothing then to do but quietly to allow the obelisk to swing round. We shall not allow it to swing quickly, but we shall have ropes and controlling tackle, which will have a very slight weight to control, as we shall only have two or three tons preponderance at the heavier end. We shall then lower the end of the girders by turning the taps of the hydraulics which support them, and let down the stone upon its pedestal. Nothing will then remain but to unfurl over it the Union Jack of Old England, "the flag that has braved a thousand ye" "the battle and the breeze."

Major GRIMSTON: May I ask how it was that the obelisk was found on beam ends in the storm, and if it was the ballast that shifted, where had it shifted to?

Mr. DIXON: The ballast was stowed, as you see, here, by an arrangement of timber. When the vessel rolled, the rails slipped over to leeward, and the arrangement came loose; as she went over to the other side, the rails followed.

Admiral JASPER SELWYN: Major Grimston has touched on the only point on which I should like to say a word. I do not think it well that this Institution should listen to a paper attacking the grave question of the stability of our ships, without our noticing the anomalies which seem to present themselves. First of all, I would like to congratulate Mr. Dixon on the ingenious manner in which he conducted his operations, and on the success which attended them, so far as he was concerned with the engineering operations on shore. But when we come to the question of the position of the centre of gravity and the meta-centre, I think there are very considerable errors involved in the paper to which we have listened. Those gentlemen who take the trouble to instruct us on the behaviour of our ships floating on the ocean, would be kind enough to say, instead of "unstable ship," "capsizable ships," we should know what they meant; but they begot themselves and us by calling a ship a stable ship which has an inclination to capsize, and an unstable ship the one which sailors would call a very stable ship—one which has an inclination whatever to turn over. Now here, for the purposes of the obelisk, there is no doubt whatever the position chosen for the metacentre was perfectly correct for smooth water, but the centre of gravity might possibly have been a little lower and answered, without any ballast, just as our iron ships might have been but sufficiently well not to require cement and bricks to be put into them afterwards to keep them on their legs. As to the position which Mr. Dixon has imagined can be taken on a raft, I am sure it is not one which any seaman has ever been able to keep. I think centrifugal force and moment of inertia are not quite the same things. We do find it is necessary to keep our vertical position even on a raft: it is only because the moment of translation has been supposed to be so excessively rapid as to produce a totally different effect from what it really does, that I believe Mr. Dixon has gone rather astray on the subject. The true fact with regard to the raft is, that it does take the inclination of the wave, and that it does not pitch or roll in the ordinary sense of those terms; but that it is a bit more pleasant to be upon, a bit less liable to be swept by sea, or a bit less fitted for that stability which is part of its nature, I cannot at all recognize. Then, as to the stowage of the obelisk. I should like to ask, does Mr. Dixon mean that, in putting the heaviest end of the obelisk forward, he desired to have a greater weight in the bows, in order to ease the pitching?

Mr. DIXON: No; the centre of gravity determined the thing, and having that thick end forward, that end is less in advance of our centre of gravity, so that the end of the stone was further from the end of our ship than if we had put the point that way. The centre of gravity of the obelisk is at one-third of its length. If

had put *this* end towards the bows we should have had the weight nearer the bows, but by putting *this*, we have a long empty space in front of our ship. (See Plate.)

Admiral SELWYN: I am very glad that I induced Mr. Dixon to make that explanation. As regards the further dealing with the obelisk after its arrival here, which I hope will be safely carried out, I think Mr. Dixon will acknowledge that an engineer would scarcely adopt the same plan for taking it through the streets of London to its destination, as was perfectly efficacious on the shores of an open sea-beach, and that the additional strength of the cylinder would not compensate for the additional difficulty in carrying it to its destination. Probably engineers will take the very easy and well-known plan of laying rails sufficiently strong to bear the weight and take it to its destination in that way. I have the utmost admiration to bestow on the ingenious nature of the mode of raising the obelisk. I think that could not be better done in any way. It is the highest engineering, because it is a contrivance which secures its object with the greatest possible simplicity. For that reason alone I admire it very much. I should wish to say one word with regard to the passage of the vessel from Ferrol. I do not know whether Mr. Dixon has used hemp cables hitherto.

Mr. DIXON: Wire.

Admiral SELWYN: Even steel wire is not equal to chain. I have had some experience in towing, and we found invariably the catenarian curve of the chain cable was brought into play so quickly as to act as a perfect spring, and that when we could not tow with hemp cables, we could tow very comfortably and easily with chain. Steel hawsers of modern days have to a certain extent replaced everything else; they have great relative strength, and they are very easily handled, but as all ships have not steel hawsers, the chain cables may be useful as a supplement. As the question of carrying persons on board the "*Cleopatra*" seems to have received attention, I would ask whether it was considered necessary to put people on board to watch what they immediately abandoned as soon as the vessel herself was cast adrift. I do not understand why this vessel was not perfectly safe against everything but the point of a rock. I believe she would float to all intents and purposes for the next twenty years on the waves of the ocean without danger, and I do not see that it is any use to have men on board to look on at what must be a very unpleasant operation—towing through a heavy sea—unless they stick to their ship when she is cut or breaks adrift. With these few words, I think I am justified in saying that the sailors of the Institution must congratulate Mr. Dixon on the extreme ingenuity and talent which he has brought to bear on a most difficult engineering operation connected with the seaman's profession.

The CHAIRMAN: As no other gentleman rises, I would ask Mr. Dixon if he can give us any information with regard to the site where the obelisk is to be placed. Some people say that the proposed site is too near the Underground Railway. If he has anything to say as to a more eligible site, we shall be glad to hear it.

Mr. DIXON: Perhaps, before replying to your question, you will excuse me if I reply to the very pithy remarks made by Admiral Selwyn. I know that there is a good deal to be said about a raft, but in a lecture you are bound to cut it short. I am afraid I have been long, and one cannot go into all little details, and the points which cause the exceptions, and at which the truth of the theory you advance ceases to hold good, and I own if you remained upon a raft, it would neither be a comfortable nor a very stable position. But that in certain points on ascent of a wave-slope my theory holds good I think you will acknowledge.

As to towing by steel rope or wire cable I may say that the towing was done, as the launching was done, in great measure by one of the best and finest steel ropes I ever had the pleasure of watching. Mr. Newall was generous enough to present me with one of his very best. It towed without a single break or accident to the cable, and Captain Carter reported to me that if they had had a hemp hawser or anything else they would have had it broken half-a-dozen times. This question of spring was very carefully gone into. I have here very careful calculations as to what the versed-sine of the curve would be at the different speeds of towing, and up to what speed we dare safely venture before our steel rope would break. The same would hold good as to an iron chain; but strength for strength the chain weighs double as much as the wire ropes does. Now we never did have any difficulty from want of elasticity or

spring, and although a hemp cable might have given us more it could not answered better than the wire did. As to why the vessel was abandoned, we can only say, that if I had been on board I should have done the same. Captain Carter said, I was perfectly convinced theoretically that the vessel would not over, but theory had not provided for the ballast being loose, and it was perfectly certain if another sea had broken upon her it would have rolled her over. No, she would have righted in time, but the time might have been too long for the sengers, and with a crew of seven men on board to look after, besides myself, think it expedient to go on board the "Olga," in fact, if I had wanted to st board the "Cleopatra," not one of my men would have stood by me.

Admiral SELWYN: My question was, why you put the men on board?

Mr. DIXON: It was this. You will readily understand as a seaman that tow heavy lump behind you, which is not steered, is a very awkward thing indeed very different from towing a vessel which has men on board to direct it, so if you have to stop for fear of a collision in passing a vessel, or for any reason to slow your speed, in the one case you may do it with safety, because you know vessel following will quietly glide past your side, and in the other case you are in the awkward alternative of having this unwieldy mass coming on behind straight, and possibly another vessel to run into right ahead. I conceived it very probable that heavy weather might require the tow line to be cast off, in v case we should have men on board to show lights in case of collision, dang yourself, or to other vessels; also to keep the vessel's head to wind as she was fectionally handy; she is not built on the model of an Isle of Wight yacht, but s fitted with sufficient canvas to hold her own tolerably fairly in a rough gale.

Now as to the site. It is a very difficult question, and the difficulty may pe be illustrated by an experience of my own. A few weeks ago I was at an er meeting of about a dozen architects. Now if there be one special class of mer should be able to give an opinion on a site, it might be expected to be archi These architects discussed it very fully; each had his own opinion, some of ther two! but all of them agreed unanimously in disapproving what everybody else posed! so that I am afraid that it would never be possible to get all to agree, ever site should be selected. If we put it on the top of Primrose Hill, in defe to the opinions of some, we should have dissents; I can only say, though I d like to cherish any strong prejudices, and am always willing to accord to ever the same freedom of opinion which I claim for myself, that when I see such g men as Mr. Edward Barry, R.A., Sir Gilbert Scott, R.A., Mr. Edmund Street, Professor Donaldson, and a great many other very eminent architects—the De Westminster, Mr. Poynter, R.A., the Director of Art at South Kensington, Fowler, the eminent engineer, besides a whole host of others, all unanimou favour of the Parliament-square site, there seems to me no reason why we sl go against the verdict of the most eminent men in the profession, who of all c ought to be best able to give an opinion. And as to the engineering question, true that site does stand directly on the centre of the Metropolitan Railway. let us here mention an interesting fact which came to my knowledge only the day. Professor Donaldson kindly sent me the section of the great French colu the Place de la Bastille, and curiously the French have selected the top of the canal as the very place on which to put that column. However, irrespecti what the French can do, Mr. Fowler and the engineers say decidedly that th no difficulty about placing the obelisk on the top of the Metropolitan Rail further than that, they say at that point the Metropolitan Railway happens imbedded in ten feet of gravel and sand, which scarcely happens at any other j mate point, and with the mass of the railway you have an infinitely better fo tion and more stability than you would have if you stuck it up on the top of a piled foundation. All our public buildings that have been constructed withi last twenty years depend on the endurance of iron, and when a thousand c thousand years hence the girders we propose to carry that obelisk shall beg decay, the people of those days, I have no doubt, will be as able to replace th we were to put them there.

The CHAIRMAN: I think the time has arrived for us to close this very inter discussion, and I am quite sure you will appreciate the very agreeable lect

which we have listened. I congratulate the members of this Institution on being so fortunate as to get this lecture from Mr. Dixon as the opening lecture of the session.

I invite you now to accord your hearty thanks to Mr. Dixon for his instructive description of the obelisk, and all its operations connected with its transport from Alexandria, and his plans for erecting it near this place, and with our best wishes for his success.