over all, but to obtain its maximum lifting power gates were fitted, which reduced its practical length to 330 feet. Its inside width was 84 feet between side walls, and its lifting power was 8,000 tons, which was sufficient for the ships of the "Bellerophon" class, to lift which it was specially designed, although it was capable of bringing the keel out of the water of vessels up to 10,200 tons, the then heaviest ships of the day, represented by the long fully-rigged line-of-battle ships "Agincourt" and "Minotaur." The present dock is 545 feet long, and having no gates, the length of ship it can take is not restricted; its clear width of entrance between rubbing fenders is 100 feet. Its lifting power up to the pontoon deck level is 15,500 tons, but by utilizing the shallow pound this can be increased to 17,500 tons, and the walls are of a sufficient height to allow of a vessel drawing 32 feet to be taken on 3 feet 6 inches keel blocks.

The present dock is of the type known as the floating graving dock, the invention of Messrs. Clark & Standfield, of Victoria Street, Westminster, London, from whose plans it was built, and who also designed the famous Algiers dock and many other similar structures. It was this firm who designed the Havana dock, which was built and launched by the same firm, Swan & Hunter, in the record time of seven and a half months. Before describing the present structure it is interesting to note the work to be done by the new dock, which is of a somewhat varied nature.

In the first place, it is primarily intended to lift battleships of the largest class, displacing about 15,000 tons on a 27 feet 6 inches draught, and of a length of 390 feet, but with a bearing length of keel of only 343 feet. It has, however, also to deal with long cruisers of the "Terrible" class, of a displacement of 14,200 tons on a 27-foot draught, a length of 500 feet between perpendiculars and a bearing keel of 383 feet; and lastly, it may be called upon to lift the auxiliary steamships of the subsidized mail lines, of which the "Campania" may be taken as a type. This ship in full fighting trim may displace as much as 19,000 tons on a 31-foot draught, but in ordinary docking condition, without full coal supply aboard, her weight will be about 16,500 to 17,000 tons. The length of this type of vessel is 600 feet between perpendiculars, while the bearing length of keel is 502 feet 8 inches.

The following are the principal dimensions of the dock:

Length over all...........	545 feet.
Breadth over all..........	126 feet 2 inches.
Length of end pontoons...	120 feet.
Length of middle pontoon.	300 feet.
Breadth between walls...	100 feet.
Width of pontoons........	96 feet.
Height of vertical walls...	53 feet 3 inches.
Length of vertical walls..	435 feet.
Thickness of walls.......	13 feet 1 inch.
Lifting power up to deck level	15,500 tons.
Extreme lifting power....	17,500 tons.
Total weight of hull......	6,500 tons.

The dock itself consists of five portions, comprising three pontoons, which form the main lifting portion of the dock, and two side walls, which, while affording a certain amount of lifting capacity, primarily serve to give the structure stability and to regulate its descent when the pontoons are submerged. The pontoons themselves are of different sizes and form; the center one, which is 300 feet long, is rectangular in shape, but the two terminal ones, which are 120 feet in length, have each 71 feet of their length rectangular, the remainder being finished off in the form of a blunt-nosed point or bow. The sides of the rectangular portion of all the pontoons are built up so as to form a broad altar, standing 12 feet above the dock. The side walls, which are of the same length as the rectangular portion of the pontoons, come along each side of these and are attached there by means of strong steel castings, riveted to their respective outside skins, and connected together by double fishplates and tapered pins.

The pontoons of the dock are further divided into forty pumping divisions, of which thirty-two are absolutely watertight and distinct. The side walls have each eight watertight divisions. All these fifty-six divisions are provided with a separate pipe, each governed by a separate valve. The pipes in the starboard half of the dock are led directly into the main drain in the starboard wall, and all those in the port half to a similar drain in the port wall. These drains are continuous over the whole length of the walls, and the four 16-inch centrifugal pumps in each wall are seated directly on them, so that any one pump can empty all the compartments of its half of dock.

Although the dock is divided into fifty-six divisions, each with its own regulating valve, the working of the whole dock is all done from two central positions on the top of the towers. Here are grouped in the valve houses ordinary signal levers, which by means of rods and cranks connect to the different valves. Each valve house is in direct communication by speaking tubes with its engine rooms, so that the man in charge can manipulate every valve, both water and steam, required for the maneuver of the dock without quitting his station. Each valve is further fitted with an indicator, which shows on top of the valve house exactly which valves are open and which shut, so that the dockmaster can see from any conning position he may take exactly how his craft is being regulated on both sides.

It is interesting here to note the difference between the English and American methods of berthing a ship on a floating structure. The English custom, and also that of Italy and Japan, is to support the armor belt on more or less vertical shores inserted under an angle iron firmly attached to the same. These shores are put in position as the ship is rising, and, as the water recedes, more and more shores are inserted. In the case of the dock under notice, large and heavy altars have been constructed for this purpose. The American method, on the other hand, is to strengthen the bilges of the ironclads with strong bilge docking keels, forming, with the keel proper, a level bottom. No shores, therefore, are required beyond those absolutely necessary to roughly center the vessel, and no great care is required in adjusting the berth, and one set of bilge blocks does for all sizes of vessels. Mr. Lyonel Clark, of Messrs. Clark & Standfield, did not hesitate to express to the writer his preference for the American system. It affords a great saving in weight and quantity of shores, and what is more important a great saving of time, for in the American plan it would be perfectly feasible to dock a vessel completely in the time required to center and adjust her with shores disposed according to English practice.

Although somewhat larger in its outside dimensions, the dock has by no means the lifting power of the Algiers structure. This latter will raise a weight of 18,000 tons up to pontoon level, which could even be increased to 20,000 tons by utilizing the pound, making it the most powerful dock in the world. As already stated, the extreme lifting capacity of the Bermuda dock is 17,500 tons.

This latest equipment to the British navy was successfully launched on the Tyne on Saturday, February 8 last. It was a bitterly cold day, snow falling fast at the time. At the appointed moment the huge craft glided into the water, and was brought to rest within a distance of about 25 feet. It is expected to be completed about the end of April, when it will be brought to Chatham, on the Medway, where it will be thoroughly tested by docking a battleship, after which it will be towed to Bermuda. It is expected to leave England about the end of May.

London, England.

THE GLASS PALACE IN "BEAUTY AND THE BEAST."

In the modern spectacular play it is often necessary to resort to quite original engineering methods in producing startling scenic effects. We illustrate (on our front page) the Crystal Palace and Illuminated Fountain, which is introduced in the Drury Lane production called the "Beauty and the Beast." Most of the pantomimes and other attractions of like nature originate in London, the people of that metropolis being very fond of such displays. "Beauty and the Beast," which is now running at the Broadway Theater, New York, taxes the resources of the theatrical engineer to the utmost. The story of the play is one which does not call for special comment. It deals with the well-known episodes in the fairy tale, in which the daughter of a princess receives gifts from her fairy godmothers, but the hapless child receives also the curse of a malignant witch. The thread of the story runs through the performance, which consists largely of splendid processions and ballets, including an aerial ballet which is a most beautiful and ingenious affair. In the last scene the curtain rises on a glass palace, shown in the front page engraving. In the palace proper and on the steps are grouped the ballet and chorus, and in front is an illuminated fountain. The palace was made in Vienna for the Drury Lane Theater, and is composed of 33,000 pieces of glass. The structure was dismantled and shipped to this country, and was re-erected by Messrs. Klaw & Erlanger for the Broadway Theater. It is lighted by 2,000 incandescent lights of small candle power, two and four, and an immense arc light in the roof. The numerous difficulties connected with the storing of the glass palace when not in use were obviated by simple but ingenious means. An immense pit was blasted out of the rock below the level of the stage cellar, to a depth of 20 feet. Heavy beams were placed at the bottom to bear the weight, and heavy timbers were put in to support the stage proper and its load. Normally, the glass palace rests in this pit, the top projecting almost to the level of the stage, the glass crown which surmounts it being removed. Some ten minutes before the curtain is raised, preparations are begun for raising it. The platform carrying the palace is counterweighted by eight tons of iron. It is raised with the aid of two winches and a bull or purchase wheel, and some seven men are required to raise the platform. The first step is to remove the stage floor, which is run into the flies and hooked up against the rear wall of the theater. Ropes are now let down from the gridiron at the top of the stage by men who operate the bull-wheels. The trussed beams which support the stage are then raised out of view. Signals are given by means of cords which pass through the stage floor. The palace is raised in a few minutes with great ease. The platform on which it rests reaches the stage level, and is brought to exact position by means of screw jacks at the four corners. The palace rests upon rollers. Two winches, shown at the rear, serve to draw the palace back some 15 feet. This is necessary, owing to the fact that the foundation for the rear wall was not of the best, due to veins of water, and it was, therefore, deemed well to sink the pit as far forward as possible. The same winches are used to draw the palace back onto its platform when it is to be lowered. Connection is made with the large switchboard, shown at the rear; the palace also carries its own switchboard. The electric lighting is most interesting. There are 2,000 feet of cable used, and the lighting is accomplished by the Elbright system, which consists of two cables with a wire core capable of being punctured. Each lamp has two pins, one of which passes into each of the two cables. The position of the lamp can be changed at will, it being only necessary to stick in the pins elsewhere and tie with tape. Every part of the palace is brilliantly illuminated, and the effect is one of surpassing beauty.

In addition to the palace proper, there is an illuminated fountain which is also most ingenious. The fountain is carried upon the floor of the palace until the stage level is reached. It is then carried down and placed in front of the balustrade. The various jets are then straightened and tested. Water is admitted from the street, and is divided into seven streams, which in turn furnish seven different rows of jets. Valve wheels with long stems are run through the floor, connecting with valves which control the flow of water to the movable hose. The fountain is illuminated from above, where arc lights are secured to a light-batten, the various colors being produced by rotating disks. By a clever manipulation of the various water jets and movements of the disks, remarkable and beautiful effects are produced.

The flying ballet, which is also a wonderful feature of this play, is the invention of Herr Zschregner, director of the Apollo Theater, Berlin, Germany, and for eight years it has been a standard attraction of the Drury Lane Christmas pantomime. The members of the ballet are all German girls, with the exception of the *première*, who is an English girl. They are all of small, slight figure, and dress in pink-silk tights with black-feather bodices and fronts of white chiffon. They have wings attached, and with their head-dresses they give an idea of something half-human, half bird. Each carries a fluffy, white muff. The costume conceals a corset of leather and iron which incases the entire trunk of the body. At the top of the back is a brass spring bolt adapted to receive a hook secured to a small wire, which passes up to a machine on the gridiron. They are raised and put through various evolutions by means of the manipulation of ropes by men in the wings. From one to three men are required to manipulate the wire for each dancer. At a signal from the director of the troop, the *première* takes the center of the stage, and is followed by the remainder of the bevy. The greatest possible attention is given to marking the place where they are to stand before they are raised, as otherwise a dancer might easily come down upon some of the ballet or chorus. Great care is used in inspecting the apparatus, as the life of everyone of the flying ballet depends upon a wire no larger than a piano wire. The mechanism used in this ballet is carefully guarded, so that no one may see its working. The chief difficulty in this ballet seems to be in finding the true center of gravity of the body. Unlike other ballet dancers, they are hired by the year and not by the engagement or season, as is customary in the theatrical profession. We are indebted to Mr. Claude L. Hagen and to Mr. Bissing of the theater for many courtesies in the preparation of the present article.

The Current Supplement.

The front page of the current SUPPLEMENT, No. 1370, presents three handsome illustrations of part of the famous Imperial silver service which the Kaiser placed at Prince Henry's disposal for the banquets given on the "Hohenzollern." Prof. Ramsay discourses interestingly on the "Inert Constituents of the Atmosphere." A new use for blast-furnace slag is described in an article on the Berry hydraulic flag-press. The latest of the big locomotives is shown in an admirable illustration. The first part of an interesting treatise by Randolph I. Geare, entitled "From Raft to Steamship," is also presented. The series will be very fully illustrated, and will present graphically the development of navigation from prehistoric times to the present day. To engineers an exhaustive account of turbine engines for passenger ships, with a special reference to the performance of the "King Edward," should prove of value. The much-discussed matter of the three-phase current is treated by Mr. Sydney Woodfield from the standpoint of power and lighting. The Rev. Herbert Thurston has an authoritative article, well illustrated, on the "History of the Rosary in All Countries." The Consular Notes will be found in their customary place.

Electrical Notes.

Electricians have taken no little pride in the splendid electrical display made in the Metropolitan Opera House, New York, in honor of Prince Henry at the gala performance. Some 8,500 extra lamps were required. Not until two days before the performance was the placing of the lamps begun.

The United States Navy Department has placed with the Allgemeine Elektricitaets Gesellschaft an order for a complete outfit of Slaby-Arco wireless telegraphy instruments. Secretary Long has decided to test the various systems of wireless telegraphy which are now in use in this country and abroad, in order to obtain accurate data of their comparative efficiency.

The darkness that has pervaded the Pyramids for thousands of years is now to be dispelled by the electric light. Maspero, the director of the society intrusted with the preservation of Egyptian antiquities, has begun work on the historic temple of Karnak at Thebes. So successful has the result been that the inner passages and catacombs of the great Pyramids are now to be lighted.

Although platinum is now obtainable from ruthrnium, F. Foerster says that it is still too expensive for many commercial uses, such as the electrolysis of salt solutions for making chlorides and soda. For this purpose carbon anodes are employed, although experience has shown that they are in no sense refractory to the electrolyte. Using graphite and molded carbon anodes of different makes for the electrolysis of a salt solution, Foerster found that while graphite showed least waste, it was closely followed in efficiency by the best of the molded carbons. The waste arises in the main from the oxidation of carbon, although there is also a loss due to disintegration.

The experiments upon the Berlin-Zossen high-speed electric railroad have come to an abrupt and unsatisfactory conclusion. It was originally anticipated that the special car built for the purpose would attain a speed of 125 miles an hour. A velocity of only 100 miles an hour was reached, however, and that only for a brief space of time. The effect of this high speed upon the track was so destructive that the attempt to make higher speeds was discontinued. The Berlin-Zossen military track was practically a straight line, so that the experiments, even if successful, would have not substantiated the possibility of running trains safely round sharp curves at these terrific speeds on a two-rail track.

In an article printed in the Physikalische Zeitschrift K. R. Koch states that he has found that lightning conductors, the connections of which have become imperfect through rusting, nevertheless act in an efficient manner during a thunderstorm. In his opinion this phenomenon is due to the oscillating character of a lightning discharge. Electro-magnetic waves have been produced, which act upon the imperfect connections as upon a coherer, restoring the conductivity for a period more or less long. Hitherto lightning has been considered a continual discharge, which often becomes apparently oscillatory by quick repetition. In order to prove his theory experimentally Koch employed a rapidly revolving camera. Unfortunately he has not been able to furnish as complete a proof of his theory as might be desired, for the flashes photographed were all too distant.

An electrical coin or metal detector is a device for which two Pittsburg inventors, Francis E. J. Litot and Adolphus Mayer, have received a patent. The apparatus is designed automatically to test the difference in quantity or quality of metals, and to separate good from bad coin. The principle of the operation consists in the use of primary coils, in inductive relation to which secondary coils are placed. Electromotive forces are thereby produced in the secondary coils, which forces are equal and oppose each other. Inductive force of the primary coils on the secondary coils is varied by the insertion of metallic substances between them having different inductive effects. This variation of the electromotive forces in the secondary coils sets up a current in the relay, producing motion which closes the circuit of the magnet controlling the operating mechanism.

The first practical trial of a new system of the single-rail railroad is to be made at the Crystal Palace, London. The line, which is to be one and a half miles in length, will be worked by electricity. One terminus will be alongside the low-level station of the London and Brighton and South Coast Trunk Railway. Thence it will run up the hill to the Palace Buildings and around the lakes in the grounds. The difference between this system and the prevalent type of monorail is that the line is on the ground, and large wheels projecting from the middle of the carriage run on it, while on each side of the carriage there are safety rollers upon guide rails. In the mono-rail the line is elevated, with the carriages overhanging on each side, thus placing the center of gravity below the rail. The experimental railroad will cost $70,000, and the line will be in working order by July.

LIGHTNING ABOVE AND BELOW WATER.

BY PROF. JOHN TROWBRIDGE.

I believe that the following experiments show that lightning never strikes the surface of the sea. In studying the spectrum of water vapor, I have often endeavored to pass powerful sparks to the surface of water, in order to obtain a strong spectrum from the resulting volatilization. In every case sparks of high electromotive force resembling, as far as possible, lightning discharges, being with my apparatus six feet in length, refuse to strike the surface of a level basin of water, and pass to the edges of the containing vessel. Even if the terminal is brought close to the surface of the water, only a brush discharge manifests itself. In one experiment I inclosed water in the ends of a vacuum tube, Fig. 1. Having exhausted the tube to the point of the vapor tension of water, I endeavored to force a discharge from the surface of the water, *A*, to that of *B*. This was found to be impossible.

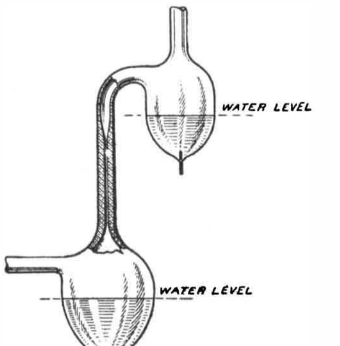

Fig. 1.—VACUUM TUBE CONTAINING WATER.

I was led to these experiments with the desire to obtain a spectrum of water vapor which would be free from all suspicion of the metallic lines of the terminals employed. Subsequent experiments, however, convinced me that with long sparks no metallic lines showed themselves at a distance of even two inches from the terminals. If the quantity of the discharge is made very large by the use of a powerful induction coil actuated by a Wehnelt or liquid interrupter, the metallic lines can be seen further than two inches from the metallic terminals.

It is also extremely difficult to pass powerful sparks from one stream of water to another. In this case we also have two liquid terminals free from any suspicion of contamination of metallic spectra. My apparatus was arranged as shown in Fig. 2. A step-up transformer, giving powerful discharges with a difference of potential of one or two hundred thousand volts, was connected to two vessels of water which delivered two streams of water. It was interesting to see the two streams approach each other under the effect of the alternating plus and minus charges. When the streams were attracted sufficiently near each other, a spark passed which, on account of the high resistance of the water, did not give sufficient light for spectrum analysis. When salt was dissolved in the water, a brilliant spectrum of sodium vapor was obtained. The experiment affords a good class illustration of the attraction of alternating currents, but did not serve my purpose in studying water vapor. It does not seem probable that lightning discharges pass through regions in the air of heavy rainfall.

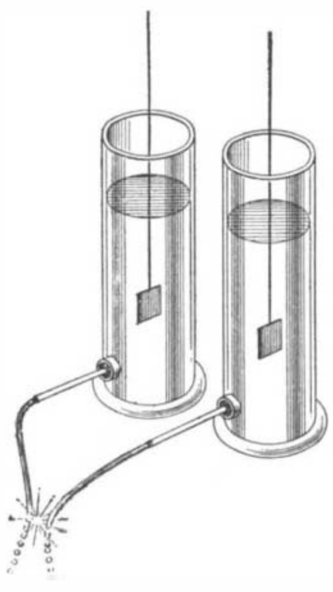

Fig. 2.—EXPERIMENT WITH STREAMS OF WATER.

Lightning discharges which seem to strike the sea really pass from one region of the air to another, and it is only perspective which leads one to suppose that the discharges strike the water. It is remarkable that sufficient electric density can accumulate in the clouds to allow a discharge from one region to another. I have reason to believe from my experiences with powerful discharges that we underrate the quantity and voltage of lightning.

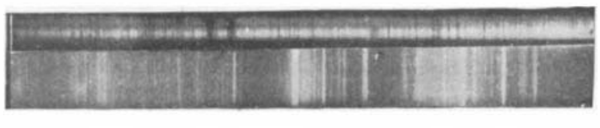

Fig. 3.—SPECTRUM OF WATER VAPOR.

Benjamin Franklin would never have tried his famous experiment if he had previously used an apparatus similar to mine.

Having failed to obtain the water-vapor spectrum with the use of water terminals, I turned my attention to the production of the electric spark under water. Certainly in this case I should have the light of aqueous vapor in excess of the light of the metallic terminals. I found it was difficult to produce a spark under distilled water by the simple immersion of the terminals. It was necessary to seal platinum wires in glass tubes, and these wires should not emerge from the glass tubes to a greater distance than half an inch, and moreover should be immersed but a short distance below the surface of the water, if the water is contained in a glass tube of not more than two inches in diameter. If they are immersed to a depth of even two inches, the sparks I employ will instantly shatter the glass tube. The light of the electric spark under water is extremely brilliant, and resembles that of an inclosed arc lamp. There are no lines, however, in its spectrum. The spectrum, in other words, is continuous and like that of an incandescent solid. How shall we picture to ourselves the formation of this light? Is it due to the combustion of oxygen and hydrogen which are set free from the water, or is it possible that the particles of water vapor sufficiently removed from a state of continuity can become incandescent? The spectrum of powerful electric sparks in the atmosphere also shows a continuous spectrum underlying the bright lines which are due to oxygen, hydrogen and nitrogen. It is probable that this continuous spectrum is due to water vapor. The various spectra of lightning obtained by different observers are due to different amounts of water vapor in the air.

Here is the water-vapor spectrum combined with air lines (Fig. 3), the study of which led me to these experiments with electric sparks above and below the surface of water. It consists of a continuous spectrum with marked bands and collection of fine lines, which are collected together especially in the blue and violet parts of the spectrum, which is represented in the accompanying photograph.

I have said that it was necessary to be careful with the employment of powerful sparks beneath water or oil in glass tubes smaller than two inches in diameter. The glass is immediately shattered by an explosion which is not due to heated air suddenly expanding. I am inclined to attribute the explosion to the combination of hydrogen with bubbles of air or oxygen. The dielectric is filled with a fine cloud of gaseous particles. When the surface of the water is covered by a thin film of oil, the water immediately, under the effect of the electric discharge, becomes opalescent and remains so for weeks. Thus we have an interesting case of troubled solutions. It seems to be an electric emulsion formed by the liberation of extremely minute particles of gas or air, which become coated by oil, and we thus have a medium filled with millions of minute soap bubbles.

In Fig. 3 the broader spectrum is that of water vapor and air lines in the blue and violet. The narrower spectrum is that of the corresponding regions in the sun's spectrum. The photograph was taken with a Rowland concave grating and is therefore normal.

The explosion is analogous to that of a dust explosion, with minute bubbles of gas instead of minute particles of carbonaceous matter submitted to quick combustion. It may be that the report of lightning, apart of course from the rolling of the thunder, is due to the explosion of the dissociated gas particles. When lightning exhibits a zigzag path, it occurs in low regions of the atmosphere, certainly below a thousand feet. Its spectrum will therefore show the ordinary atmospheric lines with a continuous spectrum underlying, which is intensified where the hydrogen and aqueous lines occur, as is seen in the accompanying photograph. The hydrogen lines are very broad. When the discharge is above a thousand feet it loses its zigzag character, and with the same voltage as in lower altitudes can be of great length. At still higher regions we have the aurora. Water vapor plays a controlling part in all these phases of lightning.

A New Process of Preserving Butter.

The researches of Fehling have established the fact that gum-arabic and its concentrated solutions are not fermentable. Emile de Meulemeester, of Brussels, Belgium, has found by numerous experiments that, by mixing powdered gum-arabic with butter in the requisite proportions for absorbing the water, the butter can be kept for a long period without becoming rancid. If a small quantity of salt be added the butter will preserve its aroma. This method of procedure is objectionable because it requires too large a proportion of gum-arabic and because the gum should be free from impurities. It is difficult to procure pure gum in large quantities, and its price would speedily become prohibitive if the consumption were large. In order to obviate these disadvantages M. de Meulemeester proceeds in the following manner: Raw gum-arabic is dissolved in water and the solution filtered to remove the impurities. The filtered solution is then mixed with the butter and the excess of liquid contained in the mixture is finally extracted.

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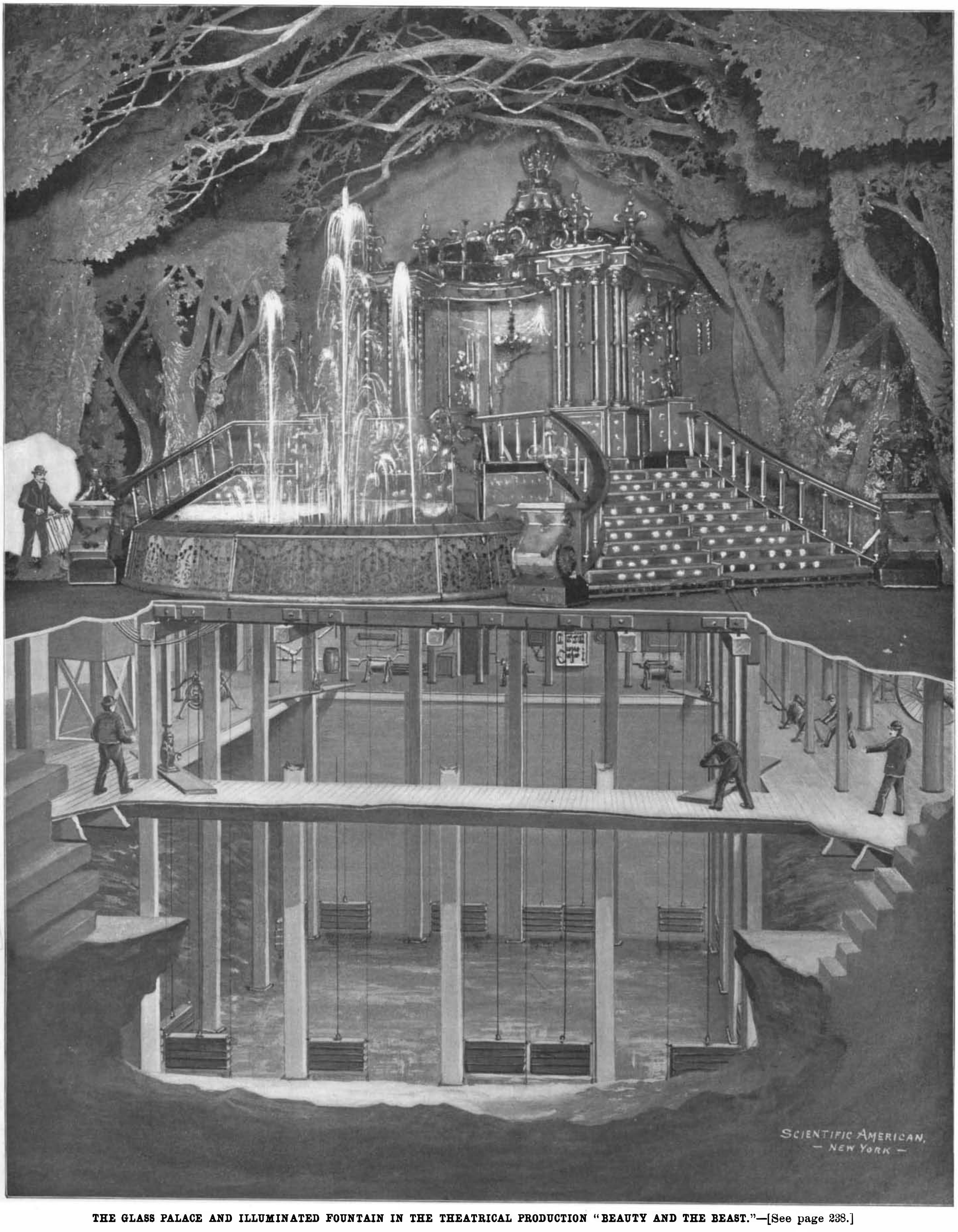

THE GLASS PALACE AND ILLUMINATED FOUNTAIN IN THE THEATRICAL PRODUCTION "BEAUTY AND THE BEAST."—[See page 238.]