

poised looked like some strange bird, then dropped heavily back into the water. Many of the rays are jumpers of more than ordinary ability, and the leap of the largest of the family—the huge manta—observed is an extraordinary spectacle. Long before I witnessed it I had heard the crash of the return of the five or six-ton body which comes on the still night like the discharge of cannon. This was on the outer Florida reef in a shallow lagoon, and as it was infested with sharks at night, I believed that the rays were attacked and were attempting to escape.

One of the most beautiful of all jumpers of the sea is the horse mackerel, or tuna. In the Atlantic the leaps of this fish are rarely seen; but in the waters of the Pacific, particularly about the island of Santa Catalina, they are of daily occurrence at certain seasons, affording a remarkable spectacle. The tuna leaps to capture the agile California flying fish, which bounds into the air, and that the big fish sometimes secures its prey like a hawk in midair there can be little doubt. Its leap is the personification of grace; rising to a distance of eight to ten feet, it turns and plunges downward like an arrow, having preserved the perfect lines of the curve. The antipodes of this is the leap of the swordfish, which I have frequently observed.

### THE CONSTRUCTION OF THE ASYUT DAM; NILE IRRIGATION WORKS.

BY OUR LONDON CORRESPONDENT, FROM NOTES BY SIR BENJAMIN BAKER, ENGINEER OF THE WORKS.

In the SCIENTIFIC AMERICAN for September 20 of last year, we published an exhaustive description of the remarkable irrigation works and barrage at Aswan on the River Nile, which on December 10, 1902, were officially opened, and handed over to the Egyptian government. But the dam at Aswan only comprises one section of these stupendous engineering works. There is another similar barrage of huge dimensions at Asyut, some 350 miles above Aswan nearer Cairo, and of greater importance, from one point of view, since the water level at Asyut influences the water level of the great Ibrahimiyah canal and other important irrigation waterways in Upper Egypt. The Ibrahimiyah canal passes through a large tract of arable land and joins the Nile at Asyut, just immediately behind the barrage that has been built across the river at this point. In fact, the object of this dam may be most succinctly described as to back up the water and thus divert it into the canals and irrigation channels traversing the existing cultivable area of Middle Egypt, right up to the borders of the desert.

The structure built at Asyut differs in design from that erected at Aswan, having, as a matter of fact, a close resemblance to the barrage built by French engineers at the delta several years ago. It consists of an open weir of 111 bays, which has a total length of 2,750 feet from bank to bank.

The openings are each of 16 feet 4 inches span, and are each supplied with steel sluice gates 16 feet in height. At every ninth opening is built an abutment pier 13 feet in thickness, the intermediate piers being 7 feet, 6 inches thick. The piers are spanned by arches, and carry a roadway, 14 feet, 9 inches wide, at a height of 41 feet above the floor of the structure. This roadway not only affords communication between the opposite banks but, as will be seen from our illustration, carries the winches and suspension apparatus for regulating the sluice gates, which controlling machinery is placed on a trolley traveling along a railroad.

Great difficulty was experienced in the preparation of the foundations for the structure, and the cost of this part of the work greatly exceeded the estimate prepared in accordance with the engineers' surveys.

The general scheme of the foundation consists of a solid platform of masonry, 87 feet in width by 10 feet in thickness, extending from bank to bank and laid throughout at one level. This solid platform is in turn protected up and down stream by a continuous and impenetrable line of grooved and tongued cast-iron, sheet piles, which are driven into the sand bed of the river, extending 13 feet below the bottom of the masonry foundations. This protective iron piling, the joints of which are cemented, prevents the water filtering beneath the masonry foundations, thus preventing any undermining or scouring action, which would impair the rigidity and safety of the structure. Provision is still further taken to prevent the erosion of the river bed in the vicinity of the barrage by stone pitching with clay puddle, which prevents infiltration for a distance of 67 feet upstream, and on the opposite side for a similar distance, stone pitching with an "inverted" filter bed.

During the season of 1899, while the river was at low level, work was commenced upon the western side, and the foundations of the navigation lock and 29 sluice openings were completed, the walls and piers being built up above the summer level of the river. In the ensuing season (1900), as the level of the Nile was abnormally low, work was pushed forward with

all possible speed, in order to get the foundations completed. The months of May and June of this year were the busiest during the erection of the entire work. During these two months no less than 13,000 men were employed every day. Even Pharaoh himself could not have crowded more Israelites upon such a confined area than did the contractors at this point; but so methodically was the work apportioned, that there was not the slightest confusion. The attempt to complete the whole of the foundations during the 1900 season proved almost successful. The *modus operandi* of the builders was to inclose the area, upon which it was intended to work during the season, by temporary dams or "sadds" in November, then to pump the water from the inclosure, and, keeping it down by means of centrifugal pumps, push forward with the work so as to build it above summer level; then, when the river was in flood, the force of the water swept away the sadds. In 1900 the whole of the foundations would doubtless have been completed, but for the fact that on July 23 the Nile suddenly rose, and made a breach in the sadds, which could not be repaired, so that 65 feet of the masonry floor remained un-built, and a further length of 459 feet was only partially completed. Regrettable though the accident was, it could not be rectified, so that work on this section had to be abandoned till the following year. In the short time building operations had been in progress, however, the navigation lock, with the exception of fixing the gates and the swing bridge, was practically finished, while 27 piers had been carried up to their full height, 43 to three-quarters of their height, 19 others to above the summer level of the river, and but the last 19 piers had not been commenced.

The foundation work left for completion in the 1901 season was the section between the middle of the river and the east bank. It was only a short length, it is true, but nevertheless it constituted the most difficult part of the whole undertaking, and considerably more money had to be expended upon this portion than had been anticipated.

The construction of the necessary sadds to inclose the site was commenced on January 28. Even this task in itself was of no small magnitude, for the first inclosure, near the middle of the river, covered no less than 6¼ acres. The centrifugal pumps to remove the water from this saddled area were set at work on March 4, and then the troubles began. The sadd at the eastern end of the site was leaky and unsafe, and it was found impossible to pump out the water for fear of a subsidence of the temporary embankment. Smaller dams were therefore hastily built within the main sadd, inclosing about three acres, and the water was removed from this sufficiently to allow the builders to continue the construction of 13 of the piers that had been commenced the previous season, and also a portion of the adjacent masonry flooring.

It was then attempted to complete the masonry platform on the river bed in the center of the river, but this was found to be a most difficult task. The water within the sadd could not be pumped out, since immediately the level of the water within the inclosure was lowered beneath that of the Nile, the embankments threatened to give way. Springs were encountered in every direction, and it was found absolutely impossible to render the present sadd absolutely watertight. The engineers then set to work to build the sadds right across the river and to connect them with the eastern bank. This in itself was a gigantic undertaking, since by this operation the main channel of the river was completely diverted. The total saddled areas reached nearly half the width of the river, and extended over approximately 13¼ acres. A comprehensive idea of the labor involved in these preliminary operations may be gathered from the fact that in one season 1,500,000 sandbags were employed in the construction of these temporary embankments. Fifteen 12-inch and several smaller centrifugal pumps were utilized to remove the water from within the sadds. The pumps had to be kept continually at work, and a watchful eye maintained upon the sadds, as powerful springs continually burst forth through the sandy river bed, which, if they had not been checked, would have threatened the safety of the workmen and structure. During this season no less than 284 of these springs had to be dealt with, while during the whole of the building operations, 974 springs received attention. By May 10, 1901, a determined start had been made once more upon the uncompleted foundations, and the section of the masonry platform so far untouched was commenced. A month later the last stone in the foundation was laid, and the construction of the twelve remaining piers was proceeded with apace. By the end of June they had all been continued to above the mean river level. To guard against the evil influences of springs which might subsequently break through, and to insure that no voids existed beneath the last constructed portion of the masonry floor, holes were drilled into the river bed, at intervals of 10 and 13 feet, and cement grout forced down through pipes standing up to 16 feet above floor level. That this

precaution was wise, subsequent inspection proved, for a long length of the floor previously built on the east side was found to be extensively undermined by springs, and this section of the foundation had to be carefully grouted before much excavation could be carried out, causing unfortunate delay.

These constantly-repeating obstacles afford a graphic idea of the many engineering difficulties that had to be surmounted, and the infinite care and vigilance that had to be exercised, to see that the work was carried out thoroughly.

While the last part of the foundations was being completed, work was in progress upon those piers which had been continued to the summer level during previous seasons. The openings were finished to the arch level, and the arches and parapets were then proceeded with. Practically the whole of the superstructure work was completed by the end of 1901, and the sluices were shortly afterward lowered to maintain a sufficient level over the raised sill of the lock, so that navigation might be rendered possible without any hindrance whatever. The gates of the lock were fitted before the Nile rose in flood, and in fact this part of the work was finished ready for use, with the exception of the swing bridge.

The whole of the foundations of the barrage is built of Isawiyah stone, laid in cement mortar, while the superstructure is of the same stone laid in homra and lime mortar.

As the object of the Asyut barrage is to throw a higher level of water into the Ibrahimiyah canal, and as the latter enters the Nile just south of the dam, a new regulator and lock has been rendered necessary at the head of the canal, to control the supply entering therein, especially in years of high flood, and to insure the safety of its works in case of an accident. The work comprises a regulator pierced with nine openings each 16.4 feet wide, and a lock 27.8 feet wide. The regulator is made by means of two gates, one upper and one lower, each 11.5 feet in height. The design of the foundations is practically identical with that of the barrage, and is likewise constructed of Isawiyah stone, with a similar superstructure. The method of construction was also the same, sadds being made around the site to enable the foundations to be laid.

One of the most remarkable features of this enormous undertaking was the changing of the channel of the river to facilitate work. For some years previous, the main channel of the river had been on the east bank, while on the western bank a large shoal had been gradually built, though it was pierced by a narrow channel giving access to the Ibrahimiyah canal. This passage had to be constantly dredged, otherwise the entrance to the waterway would have been filled up. For the first two seasons' work upon the Asyut barrage, this condition of the river favored the engineers, and enabled the foundations to be built quickly, but after the masonry flooring had been laid and the piers built, a different state of affairs was presented. On the western flank of the barrage, the navigation lock had been constructed—on the side where the shoal was—while the main channel of the river was on the opposite bank. The engineers now had to divert this channel to the western bank. This was accomplished as follows: The upstream temporary sadds, extending from the east bank to the middle of the river, were protected with vast quantities of rubble stone, so as to present an obstacle to the flow of the river when it again rose in flood, and thus force it to make another main channel on the opposite side of the river, where the navigation lock was situated. This scheme proved entirely successful, and with but little expense the channel of the river has been completely diverted.

The sluice gates, which are of steel, when lowered in position have a holding capacity varying from 7 feet, 9 inches to 9 feet, 4 inches of water during the summer months, and the water thus stored up will be sufficient to bring an additional 300,000 acres under irrigation and agriculture.

One noteworthy feature of this undertaking is that, owing to the high pressure with which all the work was carried out by the well-known contractors, Sir John Aird & Co., Ltd., of London, the undertaking has been completed and handed over to the Egyptian government in thorough working order more than twelve months under the originally contracted time, an achievement upon which the builders are to be highly congratulated, considering the magnitude of the task.

While engaged in unloading shells for the purpose of refilling them with smokeless powder, three men were blown to pieces and four fatally wounded in an explosion, in Fort Lafayette, New York Harbor, the 19th instant. Whether the explosion was the result of carelessness or of a combination of circumstances that was unknowingly brought about by the workmen, will probably never be known. The explosion was one of those inevitable accidents that even the greatest care will often prove of no avail in avoiding.

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View Looking East Along the Roadway, showing Track for Sluice Regulating Gear.



Photos. by courtesy of  
Sir John Aird, the contractor.

Asyut Barrage Across the Nile; Upstream Side Looking West.  
THE DAMMING OF THE NILE.—[See page 152.]