SCIENTIFIC AMERICAN

[Entered at the Post Office of New York, N. Y., as Second Class Matter.]

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES.

Vol. LII.—No. 6. [NEW SERIES.] NEW YORK, FEBRUARY 7, 1885. [$3.20 per Annum. [POSTAGE PREPAID.]

THE ATTOCK BRIDGE.

The bridge which we illustrate was built to carry the Punjaub Northern State Railway, and the trunk road between Lahore and Peshawar, across the river Indus, on the northwest frontier of India.

About thirty miles above Attock the river leaves the main ranges of the Himalayas, and spreads out into a wide, shallow bed, the average width being about two miles, to be again contracted by the ranges of hills which cross its course at Attock itself and further south. Through these latter ranges it winds its course for over 90 miles, the bed being sometimes narrowed to a width of a little over 100 yards and seldom exceeding 400 yards, until it finally debouches into the plains at Kala Bagh, the highest point to which the Lower Indus is navigable by steamers.

As a rule, the river is at its lowest from November until the early days of March; during this season the greatest depth of water in the contracted parts of the channel is about 30 feet, and of course less in wider places, but the highest floods have been known to rise as much as 70 feet above low water level.

A bridge of five spans, three being 250 feet and two 300 feet in the clear, was decided on, and contracts for the pier and girder work were let in England. Wrought iron was chosen as the best material for the piers, owing to the scarcity of good, sound building stone, and to the liability to extra heavy vibrations from earthquakes.

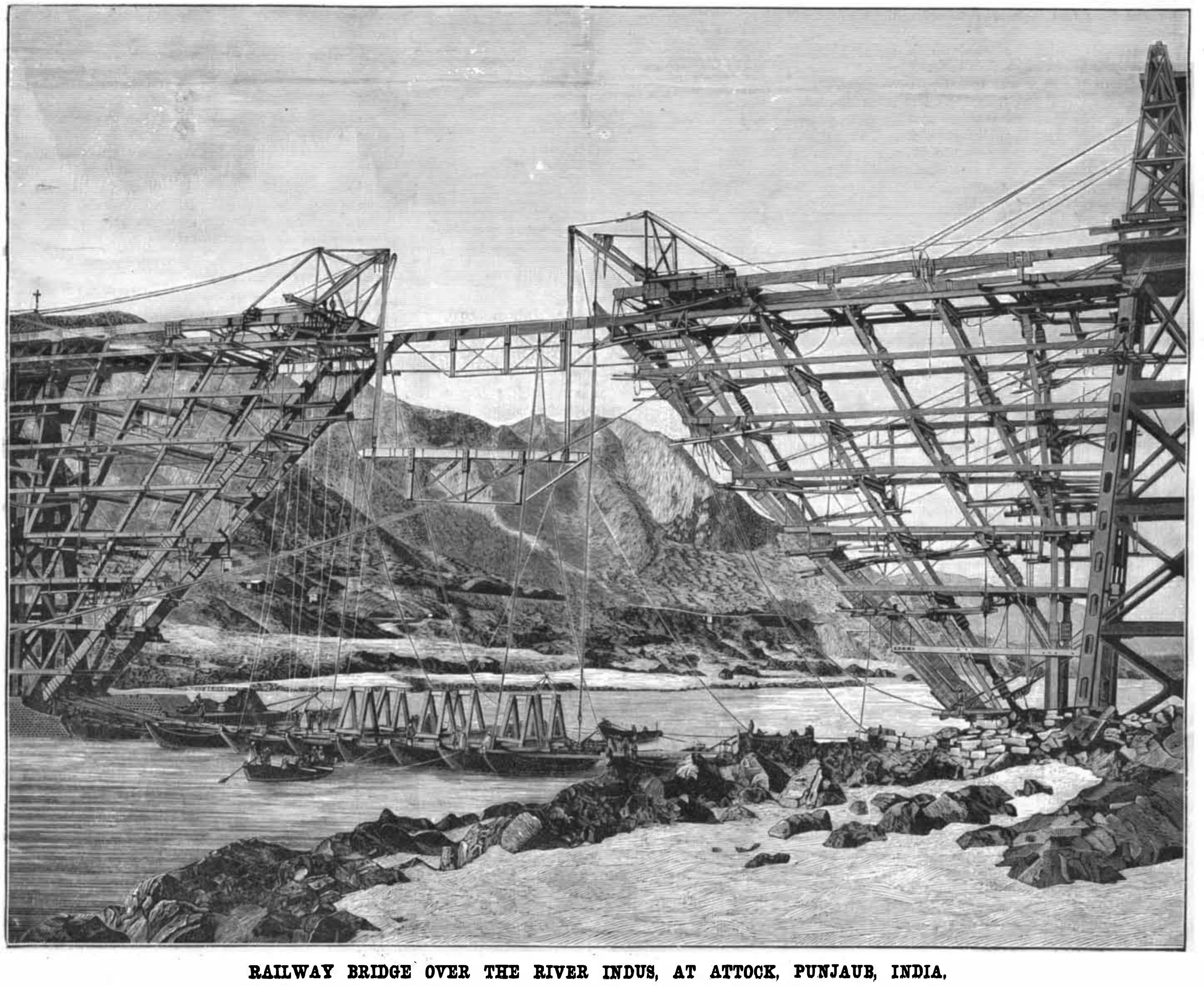
The surface of the rock at the site of the center pier, being, for the most part, exposed to the action of a strong current, was swept clean, except for fine micaceous sand which lodged in the crevasses; timber therefore could not be used to form a cofferdam. The foundation was secured by inclosing the space required with a wall made of Portland cement concrete. In the absence of driving plant a commencement was made by filling small cotton cloth bags with fine concrete and setting them by hand, the native divers first clearing the sand from the hollows in the rock, and then laying the bags in place.

The bags, capable of holding 1½ cubic feet, were about two-thirds filled with Portland cement concrete, and were laid on the rock and rammed into the cavities, and by this means the wall was gradually built up to water level. Cross walls were also put in of same material, and ten compartments formed.

Pumps were then got to work, and some of the compartments emptied. It was then found, says *Engineering*, that the surface of the rock was not so sound as had been supposed, being honeycombed and cut up by small fissures which it had been impossible for the native divers, working without diving apparatus, to close up with the cement concrete. The influx of water through these holes and fissures was too great to allow of the cells for the shoes of the pier standards being sunk into the rock.

Each compartment was then in turn filled up with cement concrete, which was allowed to set for three or four days, then a cell was cut down through it to the surface of the rock, and continued into the rock until found sound and perfectly solid. In two cases, after excavating a few feet into the rock, small passages communicating with the river outside were cut into, when the process had to be repeated over again. The cells were cut 7 feet square at top, or just a little larger than the shoes of the columns, and somewhat wider at the bottom. When all the eight cells were completed to the full depth required to insure a sound base, the bottom pieces of the column were cut to the necessary length, the shoes were riveted on, and each was lowered into its cell, and placed approximately at the proper level and position horizontally, resting on hard wood wedges. The next lengths were then bolted to them, and two tiers of horizontal braces with the intermediate cross braces were fixed in place with bolts. The whole base of the pier was now slightly raised by traversing screwjacks, and brought exactly into position both horizontally and vertically. Fine Portland cement concrete was carefully rammed under the shoes, also inside and around them, and the cells around the columns and also under them were filled with the same class of concrete up to the level of the top of the dam wall. This completed the foundation work of No. 3 pier, and the others were treated in a similar manner; there being, however, no water to contend with, they were set without difficulty of any kind.

For the two principal spans no intermediate supports could be erected, as they carry the main channel of the river, and the velocity of the water at its lowest exceeds five miles an hour in the third span, sweeping the rocky surface clean. The frequency also with which rafts of timber from the upper reaches pass, often without men to guide them, also large boats with produce, add to the



RAILWAY BRIDGE OVER THE RIVER INDUS, AT ATTOCK, PUNJAUB, INDIA.

dangers a staging with intermediate supports would have had to encounter. Moreover, it was desirable that any staging should be practically clear of cold seasons, minor floods, and should allow of a rise in the river of at least 30 feet without causing any material obstruction to the waterway.

The perspective view shows the staging in course of construction. It consisted of a series of long struts springing from a point near the base of each pier, and spreading out in a fan to support a horizontal beam of double whole timbers on which the platform was laid for erecting the girders. The corresponding struts in the up and down stream fans (which were 19 feet apart center to center, the same distance as the girders) were connected by horizontal braces, each brace being a pair of half timbers bolted together with the struts between them, and with diagonal struts in the rectangle between each pair of horizontal bracings. At equal vertical distances of 12 feet, ledgers of half timbers in pairs connected all the main struts of each fan with each other and with the main column of the pier with which they were in line, being clamped to the columns by heavy wrought iron straps. The outer main struts were built up of whole timbers clamped together, commencing at the bottom with three, one of which eventually branched into a secondary strut. Similarly the vertical next the pier commenced with two whole timbers, and divided afterward into two struts. At the level of each tier of ledgers above the fourth, counting from the bottom, sets of one inch chain horizontal diagonal bracings were put in. These chains were drawn tight by ordinary wagon screw couplings, four hundred of which were got out from England specially for the work.

The two outermost struts from opposite sides were connected at top by a beam of the same section being dropped in before the sill pieces were laid. This beam was 63 feet long and of sal wood (the rest of the staging being deodar), and was trussed by three vertical struts, 10 feet deep, with rods of 2 inches round iron forming a queen truss of 63 feet span. When in place this trussed beam, together with the long struts which it connected, formed a gigantic strut and straining beam truss under the sill pieces.

During erection and until the straining beams were in place each fan was tied back to the main column of the pier with which it was in line by the ledgers, which for the time had to bear a considerable amount of tension.

The timber readily procurable on the Indus does not exceed an average of 22 feet in length, and the number of joints in the work was therefore very great. The stagings were built out from the piers piece by piece, beginning with the vertical struts next the piers, which were soon carried up to their full height. To facilitate the hoisting of the timbers into place, two pairs of Manila 9 inch hawsers were stretched across each span, from the top of the 250 foot completed girders at the shore ends and over a pyramid of sleepers placed on the top of the center pier. From these hawsers tackles were suspended at convenient points as the work progressed.

When the building out of the fan portions was completed, rails were laid on the sills, and two large temporary cranes made for the purpose were moved out to the extremities. The 63 foot trusses were then built on boats, were brought under the cranes, and were raised into place, the cast iron angle sockets at the ends of the straining beams being dropped over the ends of the long struts, which were sprung back slightly to allow of this being done. When these were in place, the sill piece was completed over the top and the platform laid on, a line of rails to the meter gauge being put upon it to bring out the girder material. These stagings proved very satisfactory; levels were taken daily at several points during the time the girders were being built, to test the stagings for settlement, and, notwithstanding the great number of joints, the maximum deflection of the platforms under the full weight of over 600 tons (in addition to the weight of the staging itself) was only $1\frac{1}{8}$ inches. The stagings were by far the most difficult, as well as tedious, part of the work of the construction of the bridge.

Heating by Electricity.

A correspondent in *The Electrician* gives the following reasons why electricity for heating purposes cannot be economically employed, if a steam or gas engine is used to produce the current in the first instance.

In the first case, one-tenth of the heat of the coal only is recovered; then, say, 25 per cent of power is lost in the dynamo; and finally, 25 per cent or more lost on conversion of the current into heat. Thus we get $0·1 \times 0·75 \times 0·75$ of the heat of the coal $= 0·05625$, or say, at best, $\frac{1}{20}$ only. Even if coal were burnt in an open fireplace, not more than half the heat is lost. With a gas engine matters are not much better. In short, taking the expense of machinery, etc., into consideration, it is fair to assume that heating by electricity is at least 50 or 60 times more expensive than burning coal direct in the most approved stoves, and 25 to 30 times dearer than coal burnt in an open fire.

Scientific American.

ESTABLISHED 1845.

MUNN & CO., Editors and Proprietors.

PUBLISHED WEEKLY AT

No. 361 BROADWAY, NEW YORK.

O. D. MUNN. A. E. BEACH.

TERMS FOR THE SCIENTIFIC AMERICAN.

One copy, one year, postage included........................$3 20
One copy, six months, postage included........................1 60

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The Scientific American Supplement

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NEW YORK, SATURDAY, FEBRUARY 7, 1885.

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ENCKE'S COMET.

There is an excitement in the celestial court. Encke's comet has arrived, and star gazers are turning their telescopes to the skies in eager haste to obtain a glimpse of the distinguished visitor. Our eccentric guest is not a prince among comets. It is not a *cometa horrendae magnitudinis*, like those members of the family that in the olden times swept over the heavens, and threw the beholders into an agony of superstitious terror. It does not burst upon the astonished gaze at noonday with a brilliancy akin to that of the sun; its tail is not curved like a Turkish cimeter, nor does it branch out into six tails, each 6,000,000 miles long. It does not span the celestial vault from horizon to zenith; there is no danger of its being considered the harbinger of war, pestilence, and the day of judgment; and there will be no prayers read in the churches beseeching deliverance from "the Turk, the devil, and the comet."

Encke's comet is interesting chiefly for being the first known comet of a short period, for making the shortest circuit of any member of its class, for performing its revolution within the boundaries of the solar system, and for the reason that it seems to be more amenable to physical law than some of the more imposing members of the cometary family, those vast ethereal creations that visit our domain and then rush off into fathomless space,

"On the long travel of a thousand years."

This comet has a history. It is known as Encke's comet because the distinguished German astronomer was the first to carefully investigate its motion. It was first detected in 1786, again by Miss Caroline Herschel in 1795, again in 1805, and finally by Pons, the great comet finder, in 1818. He found on calculating its orbit that it was identical with the comet of 1805, but made no estimate of the length of the period. Encke then took up the task, and studied its movements with a thoroughness before unknown. He established beyond a doubt that the comet's orbit was an ellipse, that its period was about 1,212 days, and that it had made four complete revolutions between 1805 and 1818. These facts being sure, there was no difficulty in identifying it with the comets of 1786 and 1795, and in concluding that in the intermediate returns to perihelion its position had been so unfavorable that it was not seen.

Encke predicted its return in 1822, pointed out the position it would occupy among the stars, and also announced that it would be visible only in the southern hemisphere. He had the happiness of seeing his predictions verified by the observations of an astronomer in New South Wales, who followed the comet during its whole visible course.

Since that time this eccentric visitor has not failed to return to perihelion very nearly at the computed time, although at some returns it has been visible only in the southern hemisphere, and at other returns it position has been so unfavorable that the closest scrutiny has been of no avail in picking it up. Encke's comet is a veteran among comets of a short period, reaching next January the centennial anniversary of its discovery. Why should not the event be celebrated? It deserves to be, for this eccentric member of the system is an exceptionally well behaved comet, except in the matter of yielding to the influence of a resisting medium or some other mysterious power. It has neither been turned into a new path by the disturbing form of Jupiter—sometimes its near neighbor—nor has it split in two parts like Biela's comet, nor is it disintegrating into meteors, like Tempel's comet and the second comet of 1862, that lead the long procession of meteors in the November and August meteor zones.

The orbit of Encke's comet is an ellipse, inclined at an angle of 13° to the plane of the earth's orbit. At perihelion it is 31,000,000 miles, and at aphelion 377,000,000 miles from the sun. Its perihelion is between the sun and Mercury, and its aphelion is between Jupiter and the asteroids. Its motion is from west to east, and its revolution, in the days of its early history, was performed in about 1,212 days.

Encke's comet is by no means a remarkable one. It is a telescopic comet, and consists of a patch of circular light, somewhat condensed toward the center. Though usually visible only through the telescope, it has been seen by the naked eye. Such was its appearance in 1828, when it was in an exceptionally favorable position for observation, and its light was equivalent to a star of the fifth magnitude. At common times there is little trace of a tail, but, on rare occasions, a slight one has been detected, like a faint brush of light, and sometimes with a second appendage opposite the first. Its tenuity is so great that, at its return in 1878, the center of the comet passed directly over a star of the tenth magnitude lying in its path. The star was undimmed by the transit of the densest portion of the comet, and shone through the misty medium as brightly as it had before shone against the dark background of the sky.

This insignificant mass of nebulosity has been of use to astronomers. When at its nearest point to Jupiter, the mass of the huge planet was more accurately determined by means of its "excessive perturbations." In the same way, when it was nearest to Mercury, it was