

surface of the water W be thirty feet. The pressure of this perpendicular column of water, fifteen pounds to the square inch, is what prevents the natural siphon-flow of the water from F to E, and the power required from the propeller to overcome this pressure is but fifteen pounds to the square inch. Also, the water in the opposite arms of the curved tube being in equilibrium, the weight of the descending column E P assists in bringing up the ascending column F P, making a high velocity easily attained.

When all the water is discharged from the hull of the vessel and its space refilled with condensed air the vessel will easily be raised.

RAILWAYS IN JAPAN.

THE large commercial town of Osaka, in the main island, Nippon, ranks scarcely below Yedo among the cities of Japan, and it is now connected with the port of Kobe by a railroad, opened in May, 1875. The works of this line, which is to be further extended northward, through the valley of Lake Biwa, to a point near Tsuruga, on the west coast, are of considerable engineering merit. There are three tunnels, one of which, that under the Ashiya-gawa, 365 ft. long, is esteemed the finest piece of brick-work and masonry in Japan. It is a three-centred ellipse, with a circular invert 15 in. deep in the centre, and covers two lines of rails. The other tunnels, those of the Ishiya-gawa and the Sumiyoshi-gawa, are shorter than the one first named, and are circular arches, with only a single line of rails. These three tunnels are made to cross under the beds of three mountain torrents; the line passing along the base of the hills, where they slope down steeply to the sea. Other rivers, the Ikuta-gawa and the Togano-gawa, are crossed by wooden bridges about 80 ft. long. Owing to this conformation of the ground, in the first portion of the line from Kobe, sixteen or seventeen curves have been necessary, of radii varying from 440 yards to two miles. From Kobe to the bridge over the Muko-gawa the drainage and artificial irrigation of the land have necessitated the construction of 208 culverts, of which one piece of permanent way contains thirty to the mile. After passing through the last tunnel, the line enters upon a different country altogether. The hills trend away in a northeasterly direction towards Kioto, and from a deep cutting the line passes on to an embankment, through low-lying paddy-fields. The embankment is eleven miles long (less the aggregate length of the bridges), and thirty feet high close to the Muko-gawa. The culverts in this district might, from their size, be called bridges. Though the streams running through them are generally insignificant-looking dribbles, the whole country is liable to sudden and heavy floods, and any damming up of the flood-water would result in serious damage to the embankment. Two of these openings are really arched bridges. The first is over the Shindin-gawa; the next opening is a wooden trussed girder bridge on stone abutments, and having one span of 40 ft. over the Shiku-gawa; the next is one over the Hiruta-gawa, which has two spans of 30 ft. each, within a quarter of a mile of Nishinomiya station. The Muko-gawa is crossed by the first of the three bridges which form the distinctive feature of this portion of the line, as the tunnels do of the other. This bridge is an iron "Warren girder" bridge of twelve spans of 70 ft. each, resting on iron screw piles of 2 ft. 9 in. diameter, having wrought-iron blades of 5 ft. diameter and 5 in. pitch. In the stretch between this river and the next—the Kansaki-gawa—there is one curve, with a radius of a mile, and six flood openings varying from 100 ft. to 180 ft. in width (not measuring the thickness of the piers), the spans being 20 ft. each. They are built of granite to flood-level and backed with brick, nearly all the culverts here being identical in construction, and varying only in size.

The iron bridge which crosses the Kansaki-gawa is identical in construction with that at the Muko-gawa, but consists of seventeen spans. A short stretch, containing five more culverts (the last of which, a 60-ft. span, is bridged by small iron "Warren girders" instead of wooden ones), brings us to the other remaining iron bridge—that over the Jusho-gawa. This, though only of nine girders, is, perhaps, the most striking to the eye of the three, as the Jusho-gawa has always water in it. The screw piles on which the bridges rest are shortest at the Muko-gawa, none there being longer than 34 ft. and none more than 22 ft. in the ground. At the Jusho-gawa the longest are 40 ft., of which 30 are in the ground; while at the Kansaki-gawa they reach to the length of 64 ft.

These bridges are excellent pieces of work; the eye can detect no departure from their mathematical perfection; no flood in the rivers has yet caused any perceptible vibration; and they reflect high credit on the professional skill which has placed them in position. The stations at Kobe and Osaka are rather extensive. The former, which is a terminus, covers an area of sixty-four acres on the western shore of the harbor. It will contain five and a half miles of rails, with buildings for the passenger and goods traffic, and for the workshops, and with a pier 450 ft. long and 40 ft. broad, running into the sea, upon 124 piles. There is a depth of water, never less than 20 ft., alongside 200 ft. of the length of this pier at Kobe. The Osaka station has an extent of forty acres, and will contain five miles of rails, with all the necessary buildings. It has a branch line or tramway to the Mint, and another to the Osaka River. Upon the death of the English chief engineer, who was at first appointed by the Japanese Government to superintend the works of this railway, he was succeeded by Mr. R. Vicars Boyle, C.S.I., but the works of the section above described were executed under the direction of Mr. John England, C.E., chief assistant engineer. We are indebted to Mr. C. F. Walsh for the photographs which have supplied our illustrations.—*Illustrated London News*.

CHINESE SUSPENSION BRIDGES.

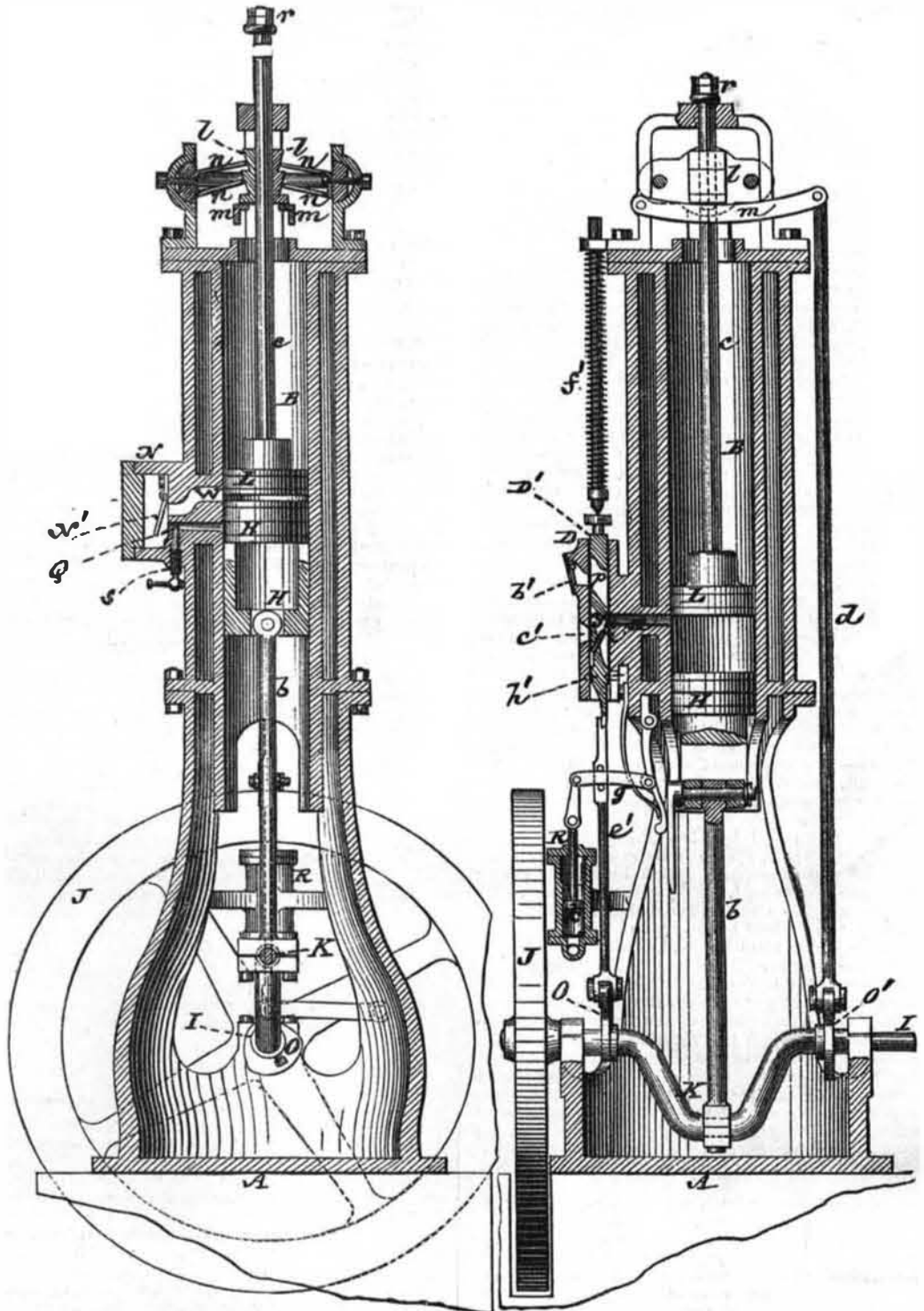
THE most remarkable evidence of the mechanical science and skill of the Chinese at this early period is to be found in their suspended bridges, the invention of which is assigned to the Han dynasty. According to the concurrent testimony of all their historical and geographical writers, Shang-leang, the commander-in-chief of the army under Kaou-tsoo, the first of the Hans, undertook and completed the formation of roads through the mountainous province of Shen-se, to the west of the capital. Hitherto its lofty hills and deep valleys had rendered communication difficult and circuitous. With a body of 100,000 laborers he cut passages over the mountains, throwing the removed soil into the valleys, and where this was not sufficient to raise the road to the required height he constructed bridges, which rested on pillars or abutments. In other places he conceived and accomplished the daring project of suspending a bridge from one mountain to another across a deep chasm. These bridges, which are called by the Chinese writers, very appropriately, "flying bridges," and

represented to be numerous at the present day, are sometimes so high that they can not be traversed without alarm. One still existing in Shen-se stretches four hundred feet from mountain to mountain, over a chasm of five hundred feet. Most of these flying bridges are so wide that four horsemen can ride on them abreast, and balustrades are placed on each side to protect travellers. It is by no means improbable (as M. Pauthier suggests), that, as the missionaries in China made known the fact, more than a century and a half ago, that the Chinese had suspension bridges, and that many of them were of iron, the hint may have been taken from thence for similar constructions by European engineers.—*Thornton's History of China*.

IMPROVEMENT IN GAS ENGINES.

By FRIEDRICH W. GILLES, of Kalk, Germany.

THE pressure produced by the ignition of an explosive gaseous mixture in the cylinder of the engine is applied to propel two pistons in opposite directions—that is to say, a working-piston and a loose piston, the former of which is connected by crank with a driving-shaft, and the latter of which is free, but is temporarily held by a clamp after its propulsion by the explosion of the gaseous compound, to secure the return action of the working piston under atmospheric pressure as against a reduced pressure between the two pistons, thereby obtaining a motive power for the working-piston in both directions of its stroke.



NEW GAS ENGINE.

The operation of the engine is as follows: Assuming the working-piston H to have reached the extreme of its inward or up stroke, the piston L then being close to it, as shown in Fig. 1, the former piston, H, by the rotation of the crank K, is drawn down or outward, and the loose piston L, backed by pressure of the atmosphere entering through an opening in top of the cylinder, follows the working-piston H till the loose piston L is checked at the extremity of its down-stroke by a stop, r, on its rod coming in contact with an upper frame on the top of the cylinder, as shown in Fig. 2. The working-piston H, continuing its downward movement, creates a partial vacuum behind it, in the space between it and the loose piston L. As, however, this begins to take place, the cam O moves the gas-slide D', so as to admit into this space between the two pistons, from the receiving-passage p of said valve, the gaseous mixture, and during the further rapid movement of said valve exposes the kindling-flame of the burner i to the gaseous mixture in the cylinder through the passage a, whereby the mixture is exploded.

The pressure produced by the explosion forces still further downward or onward the working-piston H, and at the same time causes the loose piston L to make a rapid stroke in an upward or opposite direction, the air in the space at back of the loose piston being discharged through the head or top of the engine cylinder. When the loose piston at the extreme of its up stroke enters and closes by a projection on it this air-opening in the head of the cylinder, the inclosed air serves as a cushion to check the loose piston, a spring-valve being

used in addition, if desired, to provide for a slow escape of the compressed air.

The working-piston H having completed its down or outward stroke, and the loose piston L having also completed its up or outward stroke, and the gas-slide D' having closed the passage a, or space between the two pistons, the cylinder-space between the two pistons remains charged with the products of combustion at a pressure considerably below that of the atmosphere. The atmospheric pressure consequently tends to force both pistons inward or toward each other. The working-piston H moves inward in obedience to this pressure, but the loose piston is held near the extreme of its out-stroke by the friction cheeks or clamps ll, hereinafter referred to, the ingress of air at the back of it being checked.

When the working-piston H is approaching the extremity of its in-stroke, the clamps ll are released by the action of the cam O' from hold of the loose piston L, and the discharge-valve N' is opened. This causes the loose piston L to make a rapid stroke inward till it nearly meets the working-piston H, as shown in Fig. 1, and the products of combustion compressed between the two pistons are forced out by the passage W through the discharge-valve N', after which the action is repeated, as before. The subsidiary passage Q, arranged a little below the passage W, provides for the escape of any remaining products of combustion between the two pistons after the passage W has been stopped by the loose piston, and the screw s, controlling such subsidiary passage Q, serves to regulate such escape and to retard the same, as required,

whereby a buffer-like action is produced between the two pistons.

By placing the engine-cylinder in an upright position, the weight of the working-piston is made available to assist the out-stroke of the latter, and the loose piston is assisted by its weight in its in-stroke.

In connection with the gas-valve D' is a regulating pump or device, R, which, by means of a lever, g, between stops on the rod e', is worked by the same cam, O, which operates the gas-valve D'. The piston or sucker k of this pump draws in and expels a certain amount of liquid at each revolution of the engine-shaft. If the engine be running too fast, all the liquid drawn in can not be expelled. This causes the lever g to be lifted and hold and raise the rod e' and valve D', so that a new charge of gas can not be given until the speed of the engine has been reduced.

SAN FRANCISCO TO LIVERPOOL IN SIXTEEN DAYS.

THE Allan Royal Mail Steamer "Polynesian," which lately arrived at Liverpool from Quebec with the Canadian mails in 7 days and 16 hours, brought passengers who had come, *via* Quebec, from San Francisco, and landed them in Liverpool on the sixteenth day from their leaving San Francisco: this is probably the smartest run on record.