At the crown of the arches common inch scales were used, as greater vertical movements could be expected there.

It being an assumption for the correctness of the measuring that the piles, which carried the apparatus, were standing firmly, an investigation was set on foot to prove it. In a distance of 9 feet from the bridge a pile was driven opposite each of the apparatus. The piles were connected in pairs with timbers carrying levels. These did not show any movement during the loading of the bridge.

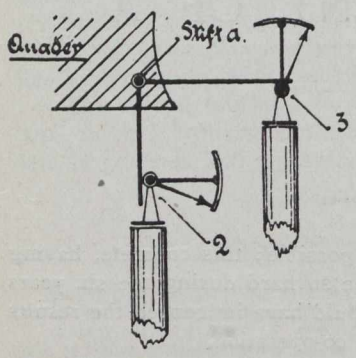


Fig. 2.

To determine the position of the resulting forces in the different sections of the arches and the value of the compression and tension stresses along the intrados and extrados a number of elongation measurements were taken at the centre of the arches by means of Martens mirror apparatus (Fig. 3 a), which give a minimum reading of 1/125,000 of an inch, and at the ends by an index apparatus (Fig. 3 b) which gives a reading of 1/60,000 of an inch. In the Martens apparatus the one end of the measuring spring is supported by a pin (p) put into the arch two inches from the edge, and between the other end and the pin (q) the mirror is placed. A change in the distance between the two pins effects a turning of the mirror to the right or the left, whereupon the variation in the length can be determined by telescope reading in the usual manner. From the elongations the stresses can be figured out directly. For the index apparatus the principle is similar. A lengthening or shortening of the measuring length effects a movement of a cylinder, connected with a long index, whose turning can be read on a scale.

On the Rhine side only were placed apparatus at the centre of the arches, at the top and below. Here was used the Frankel-Leuner's instrument, which had a turn-over ratio of 1/140 only. The alteration in the length is through a lever system carried over to a writing pin, which notes its movement on a paper roll drawn by a clock-work mechanism.

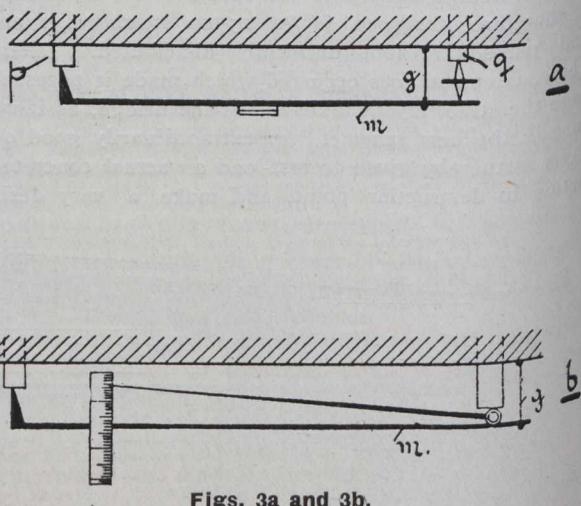
The loading consisted of pieces of steel placed on the southern half of the bridge, over an area 16 feet long and 26 feet wide. It had first been proposed to load the arch from the crown to the springing line, but this plan was given up, owing to the difficulty of procuring a sufficient quantity of steel.

As the weight on the bridge had reached 75 meters, the instruments were read for the first time, and thereafter the reading was continued during the loading. For each loading stage a measurement was taken every fifth minute, until no further alteration in the position could be seen.

The results of the observations are graphically shown in Fig. 4, which gives the alterations in the centre lines of the arch on the land side by loading increases of 75 tons; the curves give the vertical and horizontal movement of the abutment and the vertical movement of the crown, and the centre of the unloaded arch half; the measuring on the land side agreed perfectly with those on the Rhine side.

The increasing load produced first a uniformly increasing deflection at the crown and a curving and raising of the unloaded arch. In Fig. 4a and 4b is shown the movement of the arch axis under a load up to 225 tons. From Table I. it will be seen that this load gives a deflection at the crown at 2.2 of 1/25 inch and a raise in the centre of the unloaded half of the arch of 1.3.

As the test-load was increased to 225 tons a sudden change took place in the direction of the movements, due to a crack which had formed in the arch at the edge of the load. (Fig. 5). The testing institution speaks concerning this crack in the report of the experiments in the following way:—



Figs. 3a and 3b.

An hour before the load 150 tons was reached, as the load of the steel on the bridge was nearly 124 tons, more cracks, which probably did not go very deep into the concrete, were seen at the underside of the loaded part of the arch. A short time after the steel load had reached 140 tons the very fine crack (a, Fig. 5) which could be seen from the start of the experiment, commenced to enlarge, so that it could be seen under the whole bridge, and at last appeared on the Rhine side of the bridge. (Fig. 5).

At all the instruments, however, it was found that the movements of the bridge first started to go in the opposite direction to what had been the case before, when the load was 225 tons. It must, therefore, be assumed that the crack

Table I.

Point.	Movements in 1/25 of an inch.				
	75 Tons.	150 Tons.	225 Tons.	300 Tons.	400 Tons.
In vertical direction—					
Crown	—1.1	—1.6	—2.2	+0.5	+29.2
Centre of northern arch half	+0.5	+0.7	+1.3	—1.1	+20.0
Northern abutment stone	+0.1	+0.6	+0.7	+1.0	....
Southern abutment stone	+0.1	+0.4	+0.8	+0.7	....
In horizontal direction—					
Northern abutment stone	+0.2	+0.5	+0.7	+0.9	....
Southern abutment stone	—0.1	—0.6	—1.4	—1.5	....

+ Means movement upward or to the right. — Means movement downward or to the left.