occurring first under this action had penetrated so deeply into the concrete that it could influence the equilibrium of the arch. At 300 tons loading the crown had raised 2.7 (of 1/25 inch) over the position it had when loaded with 225 tons (Fig. 4c), and 0.5 over the original position at the commencement of the experiment. The next 100 tons called forth a further movement upward in this point of 28.7.

Consequent on this movement the unloaded northern arch half (to the right in Fig. 4) which hitherto had been curved strongly, was straightened again so that the centre had raised to 1.1 under the original position when the test-load was 300 tons; afterwards the arch turned upward around the hinge and at 400 tons load the centre was 20.0 over the point where it was situated when the bridge was loaded with its own weight alone.

The angle turnings measured at the levels on the hinge stones agreed with the above-mentioned movements. The crown hinge opened first downward, corresponding to the deflection at the top and toward the finishing of the experiment upward. The southern abutment hinge (to the left in Fig. 4), to which the loaded bridge is attached, opened up during the whole experiment, the northern down.

The hinge stone on the northern abutment moved in all, after the agreeing measurement on the land and Rhine side, .9 horizontally and 1.0 upward and turned ¾ backward in a loading from 0 to 300 tons. At the southern abutment a similar movement to respectively 1.5 and 0.7 took place, but the result of the level readings did not agree for this abutment with the mentioned movements. The reason can perhaps be found in the circumstance that this abutment had not been separated from the walls of a building standing close by, as the leading persons thought that it was better to save the expense of that work, as no importance was attached to the behavior of the abutments during the test-loading. As a very great number of instruments (in all 41) were used, it was possible, in spite of the many different disturbances

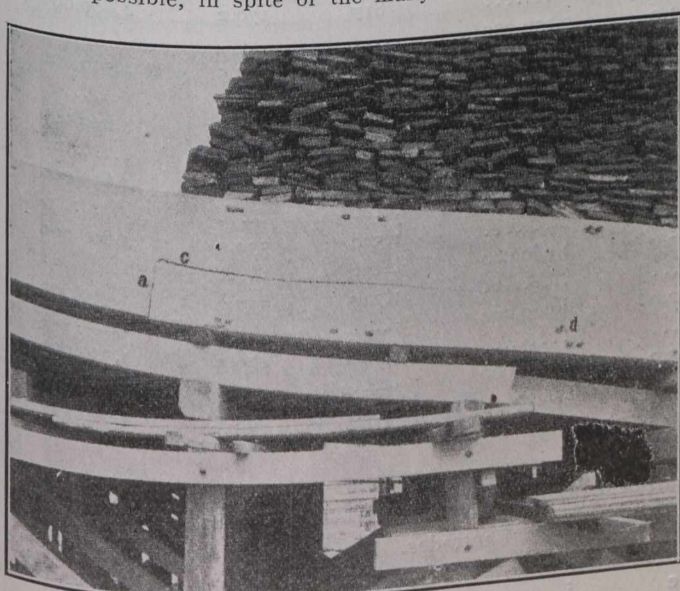

Fig. 5.

arising from changes of temperature, wind, etc., for each kind of measuring to find a sufficient number of agreeing apparatus, the reading of which could be used for comparing with the theoretical researches.

These results all aided in a determination of the pressure lines for the different loading stages. (Fig. 6). As the weight of the load and its position on the bridge were exactly measured and the specific gravity of the concrete in the arch had been found to be 2.36, the acting forces were fully known, both in regard to value and situation, and it was thus possible for each stage to draw an exactly determined pressure line, also the acting points of the pressures in the hinges had been measured. As the figure shows, the pressure line rises more and more under the loading by an increasing of the load from 0 to 225 tons, until, under influence of this load it reached the extrados of the arch. At

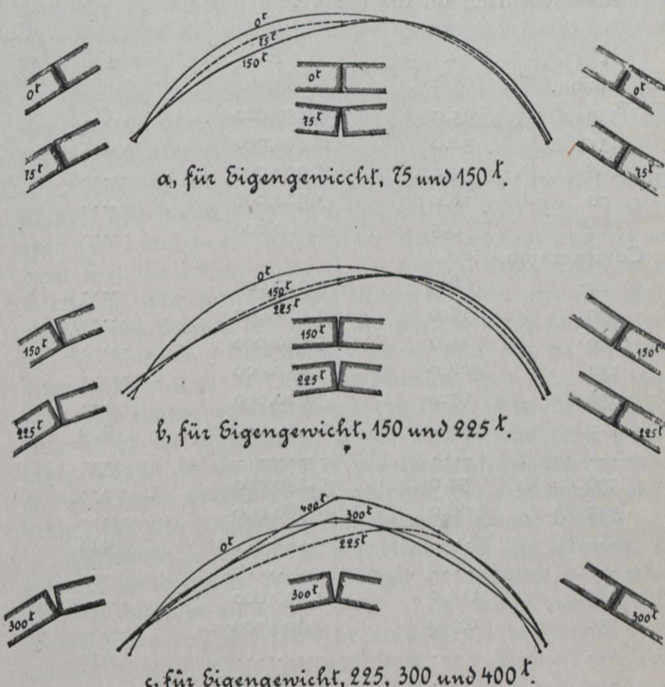

Fig. 4.

the intrados, rises corresponding to this position of the pressure line an increasing tension stress was shown. In the unloaded part of the arch the pressure line becomes more and more flat with corresponding tension at the extrados.

From Fig. 6 it will be seen that the distance of the pressure line from the centre line of the arch is essentially greater in the loaded side than in the unloaded, and greatest under that half of the steel load which is nearest to the crown; therefore, the greatest bending stress occurs here and at the same time considerable shear stresses, as the direction of the pressure line deviates so much from the centre line. The greatest unfavorable concentrated load produced such tension and shear stresses in the arch that it is not to be wondered that a poured joint, which otherwise was fully excluded from the bridge, and which accidentally was situated at the edge of the loading material, opened. The crack commenced at the intrados and was then transmitted upward into the arch and, as the statical examination shows, the crack was throughout so deep that the tension stress in the remaining concrete was 350 to 400 lbs. per square inch. When the length of the crack was equal to half of the arch thickness on the Rhine side and ¾ on the land side (300 tons load) a horizontal shear crack was visible. (Fig. 5). It was now assumed that the bridge would collapse, the thickness of the undamaged concrete being only 16 inches on one side and 8 inches on the other; but no break took place, and it was possible to increase the load by one-third up to 423 tons.

Between 225 and 300 tons the vertical crack came into full action, which can be seen from the fact that the extensometer, which was placed in the point d (Fig. 5) in the neighborhood of the crack, was suddenly unloaded, having hitherto shown increasing tension stresses. At the same time the