Noteworthy steel structures in Austria

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Noteworthy Steel Structures in Austria.

Bemerkenswerte Stahlbauten in Oesterreich.

Constructions métalliques intéressantes en Autriche.

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Since the Paris Congress of 1932, which unfortunately met when the world economic crisis was in full swing, Austria has witnessed renewed activity in all branches of the building trade thanks to the magnificent programme introduced by the Federal Government with a view to reducing unemployment. The opportunities thus offered have also been made available for the somewhat less extensive branch of engineering with which we are concerned, namely, the structural steel industry.

One of the most outstanding constructions in Austria is the new Reichsbrücke over the Danube, which is being built at present. This monumental bridge construction will be one of the largest steel structures in Europe. A classification of the biggest European suspension bridges according to the length of the main span may be of interest. The list is as follows:

(1)	Cologne-Mülheim (cable)	span	1 = 315 m
(2)	Budapest (chain)	,,	1 = 290 m
(3)	Belgrade (cable)	,,	1 = 261 m
(4)	Vienna (chain)	,,	1 = 241 m.

Thus the Reichsbrücke at Vienna takes the fourth place among suspension bridges. It ranks second among chain bridges and second also, if placed according to the amount of material used, in fact, from this point of view it follows very closely on the Cologne-Mülheim Bridge.

The plan was obtained by means of a competition organised in 1933 by the Federal Ministry for Trade and Transport. Altogether 22 plans were submitted and produced a large number of very valuable ideas which were brought to bear on the solution of the exceedingly complicated engineering problem which confronted the architects.

An official publication dealing fully with this very interesting technical event is being compiled and the authorities intend it to appear at latest directly after the completion of the bridge. The present communication is not to encroach in any way on the official report and the information submitted now will therefore only be general in character.

The Judging Committee, composed of leading representatives of the official departments concerned and of the Technical College at Vienna, after carefully examining the plans, reached the decision that, from the point of view of economy and navigational technique, the plan "Freie Donaufahrt" (Freedom of Navigation on the Danube) (Fig. 1), with its main span of 170 m bridged by a trussed arch with solid web brace girder, was the one to be recommended for execution. This plan and three others were awarded prizes as offering a combined solution.

During the negotiations dealing with the letting of contracts for the work at the end of 1933, however, the Judging Committee's recommendation was dropped, the decision revised — mainly for reasons of appearance — and a decision taken in

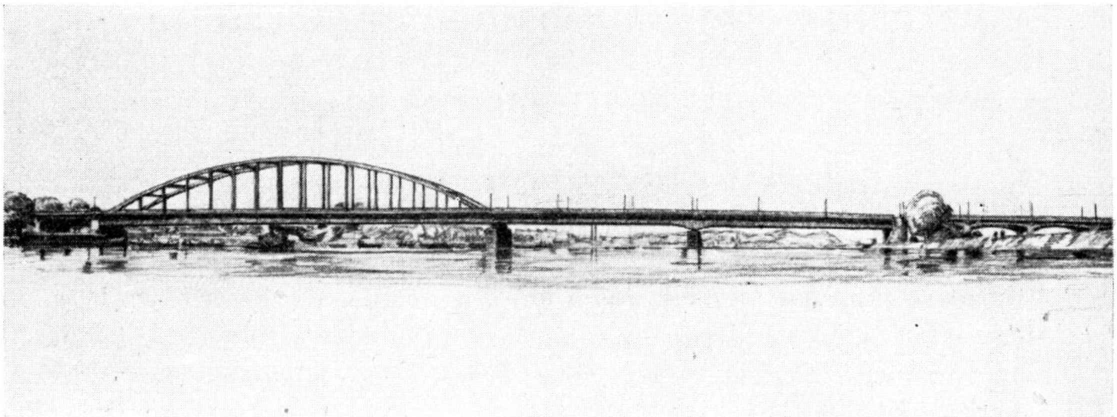

Fig. 1.
Reconstruction of the Government Danube bridge in Vienna.
(Design "Freie Donaufahrt" recommended for execution.)

favour of another solution which had also been awarded a prize, namely, the "chain bridge". This plan included an alternative design of a "cable" suspension bridge. The question as to whether the suspension member should be a chain or a cable

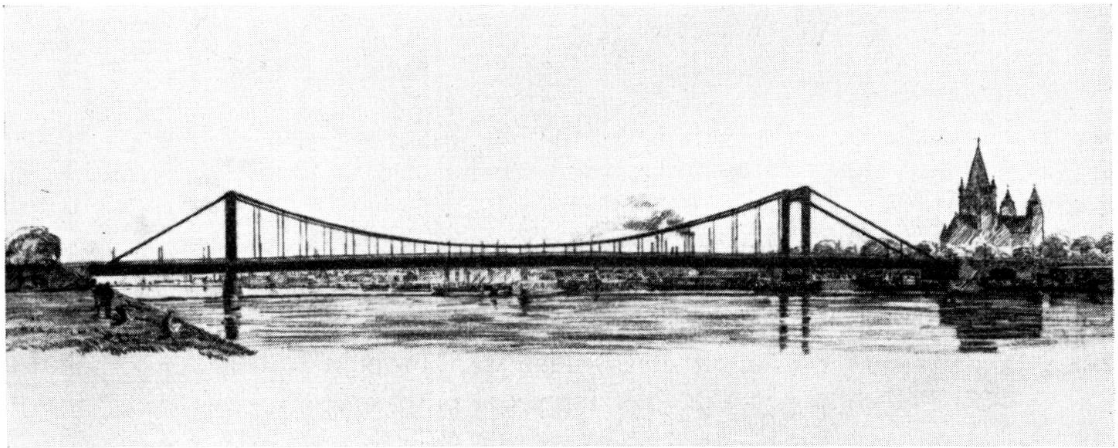

Fig. 2.
Reconstruction of the Government Danube bridge in Vienna.
(Design "Kettenbrücke" accepted for execution.)

was then raised, as indeed it is raised nearly every time a suspension bridge is planned. On the basis of an Advisory Opinion given by Professor *F. Hartmann* (engineer), it was finally decided to select the chain. The determining factors in this connection were the economic aspect, the increase of rigidity and last, but not least, considerations of appearance.

The plan accepted for execution had been designed by the Bridge Building Company Waagner-Biro, Ltd., of Vienna and Graz, and provided for an anchored chain bridge with a stiffening plate girder 4.30 m high, for bridging the central span of 241.2 m. The two side spans, each 65 m long, were made of solid web plate girders, the one on the left bank in one span, while the other — on the right bank — was subdivided by two columns, hinged top and bottom. The approaches to these girders are solid constructions. The chain over the side spans runs in a straight line from the pylons to the anchorage blocks (Fig. 2). The cross section of the design shows the roadway, 16.5 m wide with two footpaths each 3.5 m wide. The main girder distance is 19.1 m. The bridge has a capacity of two tramway tracks and four lanes of vehicular traffic. It will be wood paved, the pavement resting on a concrete bed which covers the suspension plates (Fig. 3).

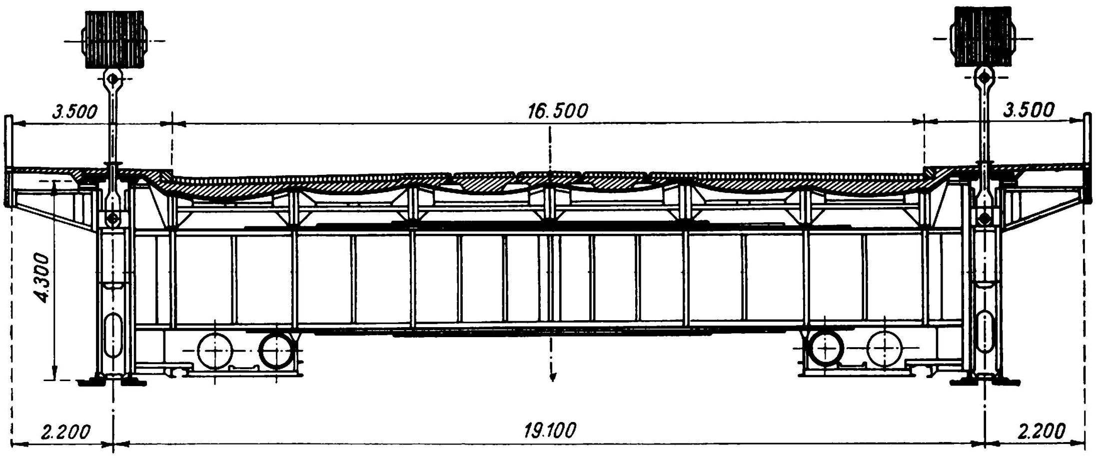

Fig. 3.

Reconstruction of the Government Danube bridge in Vienna.

Original cross section of river span.

The plan aroused great interest on account of its dimensions which are unusually large for bridge building technique. This interest was considerably increased when it came to putting the plan into execution.

Before the work on the new bridge could be started, the supporting structure of the old Reichsbrücke had to be removed (Fig. 4). In order to clear the building site for the new bridge, the axis of which coincides fairly closely with that of the old one, it was found necessary to move the existing bridge some 26 m down stream. The displacement of this continuous structure was carried out in one operation on September 12th, 1934, and took five hours to complete. The old bridge on its new site is being used as a subsidiary bridge while the new one is under construction. The cutting of the connections of the old bridge prior to its removal and its subsequent junction to the previously prepared wooden connecting bridges was accelerated to such an extent that pedestrian traffic was held up for approximately 30 hours only, while the interruption of road traffic lasted only about 48 hours.

As soon as the old bridge had been removed, work was started on the scaffolding and this was quickly followed by the erection of the new bridge. This preliminary work included putting together the stiffening girders on a staging about 85 m long and 25 m wide. After moving this structure toward midstream new sections were added at the shore end (Figs. 5 and 6). The usual procedure for advancing over rollers and fixed fulcrums was not followed, instead of this the structure was moved forward on trolleys running on fixed horizontal rails. On account of the limited length of the rails, the lengths of which were determined by the width of the intermediate supports, the advance had to be accomplished in steps. Supports had to be supplied in keeping with the carrying capacity of the stiffening girders. The piers of the old bridge, together with three wooden temporary supports, served this purpose. After one journey of approximately 2.4 m the bridge was raised by upright hydraulic presses placed beyond the trolley track, the trolley was then placed in its original position, and after the structure was lowered on the trolleys, the next

Fig. 4.
Reconstruction of the Government Danube bridge in Vienna.
Old construction immediately before shifting.

section of the journey was effected (Fig. 7). The erection of the stiffening girders, cross girders and wind bracing was completed by March 1935.

Meanwhile construction proceeded apace. The new abutment for the left hand pylon was erected by means of pneumatic caissons. In this connection the contractors had a surprise for ground conditions proved to be different from what had been expected after the examination of the soil made previously. It was found that the soil was not capable of bearing the loading that had been contemplated. As a result the bearing area of the foundation of the piers had to be extended by consoles which projected beyond the edges of the caissons. But serious doubts were entertained as to whether it would be wise to build an anchored chain bridge.

The plan which had been awarded the prize had to be revised and extended and its re-examination led to the putting forward of two proposals concerning the continuation of the bridge: (1) to increase the dimensions of the anchorage blocks, or (2) to revise the whole steel structure planned, and instead of making an anchored chain bridge to construct one with compensated horizontal thrust, this latter having vertical foundation loadings only. It was decided in the end to alter the steel structure. The decision was influenced by considerations of increased economy, and a higher safety factor, as, even with much larger anchorage blocks the risk of considerable lateral displacement would not have been eliminated.

The main thing was to reinforce the very carefully calculated stiffening girder which had been designed on the basis of a very simple procedure elaborated when

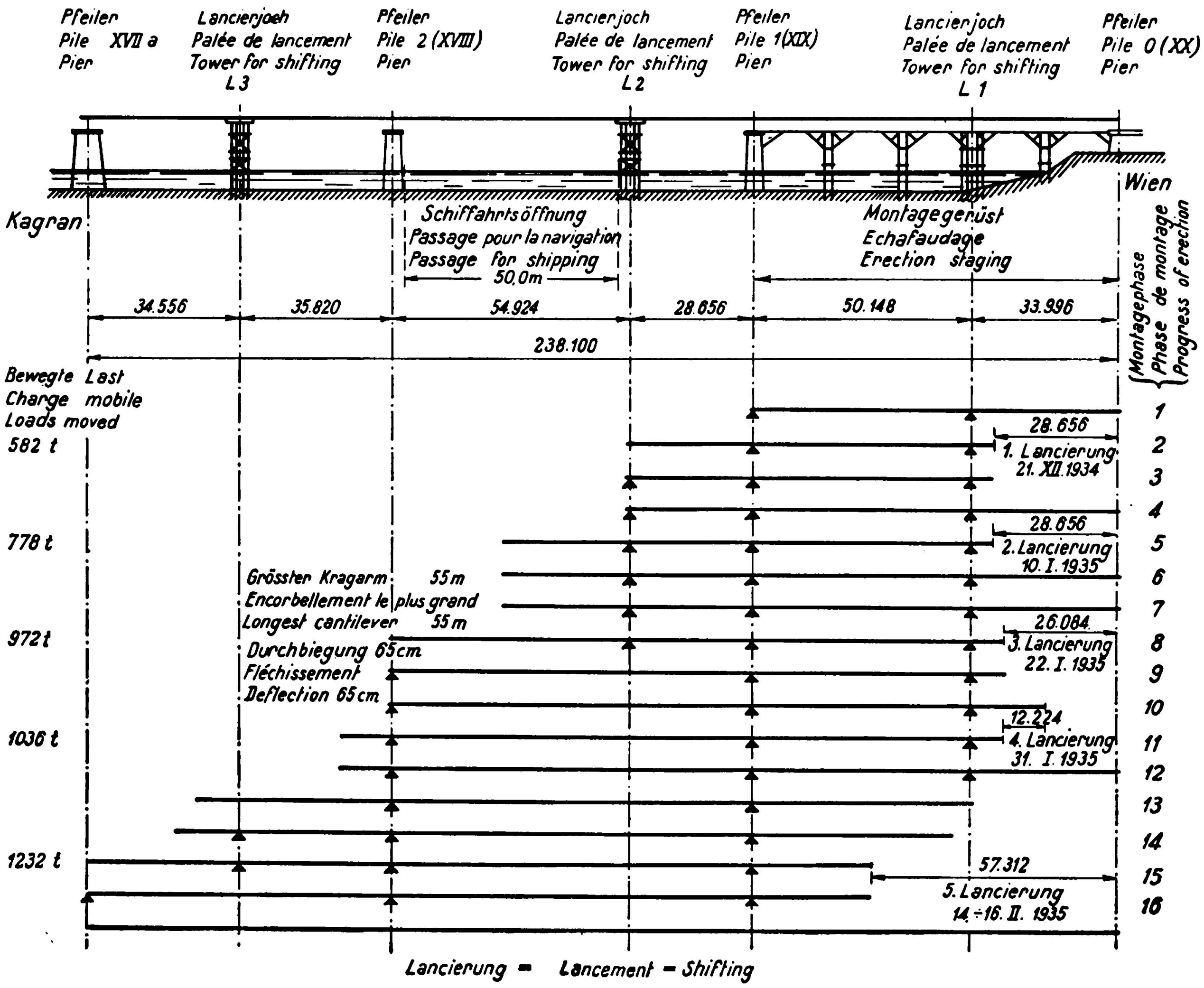

Fig. 5.
Reconstruction of the Government Danube bridge in Vienna.
Phases of shifting.

the bridge was built (called deformation theory) and enabling very precise calculations to be made. This reinforcement would have to meet the additional horizontal shear of some 7,000 tons transmitted by the chain. This was done by inserting in a vertical position four sets of plates having an average dimension of 640.150 mm (Fig. 8). Two such sets of plates, connected to the webs of the stiffening girders, were well braced so as to form buckling-proof members, and in the calculations they were considered as such. It must be remembered that the stiffening girders had already been erected. It would take us too far if we were to refer separately to all the very interesting arrangements made for inserting the reinforcement. We will merely

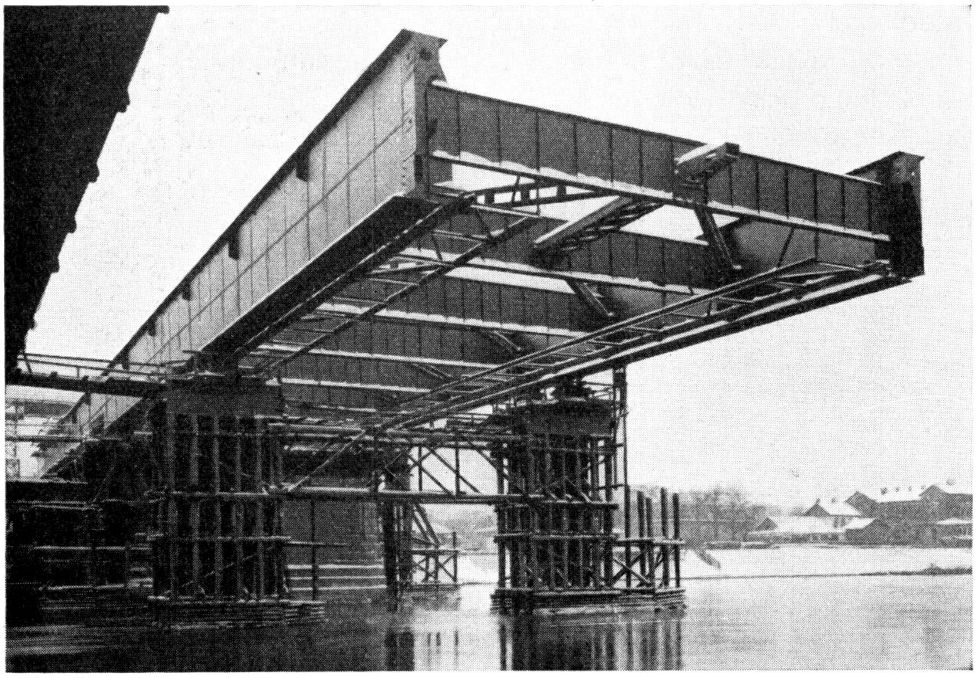

Fig. 6.
Reconstruction of the Government Danube bridge in Vienna.
State after 2^{nd} phase of shifting.

mention that by altering the height of the supports for the stiffening girder which rested on seven supports, the part of the structure being worked on was relieved of all strain.

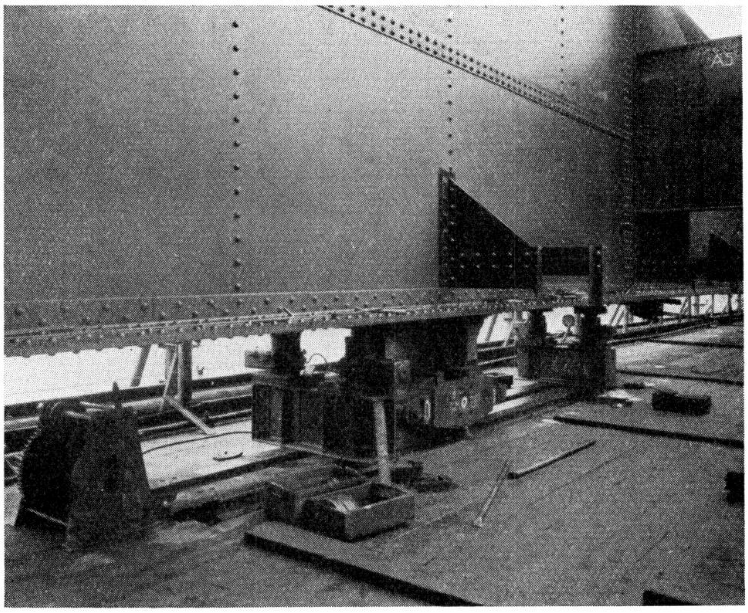

Fig. 7.
Reconstruction of the Government Danube bridge in Vienna.
Shifting track with jacking arrangement.

The increased weight of the structure produced higher strains in the chain. To be able to maintain the sections of the chain, its sag was increased by 2 m. To accomplish this, the length of a section of the pylons had to be increased.

The outside main girders of the lateral spans, which had originally been of the single-web type, were now converted into powerful box girders so as to meet the horizontal shear induced by the chain.

A few brief remarks on construction details may be mentioned here. The most important supporting member, the chain, has an average height of 1.20 m and is composed alternating of 13 elements of 22 mm thickness and of 12 elements of 24 mm thickness. The links of the chain are rectangular and at the ends where the chain bolts of about 450 mm diameter pass through them, they are reinforced by plates. The dimensions and connections of these were determined by the Material Testing Laboratory of the Technical College at Vienna (Prof. Dr. *F. Rinagl*, engineer), after very thorough experiments had been carried out. We have already referred to

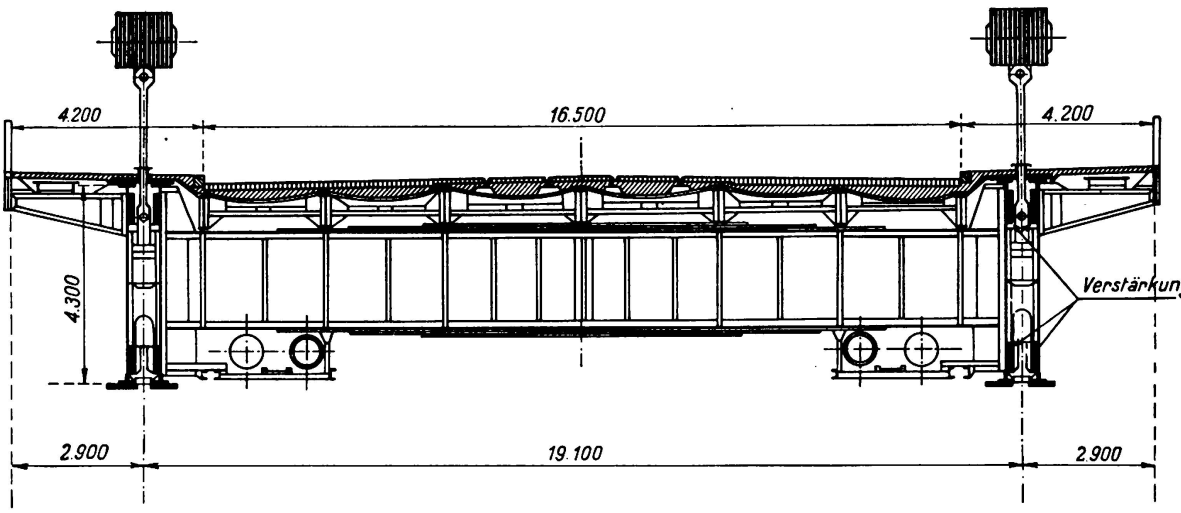

Fig. 8.
Reconstruction of the Government Danube bridge in Vienna.
Strengthened cross section of river span.

the stiffening girder (4.3 m high) and its reinforcement. The connection between the back stays and the outside main girder of the side openings is effected by large bolts having a diameter of 900 mm and which are placed slightly below the axis so as to partially relieve the bending moments in the outside main girders. The point of intersection of pylon and stiffening girder raised structural difficulties as both these members had been terminated. This complication was solved in the following manner: in order to transmit the horizontal shear, stout steel castings were fitted to the central and side openings, these pass through comparatively small windows in the pylon and are shored up against a spherical bolt which is perpendicularly supported and situated in the axis of the pylon. This prevented a weakening of the upright post of the pylon and at the same time a clear transmission of the forces was secured. Further particulars will be contained in the report the publication of which has been announced.

The following building material is being used: carbon steel St. 55, 12 for the chains, suspension members, pylons and outside main girders of side spans; carbon steel St. 44.12 for the stiffening girders, roadway and interior main girders of the side openings; cast steel Stg. 60,81 B for the bearings, forged steel St. 55.11 for the bolts and connections for suspension members. The total weight of the steel used is approximately 12 000 tons.

Next year, with the completion of this bridge, Vienna will possess an additional attraction.

Another bridge engineering feat was accomplished towards the end of 1933 when the old double track railway bridge belonging to the Eastern Railway Company and crossing the Danube at Stadlau, near Vienna, was replaced by a new one (Fig. 9).

Fig. 9.

New structure of railway bridge over Danube in Vienna-Stadlau.

The new bridge spans the Danube with a large meshed truss over four openings of about 80 m. The trusses are continuous over two spans. On the side of the town the bridge is joined to the Kaibrücke which is a solid web cantilever girder of the "Gerber" type, having seven bays of 12 m span each. In the even bays are the cantilever girders, which form with the two columns two legged bents. On the Stadlau side there are two bays of 40 m and then ten bays of 36 m each which span that part of the Danube which is often flooded. These bays are connected by continuous two span solid web girders, just as in the case of the main span. The two last bays form an exception; on account of a bend in the railway track the continuous girder is replaced by a cantilever "Gerber" girder.

With the exception of the main span, both the old and the new bridge had been designed so as to form two singletrack structures placed alongside of each other. This was done to maintain traffic on one structure while the other was replaced by the new one. In the case of the main span, it was necessary to shift the bridge to provide space for the new one. The old bridge was different in that it had five bays over the river; this was done because when it was built (in 1870) no definite information was available concerning the size of the river bed which was at that

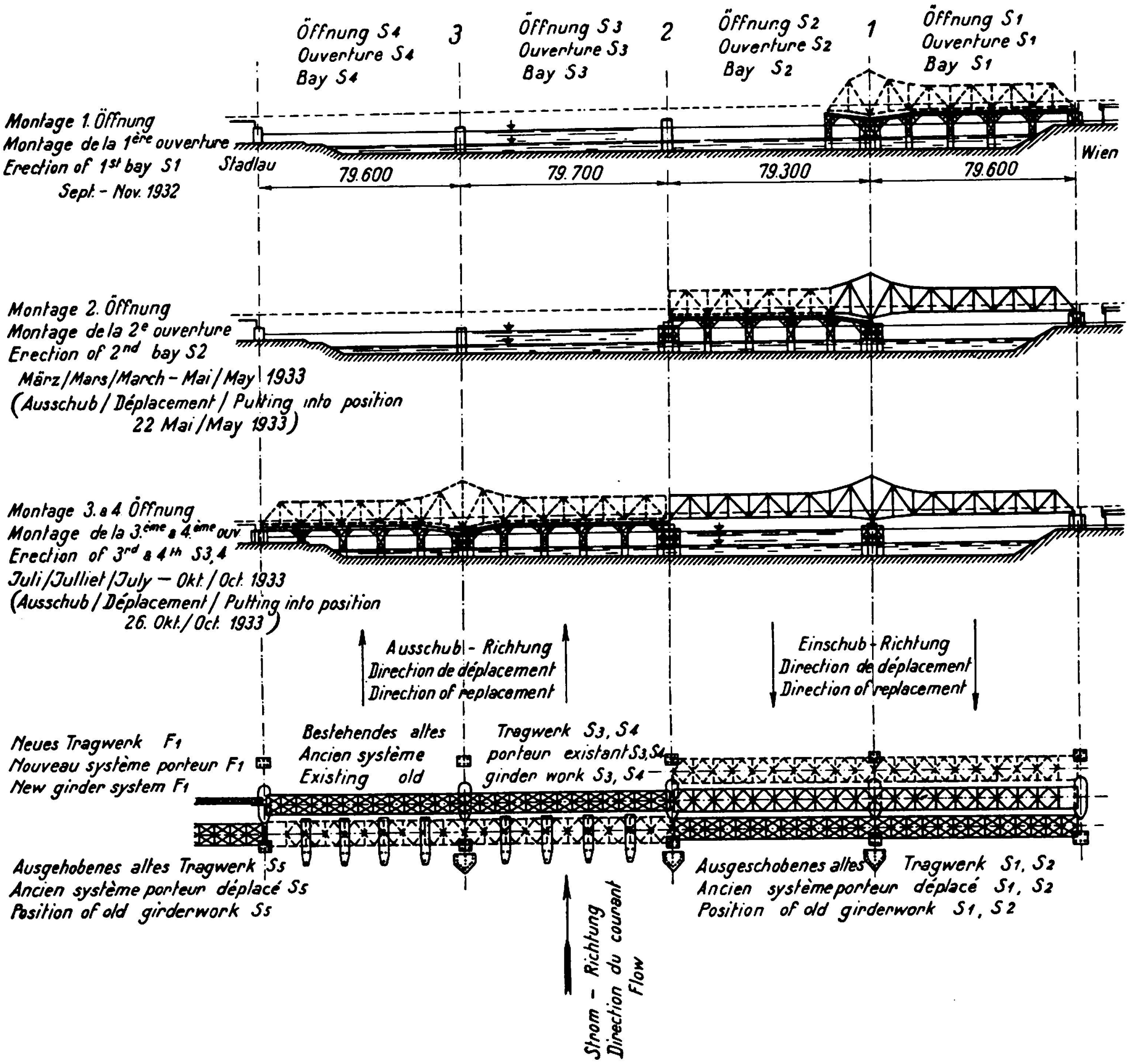

Fig. 10.
Erection of railway bridge over Danube in Vienna-Stadlau.

time excavated. To-day the bed of the river is not quite as broad as the four openings, so that there was no need to extend the new bridge over five openings. After cutting the old bridge over the second and fourth piers and partly strengthening them by wooden bents, the new structure of the two first spans could be built on the down stream side of the existing bridge. After shifting the bridge upstream the new bridge could be shifted in its final position on the old piers. The work proceeded in the same way at the last (fifth) opening. Here a second intermediate pier had to be erected, as the old bay spanning the river was replaced by a continuous plate girder of two spans. The new structure of the third and fourth span over the river was erected next to the old bridge on the up stream side of the existing bridge. That was done to simplify the transport of the material which passed over the first two bays of the old bridge. Fig. 10 shows clearly the processes just described. In the case of the two main displacements (first and second, or third and fourth openings over the river) the load to be removed was about 2 000 tons. The distance over which it had to be transported was roughly 11.5 m.

About 7 300 tons of structural steel were used in the construction, the quality being St. 44.12. The wrought-iron bridge weighed only about 3 200 tons.

About road bridges the following is worth mentioning: the reconstruction of two bridges in Vienna. In the year 1931 the Augarten Bridge over the Danube Canal was completed. This is a bridge of 80 m length, consisting of seven continuous plate girders entirely below the bridge decking. From aesthetic point of view this bridge can be regarded as giving full satisfaction and has been well received by foreign experts (Fig. 11).

The other bridge in Vienna, the Rotunden Bridge also over the Danube Canal is at present under construction.

Before concluding we would mention a noteworthy highway bridge: the Rotundenbrücke (Fig. 12), at present under construction over the Danube Canal at Vienna. The structure consists of solid web two-hinged tied arches of 67 m span. The supporting structure could not be built below roadway, as available space was very limited. The method of erection of this bridge is interesting. A fairway of 35 m width was required for the river traffic. The scaffolding could not be erected over the whole site so that a kind of "catapulting" process, not unlike that described in the case of the Reichsbrücke, had to be carried out. In order to construct the span over the fairway, the steel structure was first made to project some 17 m beyond the scaffolding. Then an open 670-ton tug, fitted with suitable staging, was floated below the projecting part of the bridge. Leverage was effected from the ship and so the two fulcrums of the bridge on the river side were removed. Then the bridge, resting on two trolleys on the fixed scaffolding and on the tug was moved along its axis some 18 m. After the structure had been supported on the other shore the tug was released. This work necessitated stopping the river traffic for two days. Building was then proceeded in the same way as before by advancing in stages.

The latest application of welding in bridge construction is found in the highway-bridge across the Mur in Styria. This continuous solid web girder bridge with two spans of 39 m each was erected by exclusive use of electric welding (Fig. 7, III d Zelisko).

In both of these constructions referred to, high grade structural steel St. 44.12 was used. At present this quality is being increasingly applied in Austria as a standard building material.

Leaving steel bridge engineering we will now give a brief survey of the application of steel to structural engineering.

There is not a great deal to report about large structures erected recently.

The widespread development of broadcasting and the improvements constantly being made to broadcasting stations have given an impetus to this industry in Austria and new installations are being erected in many places. The most important

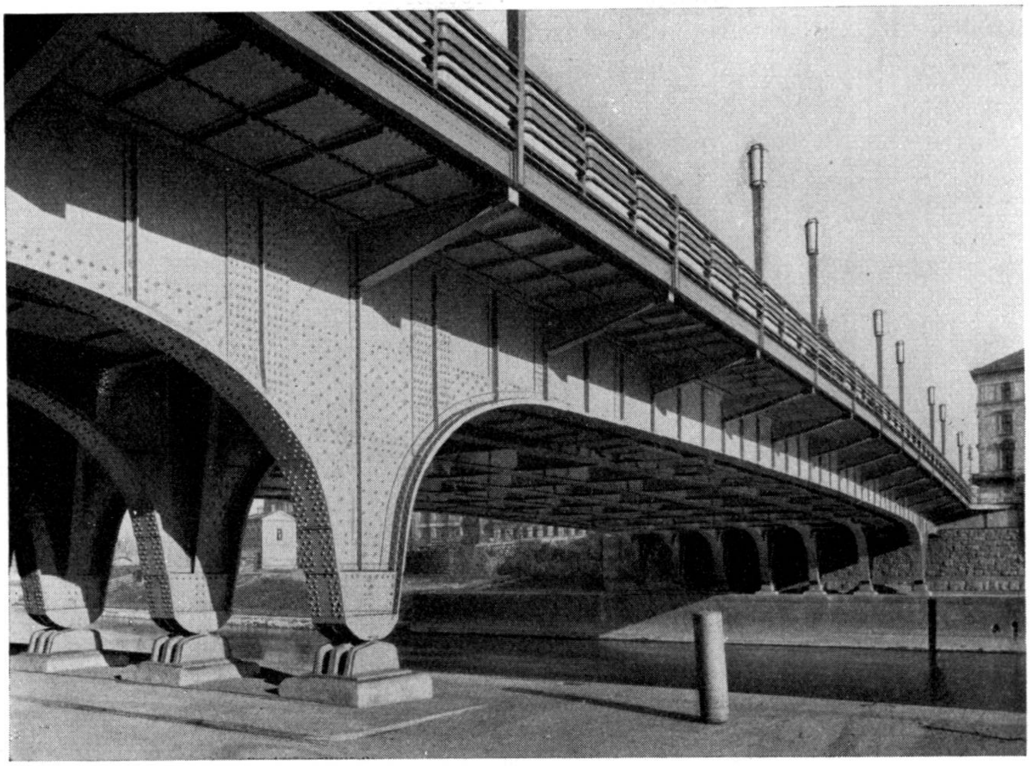

Fig. 11.
Augarten Bridge over Danube canal in Vienna.

of these is the Viennese broadcasting station on the Bisamberg near Vienna. Fig. 13 shows its two masts, each 130 m high.

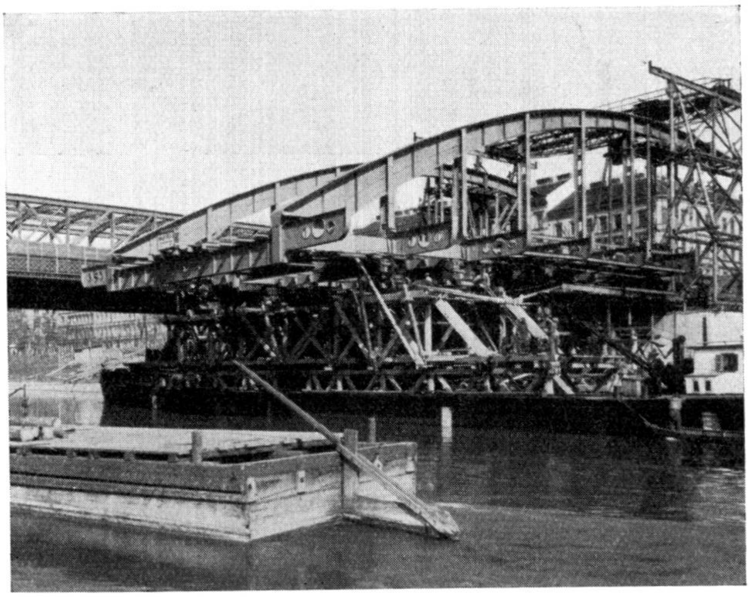

Fig. 12.
Rotunden Bridge over Danube canal in Vienna.
During shifting with pontoons.

This Paper aims at presenting a small selection of structures exemplifying what is being done by the Austrian structural steel industry. Even if the post-war political machinery of Central Europe has turned Austria into a small country and deprived her of nearly all her foreign markets, the Austrian structural steel industry has been able to maintain its technical standing. It collaborates constantly with scientific research and as a result of this, many new policies have been laid

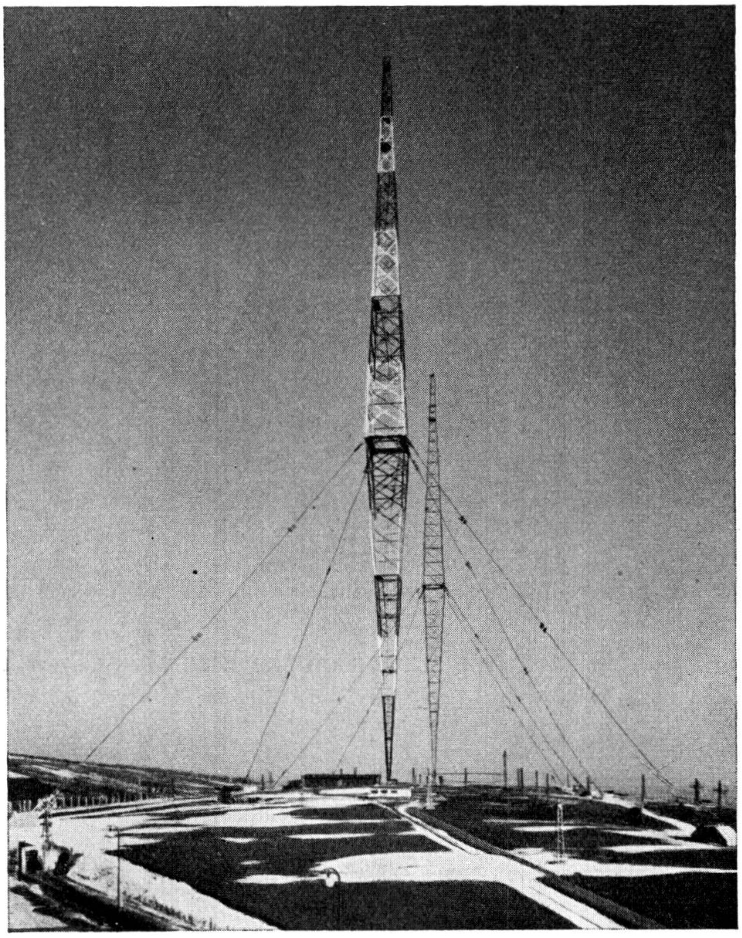

Fig. 13.
Broadcasting masts on the Bisamberg near Vienna.

down thanks to the initiative of Austria. Already in 1919, Austria was instrumental in inducing a better utilisation of this building material, and her example was finally followed all over the world. Her latest move, which is based on the most recent results of scientific research and practical experience aims at further improving the methods of utilisation of structural steel along systematic lines.

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Summary.

In this Paper a review of Austrian activity in structural steel building in the past few years is given by means of a brief description of certain selected steel structures. Special emphasis is laid on the Reichsbrücke across the Danube at Vienna which is at present being built and which is the second largest chain bridge in Europe.

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