Welded weirs and sluice gates in Belgium

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Welded Weirs and Sluice Gates in Belgium.

Geschweißte Wehre und Schleusentore in Belgien.

Barrages et portes d'écluses soudés en Belgique.

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Foreword.

The construction of the Albert Canal, and the great operations for improving Belgian waterways, have necessitated the building of numerous weirs and locks during the last five years.

Nearly all of the steel structures of these plants have been welded.

In a series of articles, some of which have been published in this country, we have shown the remarkable progress that has been made since the erection of the first welded bridge in Belgium — the "Pont de Lanaye" on the Albert Canal, in 1931. Welding had not only become firmly established, but had also become the object of general attention.

In the construction of fixed framework, welding has proved itself a particularly economical and convenient method; it should be so with greater reason in all cases of movable structures, such as swing-bridges, movable bridges, railway wagons, etc., on account of the resulting decrease in weight and, in the case of hydraulic structures, by reason of the water-tight joints assured by its use.

If, even in the present state of the art of welding, and from the standpoint of the sole criterion, the total cost price, competition can still be regarded as possible between riveting and welding in certain operations — it is beyond doubt, that for many structures, and apart from the question of cost, welding can come to the fore by reason of its intrinsic properties.

Thus, in connection with weirs and lock gates:

1) The lightness of the metallic framework will admit of an appreciable reduction in the mechanical appliances and of the working expenses, whilst fully assuring great rigidity of the structure.

2) Perfect water-tightness can be easily and economically obtained.

3) The facility of maintenance, characteristic of all welded structures, will ensure greater durability.

Now, rigidity, lightness, water-tightness, ease of maintenance, constitute the principal qualities which well-designed lock-gates should possess.

It is, therefore, not surprising that after the first welded lock-gates or weirs had been constructed — on the initiative of a single constructor — the Belgian Bridges and Roads Department began to specify welding.

Structural Designs.

A lock-gate is only another type of bridge decking with a plated surface carried on girder work.

The thickness of the plates is generally the minimum compatible with the task to be performed. Nevertheless, it is possible to keep down to these minima by the ease with which stiffeners can be arranged, and there is nothing to prevent building the gates with plates of one thickness throughout.

Moreover, the monolithic character of the structure allows the skin plating to be employed to a certain extent as an integral part of the intermediate ribs and for reducing their weight, just as in the case of ribbed slabs in reinforced concrete.

The intermediate beams, the main cross girders and the verticals, can be built up of sections or of welded girders. Both methods have been adopted, according to the circumstances, in the construction of Belgian lock-gates.

The monolithic character of the welded structure is in itself sufficient to ensure inflexibility; nevertheless, cross bracings of the St. Andrew's cross type have generally been provided.

Apart from these few special features, the essential attributes of a good design remain the same both for riveted and welded work.

The main, if not the only, difficulty attaching to the construction of a welded lock-gate is the temperature deformation set up by the asymmetry of the constituent parts (a single skin plate, for example).

The method of performing the welding should be specially studied and every means adopted to avoid deformations, with a view to preventing serious miscalculations.

A brief description will now be given of some of the works recently carried out in Belgium.

The Marcinelle Lock.

This great undertaking of correcting the Sambre at Charleroi, so as to prevent calamitous floods and at the same time to facilitate navigation, was put up for tender in June, 1931, on the basis of the general scheme of M. Caulier, chief engineer of the Bridges and Roads Department. The metal portion formed the subject of a competition and the welding scheme adopted was that of the Societé Métallurgique d'Enghien, St. Eloi.

A complete review of the work is outside the scope of this paper, which will be confined to a description of the essentially metallic portions.

Lock-Gates: — The gates of the lock, whose chamber is about 130 m long, are of the single leaf type, moving in a plane at right angles to the axis of the lock chamber. Each gate (Fig. 1) is suspended by steel cables from a carriage which runs on a foot-bridge supported by concrete columns. The suspension of the gates from the foot-bridges is designed in such a way that the leaves can be easily lifted clear of the water by means of tackles.

The opening of each leaf is effected by the pull exerted on the gate by the metal cable connected with a winch with straight gear-teeth and mounted directly on the lock wall for the up-stream gate, and on the shore wall for the down-stream gate.

The closing of the gate is similarly effected by the pull exerted on the gate by the metal cable connected to the same winch. The hinged sluices are operated by winches at the gangway level of the gates.

Down-stream gate:— Width of gate 12 m 90,
Height of gate 7 m 10,
Thickness of gate 0 m 70.

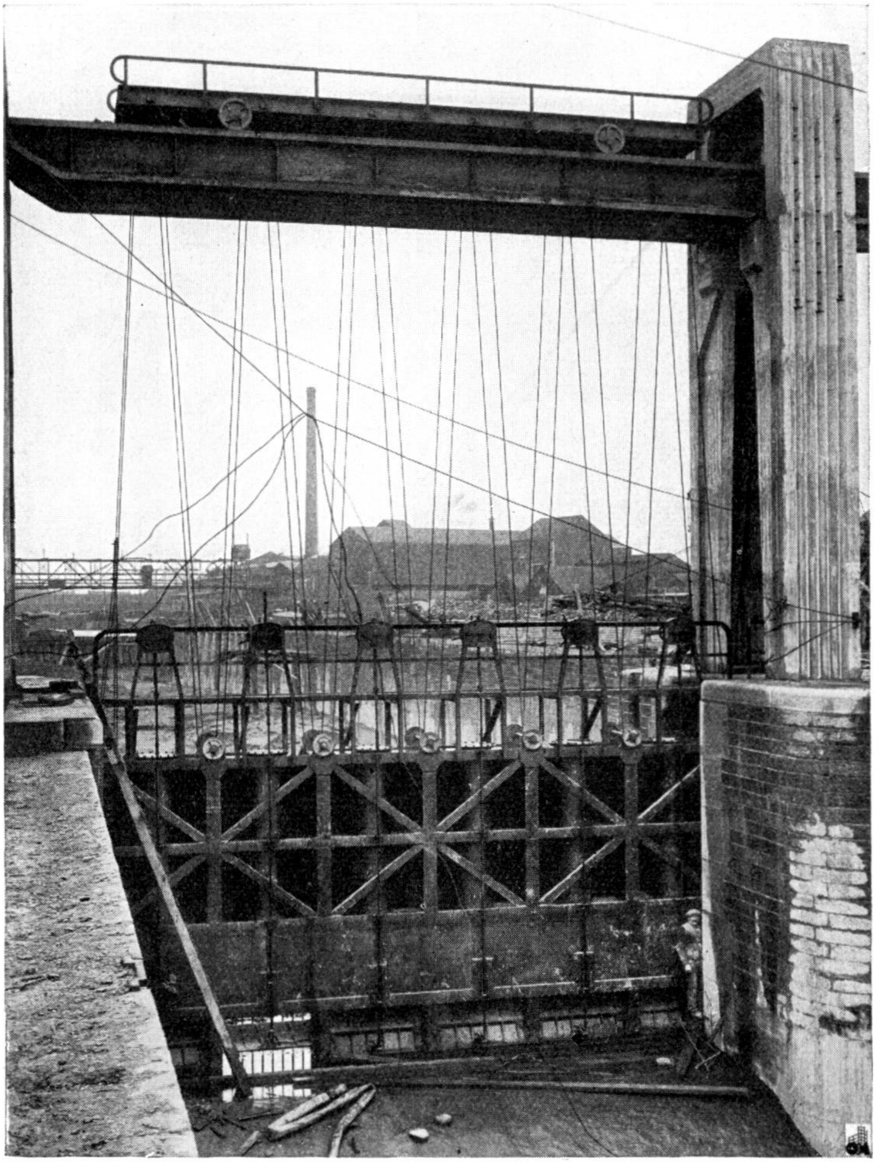

Fig. 1.
One of the lock gates at Marcinelle Lock.

The gate is calculated to meet the two following conditions:—

1) Full pressure on the up stream side with no water on the down stream side: stress 12 kg/mm^2.
2) Under normal conditions, with a difference of level of 2 m 35 and a stress of 10 kg/mm^2. The weight of a riveted leaf was 25,384 kg, The weight of a welded leaf was 20,234 kg, i. e. a saving of about 20 % in weight.

The gates consist of a double skin of 10 mm plate, thus providing buoyancy for balancing the gate. Water-tight inspection ducts are provided to facilitate maintenance of the interior.

The gate is built up of six cross girders having a web 750 mm by 10 mm with welded flange plates of varying width and thickness. The two vertical end frames have exactly the same scantling. The intermediate verticals have a web 750 mm by 10 mm, the flanges being formed by the skin plating.

A certain number of stiffeners have also been provided in the form ol light standard sections.

On account of the double skin, the plating extends only as far as the cross girders and is welded to the latter.

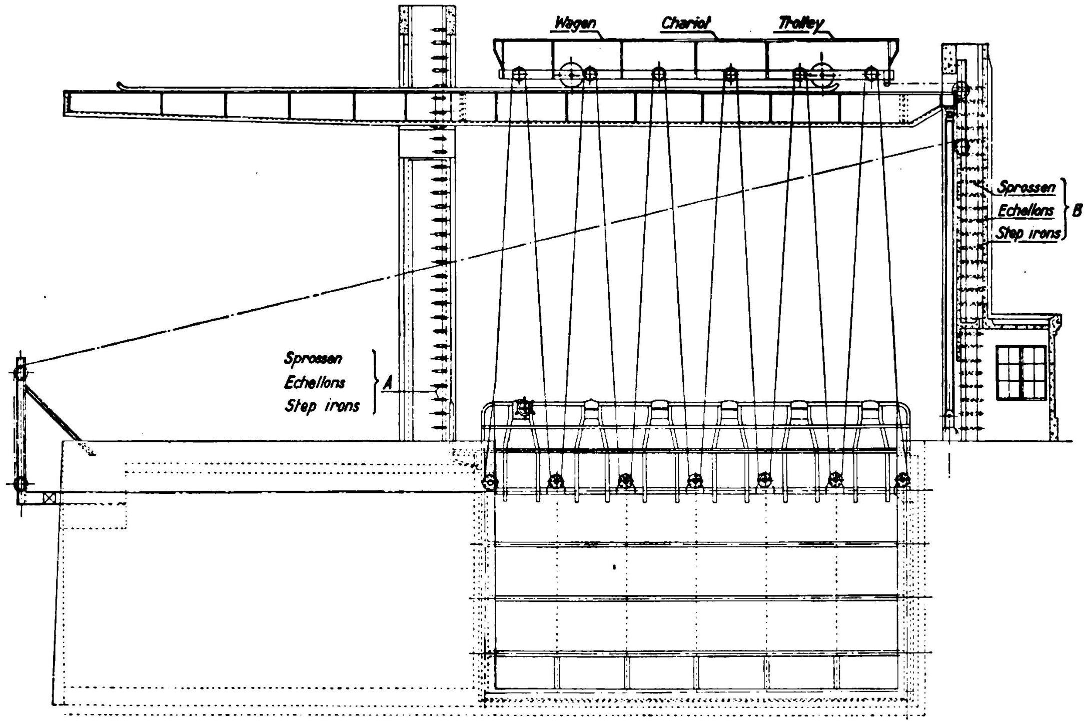

Fig. 2.

Marcinelle Lock, Upstream gate, general arrangement.

A monolithic system is obtained (Fig. 2) which is perfectly rigid; cross bracings having, however, been nevertheless provided.

The gate was delivered (the gangway and the two end verticals being detached) in two sections, each comprising three cross girders. These two pieces were joined up at site by welding on the central skin plating, the end verticals and gangway being then welded.

Up-stream gate:— Width 9 m 40,
Height 4 m 55.

As in the down-stream gate, and for the same reason, a double skin is provided, the construction being exactly the same, but comprising five cross girders. The up-stream gate weighs 15780 kg welded, as compared with 20200 kg riveted, thus giving a similar saving of about 22%.

Lock. The actual lock comprises a sluice of sufficient dimensions to justify the use of the Stoney type.

The sluice (Fig. 3) is composed of a vertical steel wall supported on two main horizontal girders of the Vierendeel type. This type was chosen, not with a view to obtaining an illusory saving in weight as compared with a framed girder with parallel chords, but in order to have the heavy ironwork, rather than small parts, in the water. At the up-stream side, the main girders serve to carry the points supporting the skin plating (Fig. 4), and are cross-braced on the up-stream face. These two principal girders are joined to the vertical end girders supporting the trains of rollers.

Each sluice presents a recess 10 m 39 wide forming an overflow, which can be controlled by means of a baffle plate movable about a horizontal axis.

The "Stoney" rollers are carried on roller tracks of steel secured in guide grooves provided in the masonry.

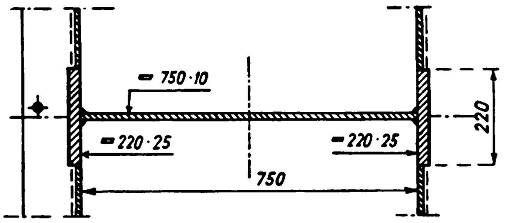

Fig. 3.
Marcinelle Lock
Detail of cross girder and connection of plates to flange.

The lateral water-tightness is obtained by upright steel bars, covered with rubber. These bars bear against the skin plating of the sluice and on castings fixed in the grooves. The water-tightness between the sluice and the sluice valve is obtained by means of chrome-leather joints.

The sluice wall is suspended by cables to the operating winches located on a concrete service foot-bridge and balanced by cast-iron counterweights housed in the columns.

The dimensions of the sluice prevented delivery in a fully assembled condition. The two end verticals forming the framework of the sluice valve had to be sent to the site dismantled and to be welded during erection. The great difficulty in erection was that the play between members had to be reduced to the minimum compatible with good water-tightness and the working of the sluice valve.

The width of the sluice is 13 m.

The height of the sluice, less the adjustable fittings, is 2 m 68.

The maximum height with fittings in position, is 4 m 60.

The total weight in riveted structural work would have been 43000 kg. The weight of the welded work is 35 864 kg, i. e. a saving of 16.8%.

Sluice Valve:— The sluice valve also comprises two main horizontal girders to which is welded the 10 mm plating with stiffeners of plates and standard light sections. These girders are supported by two end verticals, by means of which the structure can be lifted.

On account of its special design (Fig. 5) and the arrangement of parts which are entirely asymmetrical, very careful precautions were needed to avoid any kind of warping and thus to maintain the axes of rotation in a rectilinear plane and obtain perfect water-tightness combined with efficient performance.

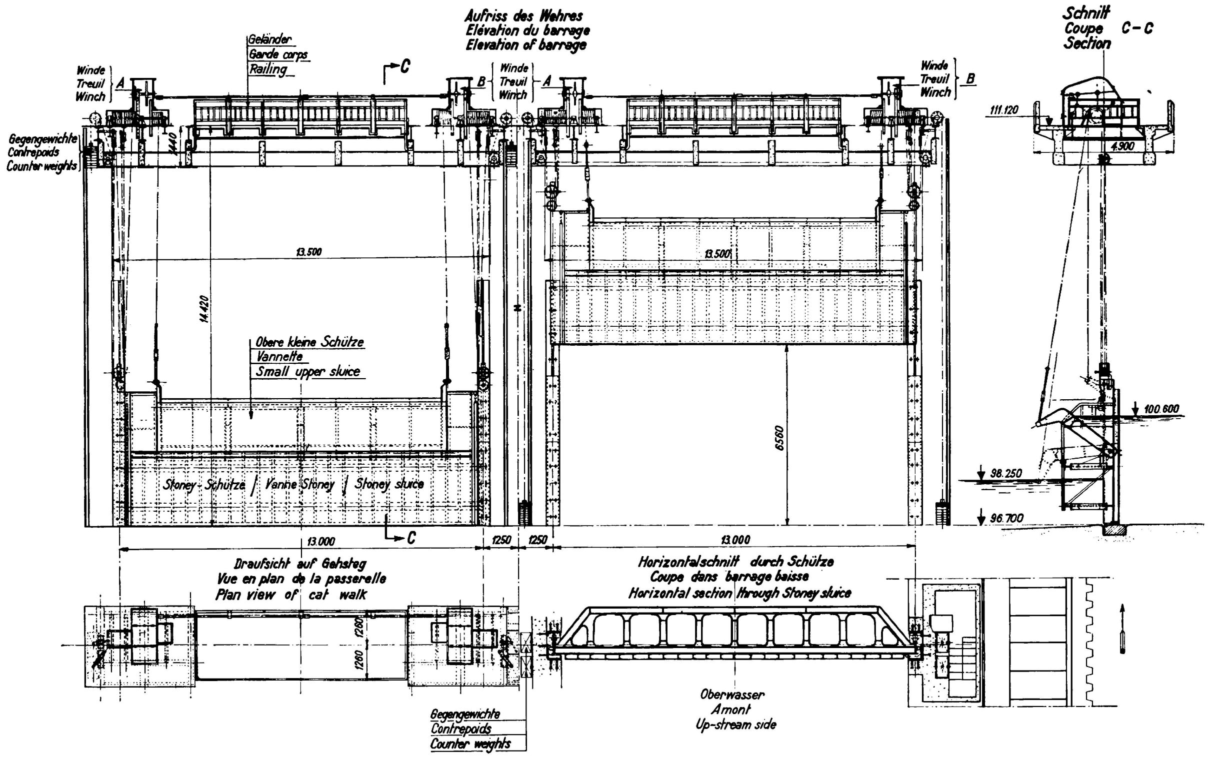

Fig. 4.
Marcinelle, General view of Lock

The welded sluice valve weighs 10 tons, as compared with 11 tons for riveted work.

Sundry Details: — Many interesting examples could be cited in which welding has resulted in great simplification in carrying out the work, or economy of material.

It was quite by chance that the first welding executed in lock work should be the Marcinelle weir, in which the variety of shapes and of members was very great. Being afraid of unduly prolonging the present paper, we will merely cite

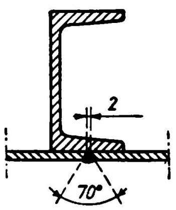

Fig. 5.
Stoney Sluice, connection between plating and channel sections.

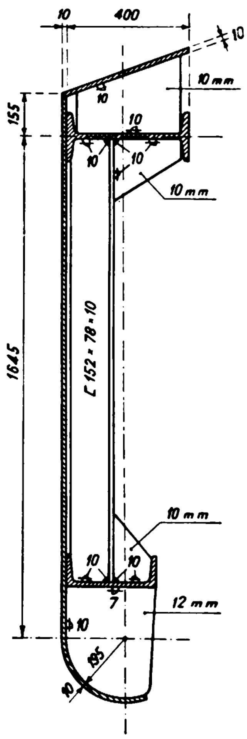

Fig. 6.
Marcinelle Lock
Small uper sluice

an example of replacing a piece of cast-steel — a suspension device (Fig. 6) — by welding.

The Wyneghem Lock (1933—1934).

The Wyneghem Lock is one of the six locks in the rise between Antwerp and Liége, and is in duplicate, so as to be independent of any damage and in respect of repairs. Each lock chamber is 136 m long with a breadth of 16 m, and represents a difference of level of 5 m 70.

The lock is constructed on new principles with regard to the filling and emptying of the lock chamber: discharge channels in the lock wall have been dispensed with and the water for filling and emptying flows through sluices constructed of cast steel segments provided in the gates themselves, two being contained in each leaf, and each presenting an opening 2 m 20 by 800 mm.

The lateral water-tightness of these sluices is obtained by means of flexible, rustless steel plates, covered with bronze sectors and moving over cast-steel members fixed on the walls of the gate openings. At the bottom, these sluices rest on plates (also of bronze) and the water-tightness of the upper part is attained by means of rubber joints pressed against a cast-steel guide by means of flexible, rustless steel plates.

The kinetic energy of the water is absorbed in the vortex chamber (faced with cast steel) built in the up-stream head, in such a manner that refilling is effected without affecting the steadiness of the boat in the lock. Similarly, chambers for absorbing energy are provided at the down-stream head to check the flow of the outlet water.

The lock, designed by Mr. A. Braeckman, Chief Engineer of the Bridges and Roads Department, is the result of careful tests on models which enabled the

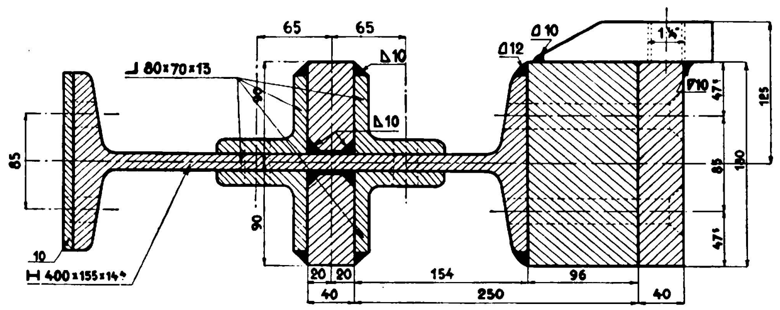

Fig. 7.
Marcinelle Lock Details of suspension for Stoney sluice

shape of the chambers, the width of the sluices, and the method of working to be decided upon.

Intercommunication between the two lock chambers is provided by means of segmental sluices similar to those of the gates. They are formed in the central wall and coupled in pairs, each pair serving to empty one of the lock chambers into the other. In this manner either of the lock chambers serves as a reserve basin for the other in case of shortage in the water supply.

The only difference between the intercommunicating sluices and the gate sluices is in the design of the lateral water-tight joints, which had to be so arranged as to obtain water-tightness in both directions. Actually, in the case of the gates, the pressure on the sluices is always exerted from the up-stream towards the down-stream direction, whilst in the case of the central wall, it is exerted on the one side or the other, according to whether the water in the right or left hand lock chamber is at the level of the down-stream, or at that of the up-stream.

The whole of the operating machinery is placed below the platform level, for which reason the general appearance of this very important work has a character of its own.

The gates are of the arched type.

Down-stream Gate:— Width of one leaf 8 m 839,
Rise of arch 3 m 00,
Total height 9 m 95.

The gate comprises seven equidistant transverse beams resting on the two end verticals. To avoid deflection of the vertical members, the transverse beams have separate cast-steel supports against the jamb. These transversals are composed of a web 890 mm by 10 mm and welded flanges of variable width and thicknesses. The single 10 mm and 11 mm plating is fixed to the flanges of the cross girders by two fillet welds, thus assuring good water-tightness (Fig. 7). Verticals are provided, composed of a 940 mm by 8 mm web and two flanges, one of which is a flat 120 mm by 8 mm member, and the other is formed by the skin plating. The end verticals have a web 568 mm by 10 mm and flanges 280 mm by 10 mm.

The plating is also stiffened, horizontally, by light sections.

The weight of a welded leaf is 23.5 tons; in riveted work it would have been 27 tons. Thus a saving of about 13% has been obtained.

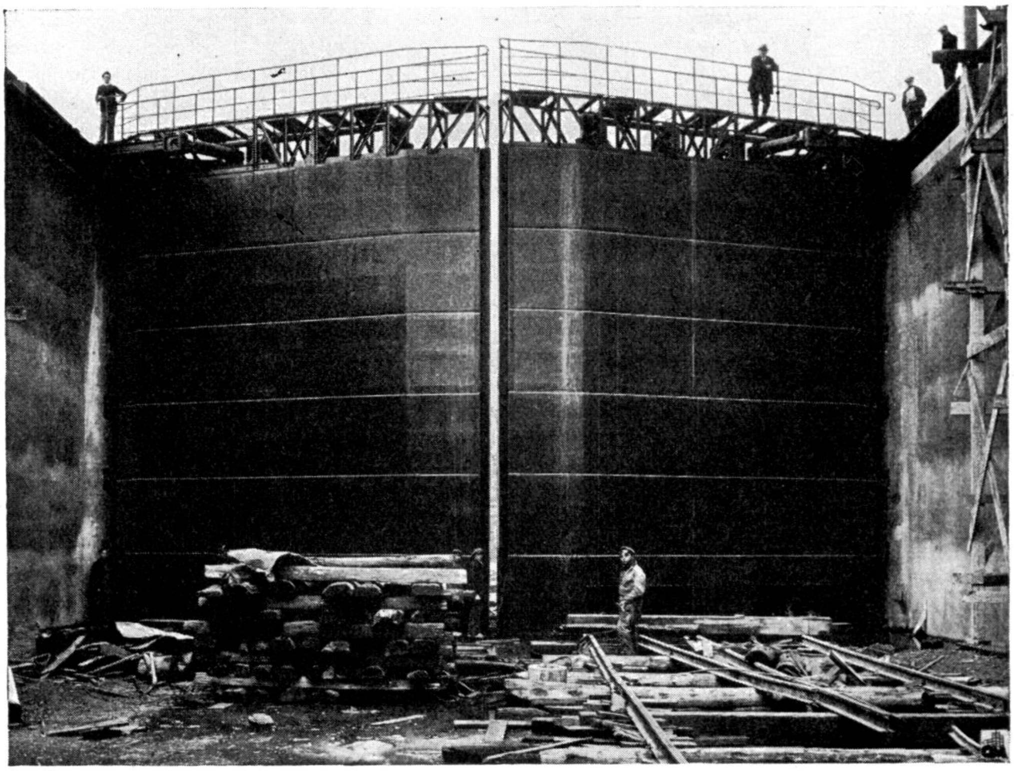

Fig. 8.
Downstream gate of Wyneghem Lock, seen from upstream.

Notwithstandig the high rigidity of the whole, a cross bracing, in the form of a St. Andrew's cross, has been provided.

The Up-stream Gate (Fig. 8), having a theoretical height of 5 m 75, is of similar construction to that of the down-stream gate. There are four cross girders having a web 868 mm by 10 mm; the end verticals have a web 568 mm by 10 mm with flanges of varying sizes; the intermediate verticals have a web 840 mm by 8 mm, and the skin is a single 10 mm plate, the stiffeners being flats.

The Hérenthals Lock.

The Hérenthals Lock is situated at the junction of the Hérenthals wharf basin with the Albert Canal. This junction is designed for boats of 600 tons.

The lock, which has a fall of 7 m 30, has a lock chamber 55 m long and 7 m 50 wide. In the lower part of the wall is a wide longitudinal channel with three filling openings in the chamber. In its upper part, the wall contains a small independent channel serving to feed the down-stream reach. The filling is effected by cylindrical sluices, all on the up-stream side, and by the rolling sluices on the down-stream side. The cylindrical sluices are of great utility, but their dimensions become excessive in the case of down-stream sluices of a lock with a high fall.

The lock is the work of Mr. M. A. Bijls, Chief Engineer and Director of the Bridges and Roads Department.

The arched gates are of the pointed-arch type.

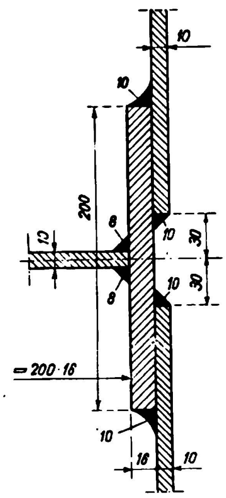

Fig. 9.
Wyneghem Lock
Details of welding for plate connections.

Down-stream Gate:— Width of a leaf 4 m 12,
Rise of arch 1 m 65,
Total height 10 m 975,
Single skin plating of 10 mm plate.

The gate consists of three verticals, on which rest the four rows of the transverse beams, and the verticals are of DIN 65 sections. The stiffeners are of standard light sections and the diagonal bracings in the form of St. Andrew's cross, are of channel section 200 PN.

The gate, of particularly strong and economical construction, weighs 18412 kg.

The Up-stream Gate has a height of 3 m 525 and a single skin plating 10 mm thick. The verticals and transverse beams are of section DIE 45. The construction is identical with that of the down-stream gate. Its weight is 3,980 kg.

The cylindrical sluices and the roller sluices are also of welded work throughout. The cylindrical sluices are composed of a cylinder of 10 mm plate, to the lower part of which is welded the forged steel valve, which rests on a cast-steel seating embedded in the concrete. The cylinder, strongly stiffened inside by diagonals and cross members of rolled sections, is guided in the pit by means of rollers.

The roller sluices, of trapezoidal form, are built up of "Grey" sections with single skin plating. They run on vertical roller tracks fixed in the concrete, and provide water-tight jointing by bearing against fitting strips in cast-steel frames fixed in the masonry.

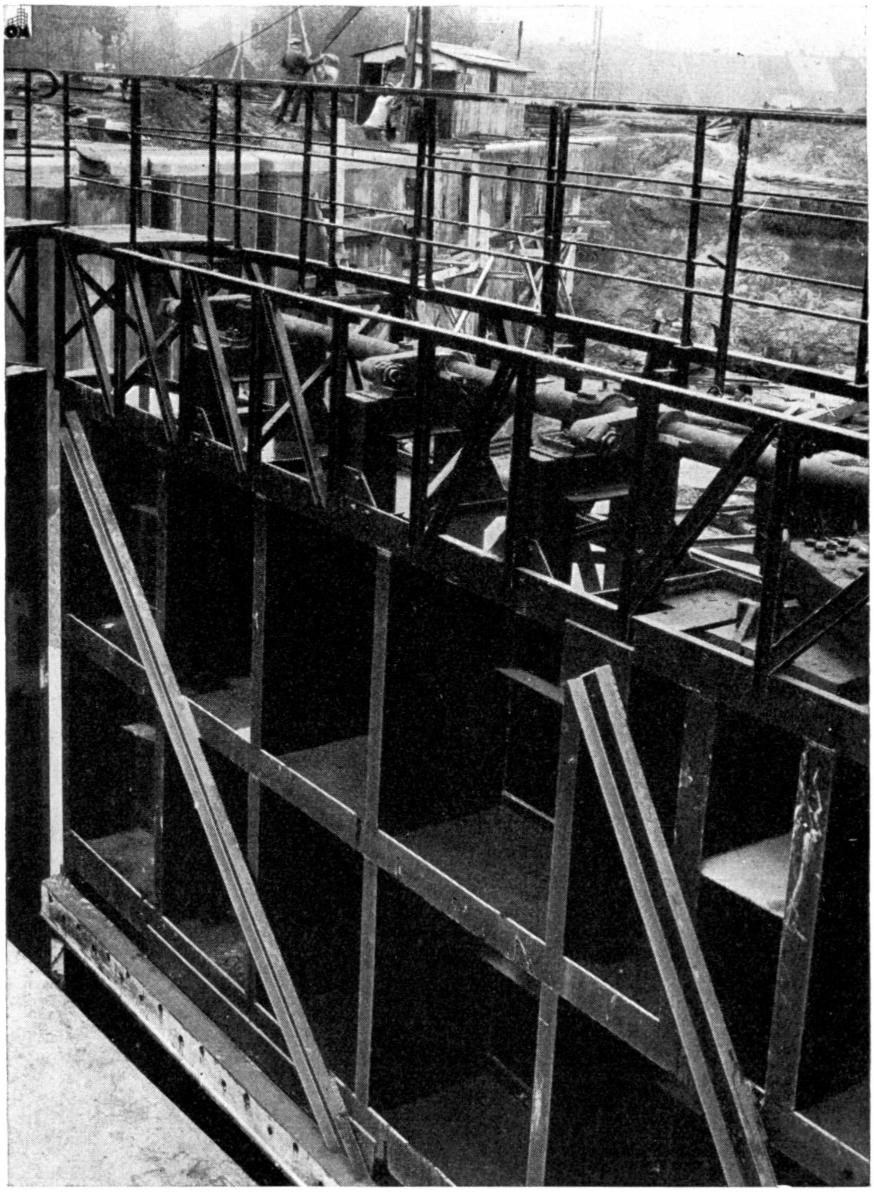

Fig. 10.
Upstream leaf of Wyneghem Lock.

The operating gears of the gates and sluices are electro-mechanical, of the rack and pinion type.

The Nèthe Lock.

The Nèthe Lock is the work of M. Claudot, Engineer-in-chief. This work, situated on the River Nèthe, provides a connection with the Albert Canal and is normally designed for boats of 600 tons. It will, nevertheless, allow the passage of boats of 1350 tons.

The lock comprises a lock chamber about 82 m long and 12 m 50 wide, for a fall of 5 m.

In general arrangement, this lock is of the Wyneghem type, that is, with cast-steel sluice segments in the gates. The gates are of the pointed-arch type, like those at Hérenthals. However, their design is not so simple, the space taken up by the sluices having necessitated increased thickness in the lower portion of the gates (Fig. 9).

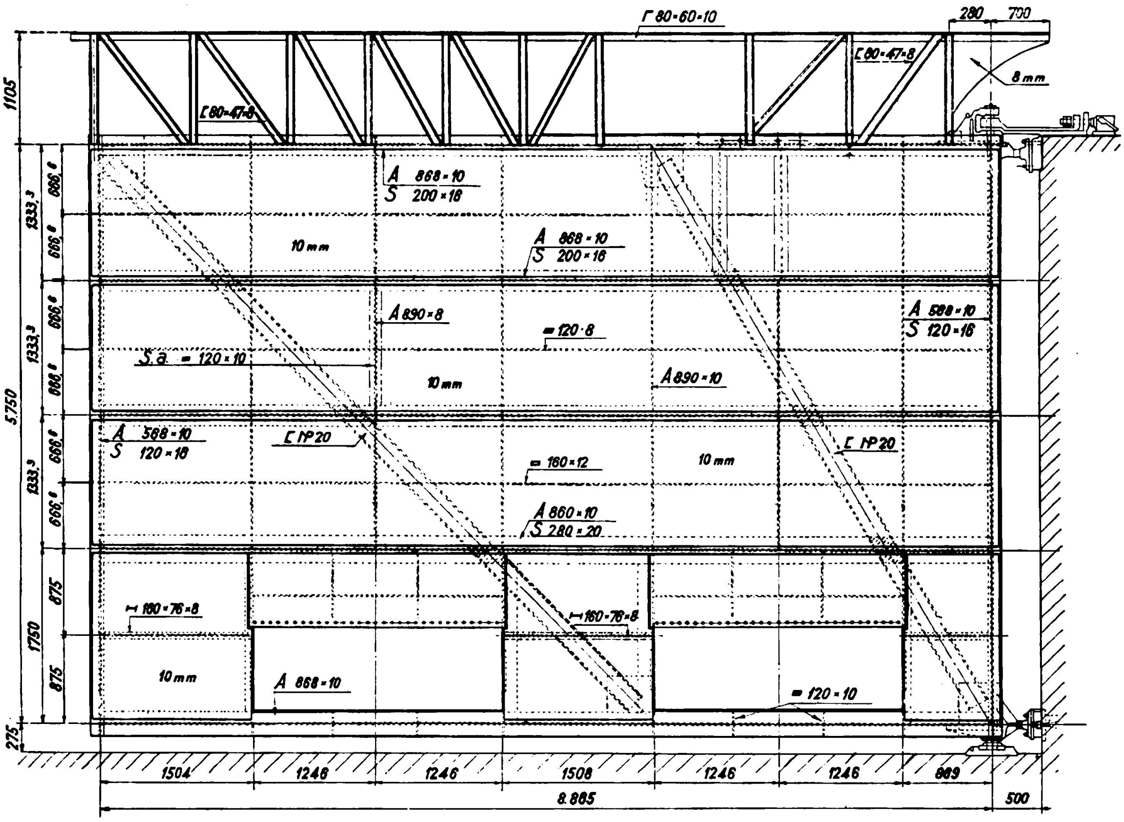

Fig. 11.
Wyneghem Lock, General arrangement of upstream gate.

The principal characteristics of the gates are the following: —

Down-stream Gate: — Width of a leaf 5 m 67,
Rise of arch 1 m 90,
Theoretical height 9 m 49.

The single skin plating is of 10 and 10,5 mm plate. The framing and the central verticals are of DIL 50 joist. The transverse beams, except the bottom one, are of PN 500 pattern; the stiffeners of PN 120, 200, and 280; the St. Andrew's cross bracing is of channel section PN 240. The weight of a leaf is 19,524 kg.

The Up-stream Gate, of similar construction to the down-stream gate, has a height of 5 m 365 and weighs 12 tons.

The method of making the sluices water-tight adopted at Wyneghem has been completely modified at Hérenthals.

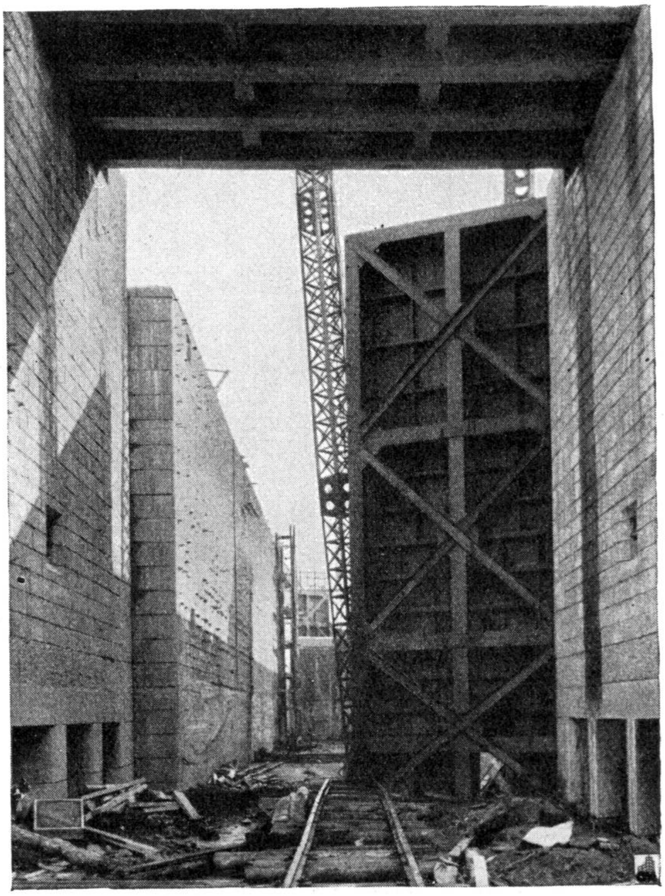

Fig. 12.
Erection of downstream gate of Herenthals Lock.

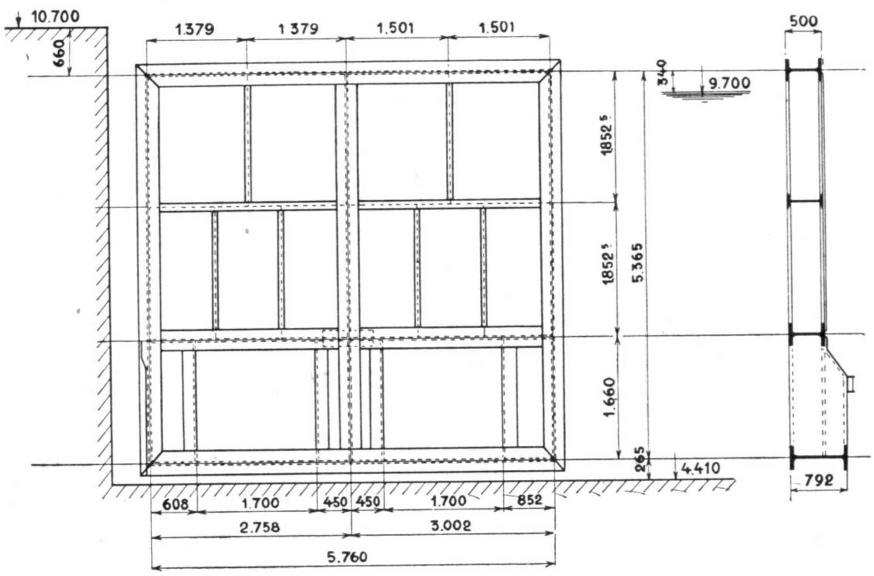

Fig. 13.
Nèthe Lock.

The rustless steel plates with bronze sectors have been discarded, and replaced, on the side and upper walls, by a one-piece rubber joint. For the lower part, the bronze plate has been retained. The rubber joint presses tightly on cast-steel

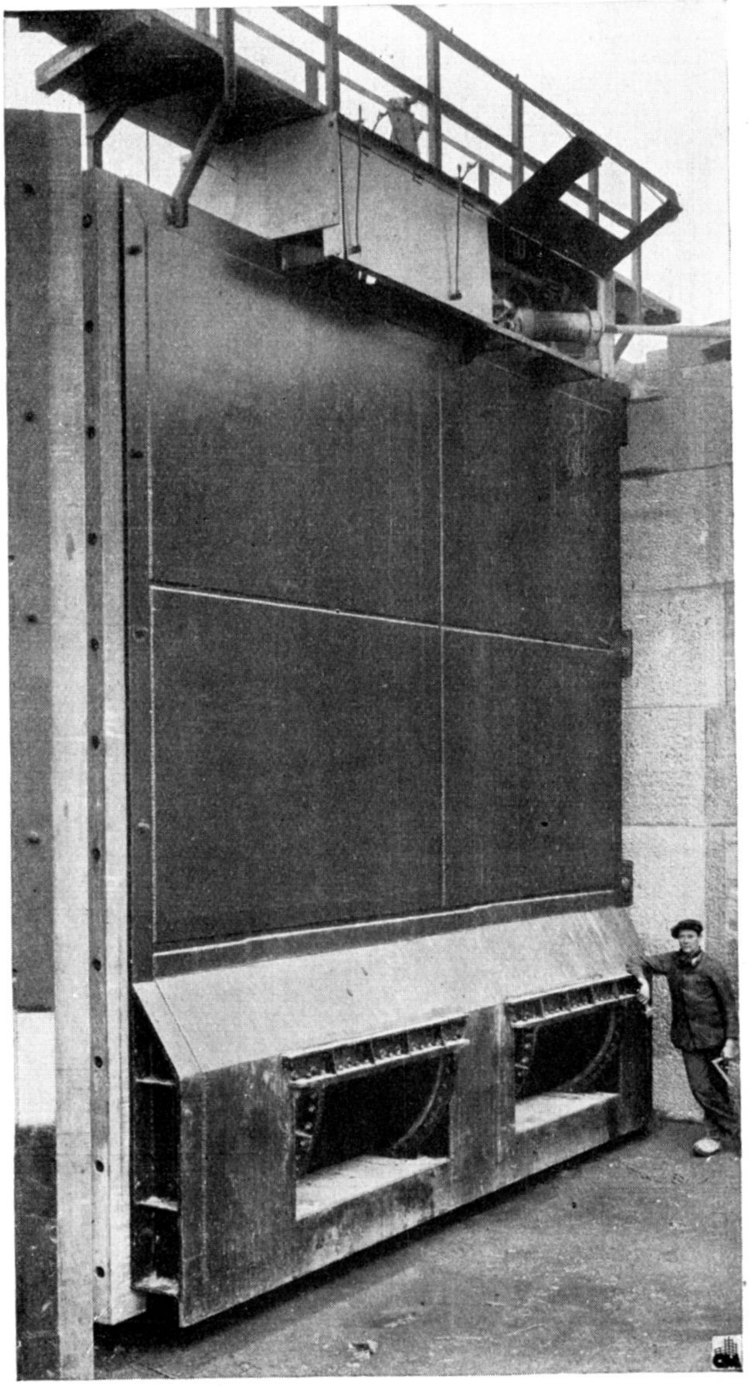

Fig. 14.
Leaf of upstream gate of Nèthe Lock.

guides fixed on the gate, and by means of a hollow round bar adapted to flatten out under the pressure of water, thus assuring perfect water-tightness.

The operating gears of the gate are of the type known as "Panama". The sluice segments are actuated from the foot-bridge of the gate by means of a rod and crosshead. The two sluices of each leaf are operated simultaneously. The gears are actually worked by hand, but are designed for subsequent electrification.

Summary.

In the course of the last five years, several lock-gates and sluices have been constructed in Belgium, partly on the new Albert Canal, partly for carrying out extensive works for the correction of waterways.

Most of these works were carried out with the aid of welding, which has brought about: —

1) A considerable saving in weight.
2) Perfect water-tightness.
3) Facility of maintenance.

As examples of these constructions, a description has been given of: —

1) The Marcinelle Lock, on the Sambre at Charleroi, in which the sluice is of the Stoney type and the lock-gates have a single lifting leaf.
2) The Wyneghem Lock with arched gates:
3) The Hérenthals Lock with arched gates.
4) The Nèthe Lock with arched gates.

Belgian constructors have completely solved the problem of welding for lock-gates.