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Autor: Bryla, St.

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Experience obtained with Structures Executed in Poland.

Erfahrungen bei ausgeführten Bauwerken in Polen.

Observations sur les ouvrages exécutés en Pologne.

Dr. Ing. St. Bryła,
Professor an der Technischen Hochschule, Warschau.

The development of welded constructions began in Poland at a relatively early date, namely in 1927. The following year, 1928, saw the first large and important construction, the road bridge near Lowicz, the first welded road bridge in the world. At about the same time the Ministry of Public Works issued its first official regulations concerning welded constructions; these remained the only official regulations in this sphere until the German prescriptions were published in 1930. Although the bridge over the River Sludwia at Lowicz certainly fulfilled its purpose as a pioneer construction, its influence was more perceptible abroad than in Poland itself. In spite of the fact that this bridge was really successful, the successors of Minister Moraczewski were not inspired by the latter's initiative. It was only under the influence of the development of welded bridges in other countries that Poland again began to build such bridges; one is at present under construction near Mosina with a 40 m span. Yet Poland has not kept pace with her neighbours in this respect, even though the welding process has made rapid strides there in the field of structural engineering. The majority of the Polish steel constructions today are being entirely or at least partly welded in the workshops; the percentage of riveted constructions, already small, is decreasing still more as time goes on.

This tendency is to a great extent due to the new regulations issued in 1932 by the Home Office, who had taken over part of the duties of the former Ministry of Public Works. These regulations combine a liberal attitude with demands for high efficiency and extensive supervision and inspection.

The Home Office policy as regards welded constructions, as it is clear from these regulations, tends both to favour workshops of a high technical standard and to assist them still further by taking a special interest in really good products, without however making things more difficult for workshops of a lower standard. The way was also left open for free competition between welded and riveted constructions, so that the most economical and rational type of structure could always be chosen.

As the appended table shows, the majority of the steel constructions executed in Poland during recent years were welded not only in the workshop but also at site; a certain percentage, however, were also riveted at site. This type of structure is generally employed in cases where the workshops carrying out the work are not equipped for welding at site, or where there is no electric main and current is therefore expensive to obtain. This is an important factor in Poland, where electrification is still in its first beginnings and current has often to be generated at the building site, thus making welding an expensive process. The increase in price thereby involved works out at about 50 Zl. (app. 40 RM) per ton of steel construction at an average cost of 600 Zl. per ton. And even when a supply of current is available, welding increases the price per ton by about 10 to 20 Zl. As welding at site means a reduction in the weight of steel, however, this procedure is always worth while when there is a supply of current at hand. When there is none, welding at site may or may not prove an advantage. A number of workshops with experience in this line advocate riveting at site in the majority of cases. The position always varies, however, when it is a question of constructions entirely welded, not only because the welding process is becoming more and more wide-spread and is in itself more economical, but also because it is noiseless in execution. For this reason the Home Office now intends prohibiting the riveting of steel constructions at site within municipal areas.

Till now the same rolled sections have generally been used in welded as in riveted constructions, though a tendency to vary the profile for the purpose required is slowly but surely becoming apparent. The reason for this lies in the different types of connection. Riveted connections require the existence of suitable surfaces for the application of rivets and straps. The dimensions of these surfaces had also to offer adequate room for sure and convenient support for the rivets and riveting machine. These facts led to the wide-spread use of angle-irons, though they usually form unfavourable cross sections in respect of buckling. At any rate, they have certainly been the most important form of section in lattice structures, and easy to connect to the gusset plates and, in twos and fours — especially cruciform — to each other. The angles have also played the most important part among the connecting elements, particulary among those parts jointed at right angles (connecting joists to girders and columns, etc.). Sometimes they also form the connecting and bearing element, as for instance in the case of plate girders.

The above factors do not come under consideration when the connections are welded. T-sections or angle-irons are easy to connect to plates, so that with the introduction of welding the angle loses its importance in combination with rolled sections. To a certain extent the T-section is coming into its own; it is a type of section that has hitherto been but little used, its flanges being too small to permit the use of stout rivets and bolts. However, it possesses a symmetrical axis. T-sections can simply and easily be converted into lattice girders, but as they are only manufactured in a small number of sizes, it is often necessary to form a T-section out of an I-section cut in two, which naturally makes the job more expensive. It has thus become absolutely necessary that more T-sections be manufactured by the rolling mills, i. e. a larger range of sizes and of forms adapted to the requirements of the construction. One of the most important requirements in this connection is an equalisation of the moment of inertia $I_x = I_y$, so that the T-section possesses the same resistance to buckling in all directions.

Furthermore, the introduction of welding allows of a more general use of I and [-sections, and even extends their field of application to a certain extent, affording as it does their easy connection (as with lattice girders) and also permitting their use as girders. Other rolled sections are of less importance in constructional work and are comparatively little used. As a matter of fact, welding rather tends to reduce their number, since it permits a combination of any desired forms from the material available. On the other hand, flats and plates are being more and more used on account of welding, though in increasingly larger dimensions than those normally employed. This is becoming apparent even now in the chords of lattice and plate girders, in the stanchion bases, etc. Round and square bars, too, which formerly were not used at all, are now beginning to come into vogue because there is no difficulty about welding them (see Fig. 10).

Special types of section such as those now being rolled in Germany for welded plate girders, are not yet available in Poland. There is, on the other hand, a trend towards the employment of tubular forms which, at any rate for larger dimensions, are mostly manufactured in suitable forms from plates. There is also a tendency here and there to roll semi-tubular sections in readiness for the manufacture of such forms, two of these being connected to form a single tubular section. This procedure has not, however, been definitely introduced as yet.

Sections composed of different forms of rolled sections combined offer just as much scope in welded as in riveted constructions. The principal reasons for this are the type of connection and the use of oxy-acetylene burners for cutting the sections. Similarly, certain composite forms are more suited than others for carrying out certain types of connection. In general, welding offers much more scope and facility in construction, although there are naturally exceptions to the rule. One example of this is the cruciform connection (for columns or lattice girder bars), particularly when it is formed by four angle-irons. In a riveted construction these angles can easily be connected among themselves and with trapeziform base plates (Fig. 1). The same applies for the sections shown in

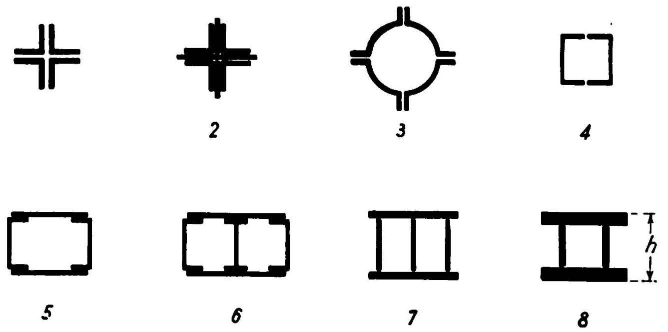

Fig. 1 - 8.

Figs. 2 and 3. This type of connection is possible when slotted welds are used, though the latter involve a considerable increase in cost.

On the other hand, welding has led to the introduction of a large number of new forms of columns, in particular such as enable the material available to be employed to greater advantage in order to reduce the cross-sections of the columns without affecting the resistance to buckling (or in some cases the resistance to bending). Some examples of these columns are given in Figs. 4—7. All of them are impossible of execution in riveted constructions, and offer the two advantages mentioned above. Form No. 6, for example, was used in the construction of the Jagellon Library in Cracow, where the following specifications had to be observed: Dimensions of columns 140×500 mm; a rectangular, flat cross section enclosed on all sides and with sufficient space inside it for the passage of conduits. The round forms, too, can easily be carried out in welded constructions, a fact which opens up new possibilities in the field of reinforced concrete columns. One of these columns filled with concrete is much more advantageous than one with lateral reinforcement.

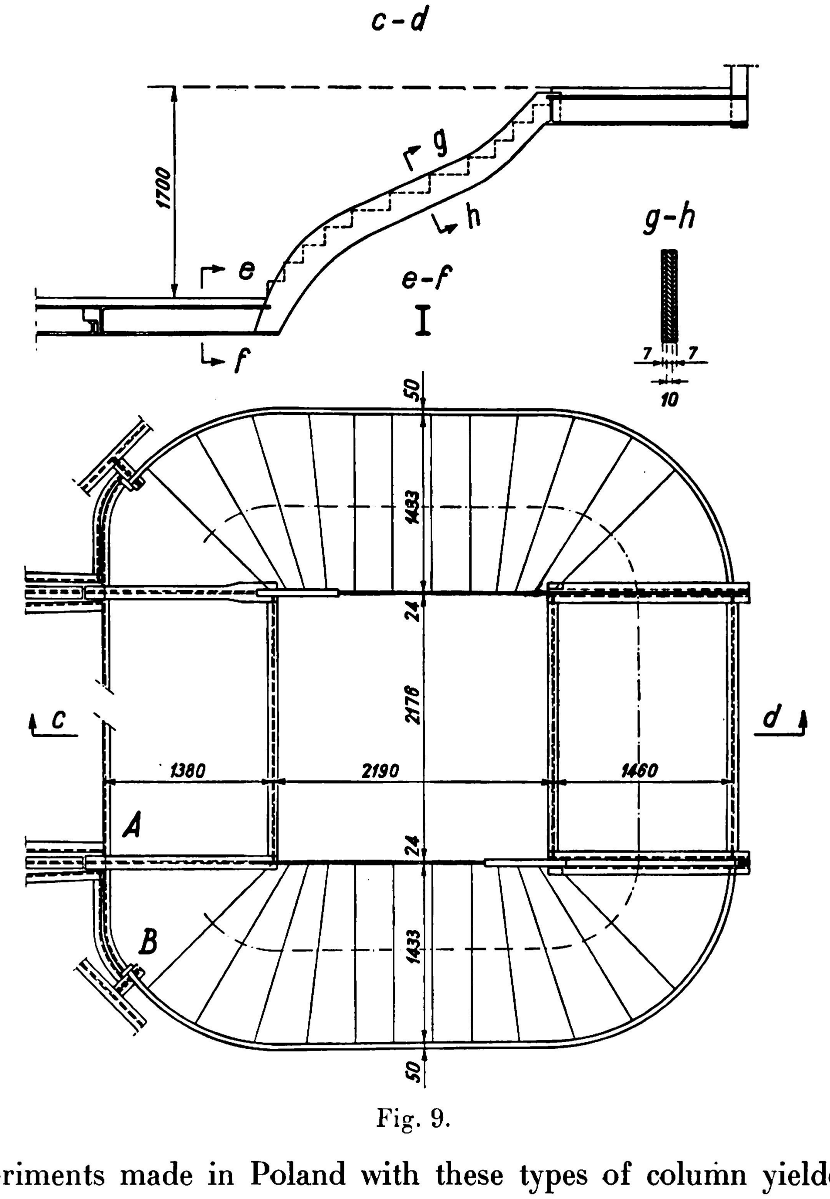

Fig. 9.

The experiments made in Poland with these types of column yielded excellent results as regards strength which should lead to better utilisation of the structural material.

The possibility of a much better distribution of the material opened up by welding also enables new cross-sectional forms to be employed in arched girders. Even rolled sections make reinforcement possible — a procedure that was out

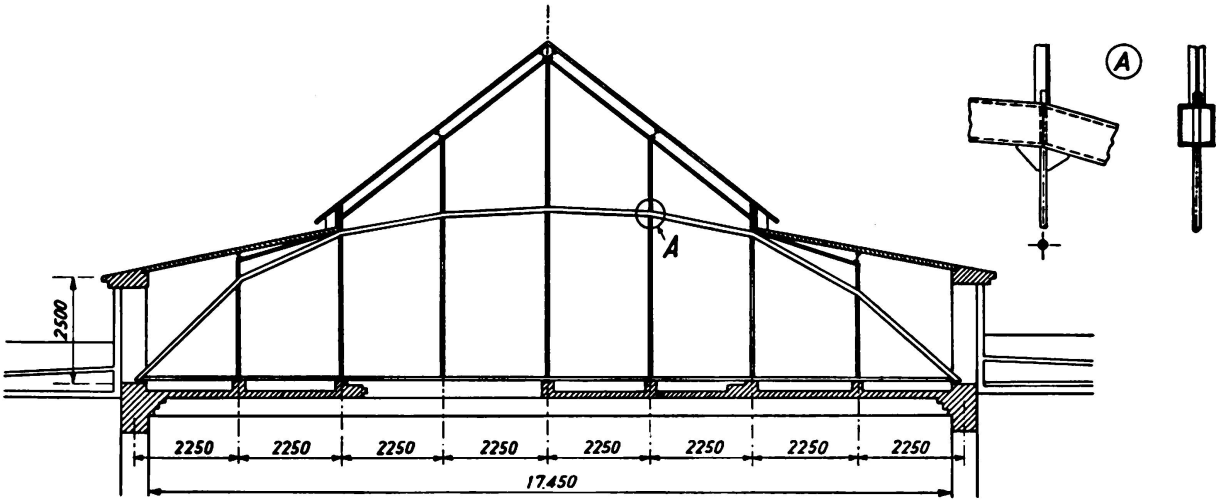

Fig. 10.
Jagellon Library in Cracow. Detail of upper portion of arched roof.

of the question in riveted constructions — by means of straps, by cutting and increasing the height, and by welding on lateral ribs at the points of application of the concentrated loads.

It must be emphasised that, in contrast to the tests carried out in Germany, those made in Poland with reinforced girders have proved that as regards strength the latter are more advantageous than plate girders of the same amount of material. The progress made by employing welding is chiefly visible in cases where a curved beam transmits a considerable bending moment and is itself

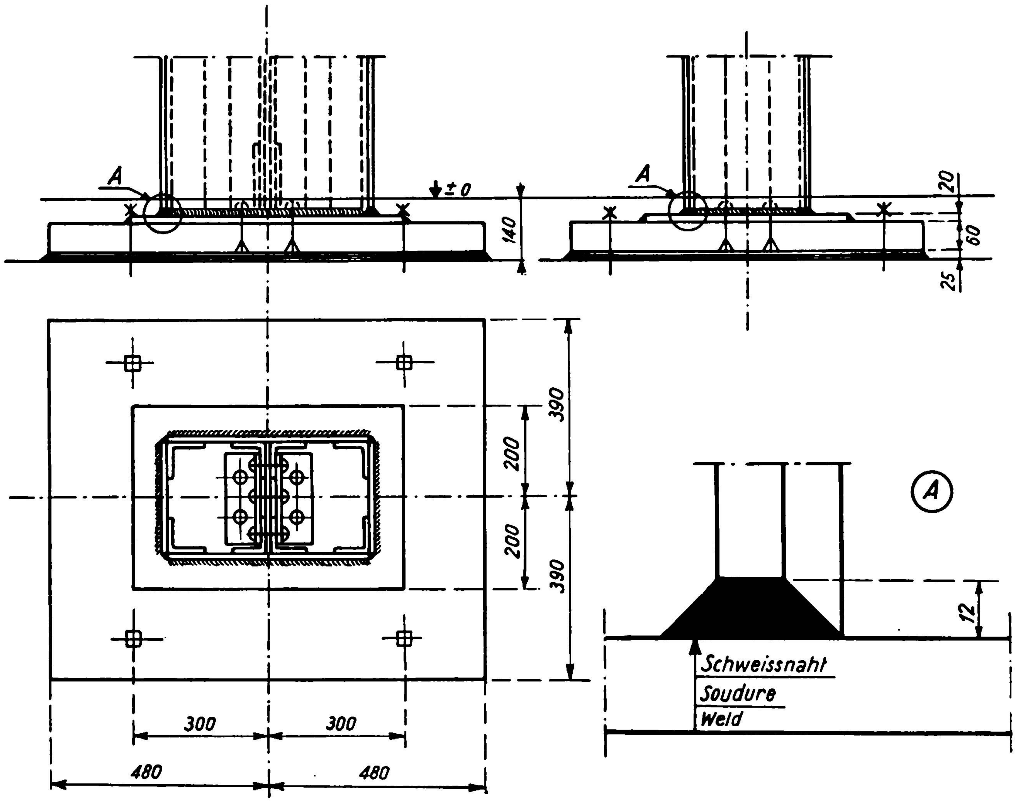

Fig. 11.

restricted in height. In one of the constructions in Warsaw, where the ground floor had to be extended without any alteration to the upper storeys, a double plate girder (Fig. 8) was used. The thickness of the horizontal web was 50 mm; the constructional height had to be restricted to 450 mm for architectural reasons.

In another case a straircase stringer had to have a maximum height of 200 mm, a maximum width of 24 mm and a high resistance to torsion. The construction of the staircase is shown in Fig. 9; it was suspended on flats at

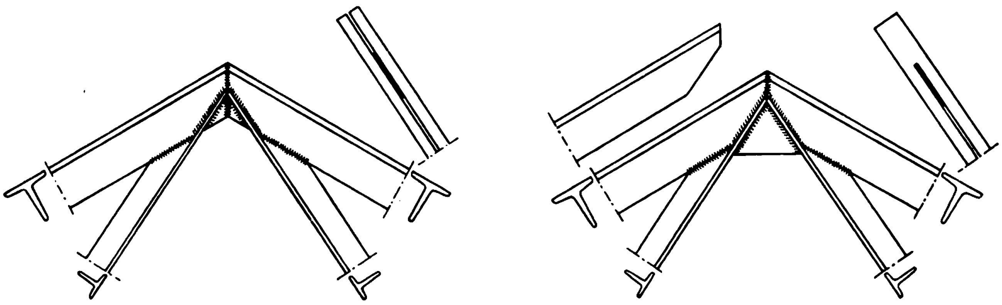

Fig. 12 and 13.

Two panel-point arrangements. (There are many other alternatives).

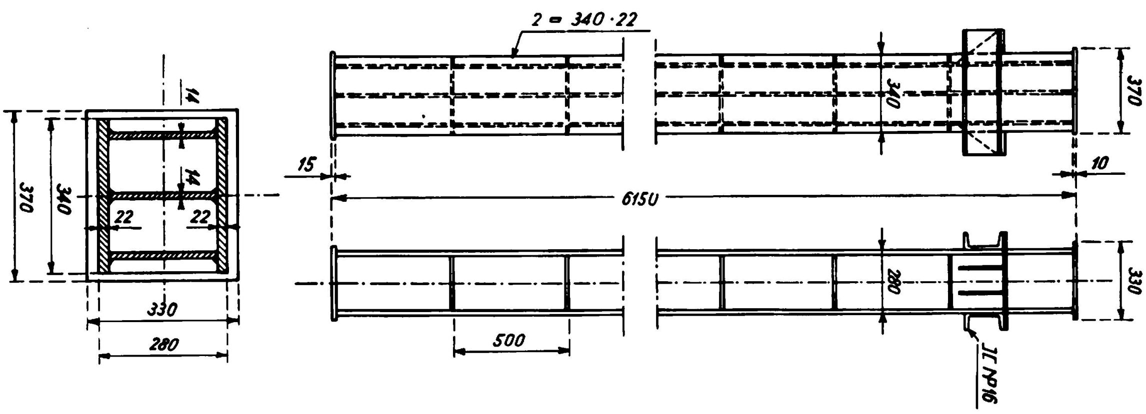

Fig. 14.

P. O. Savings Bank in Warsaw.

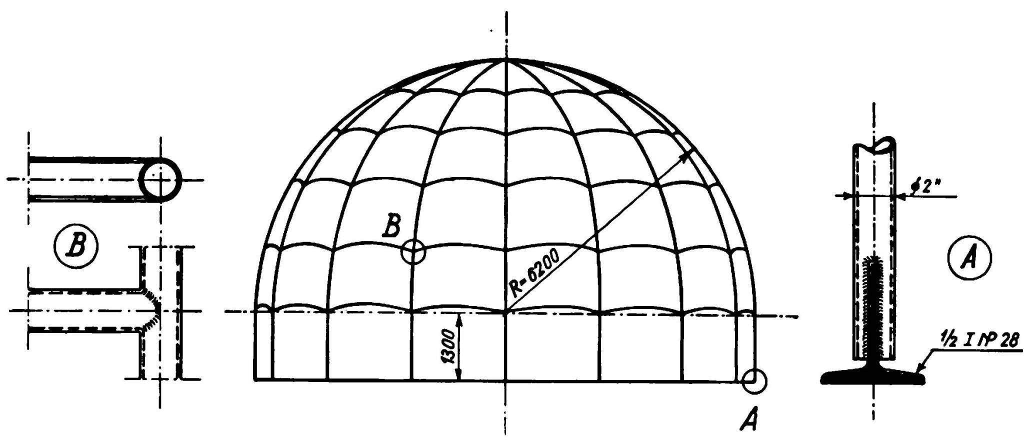

Fig. 15.

Dome, made of tubular sections, of the P. O. Savings Bank in Warsaw.

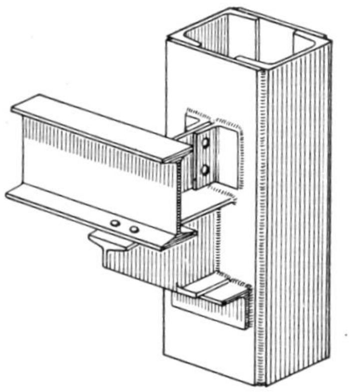

Fig. 16.
Prudential Building in Warsaw

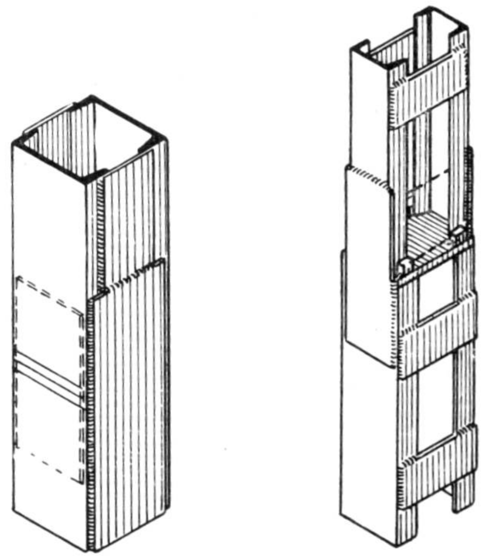

Fig. 17 und 18.
Billeting Fund Building in Warsaw.

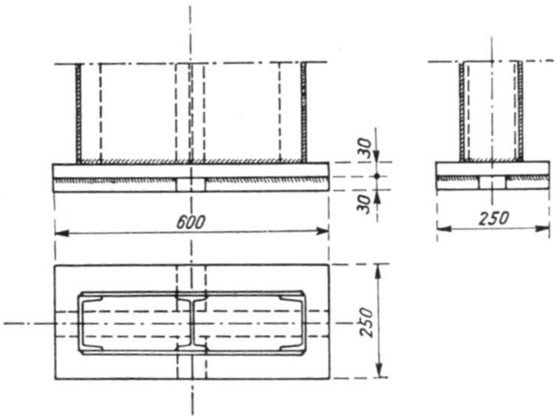

Fig. 19.
Base of column, Jagellon Library in Warsaw.

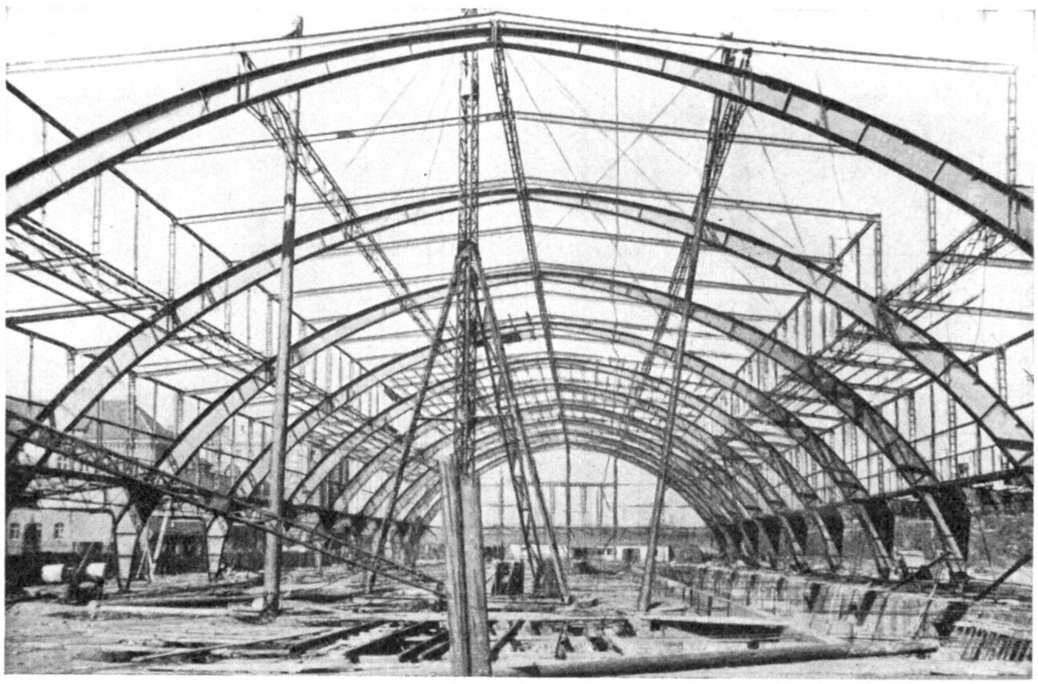

Fig. 20. Market Hall in Kattowice.

the points marked A. In accordance with the architectural requirements sections *1* are I-shaped and sections *2* rectangular and composed of three different plates (the curving of a thick plate into vertical and horizontal surfaces would have been impossible) connected with one another by means of exterior and slotted welds.

An example of an extremely serviceable type of arched formation is that employed in the construction of the Jagellon Library in Cracow (Fig. 10; see also Fig. 4). Here it was a question of obtaining minimum cross section in conjunction with maximum strength. This was attained by using a box section composed of two ⊏-sections. These were joined together and the tie, made of round bars, welded on in the middle.

Quite a number of new types of connection should also be mentioned to which the process of welding has given rise in the construction of skeleton frames. This applies chiefly to beam and girder connections and also to column splices.

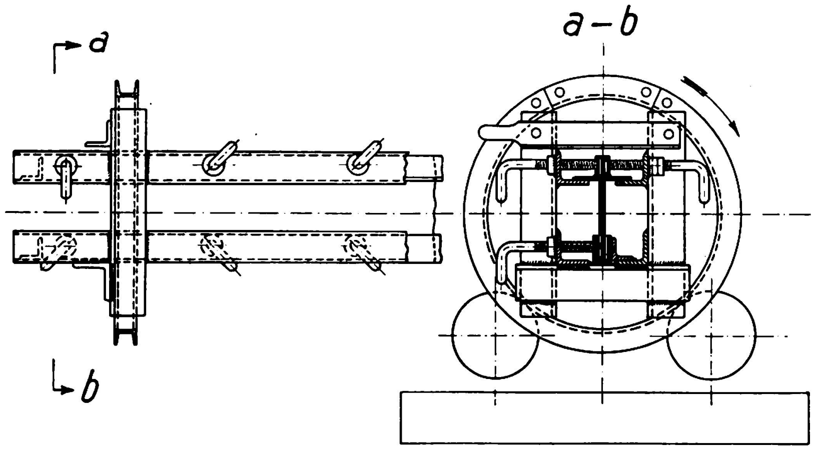

Fig. 21.
Turn-table used in welding columns.

The base plates of columns are mostly constructed of thick steel plates which are welded on even for otherwise riveted columns, giving in every respect a much more convenient solution than the trapeziform base plates generally used (Fig. 11). This latter constructional detail is, in fact, often employed in Poland, even in otherwise riveted structures.

Traverse connections, too, are nearly always welded even in riveted constructions, since they allow the column sections to be utilised to greater advantage. Quite often knees of frames are also welded.

Owing to the great variety of connections possible with the same sections, there is and can be no such definite classification of connections in welding as there is for riveting. The range is still further increased by the use of the fusing burner. I append some descriptive details of various buildings (Figs. 12—20).

In conclusion I wish to emphasise the fact that welding not only involves alterations in construction, but also in the workshop. Constructional workshops are procuring equipment enabling them to do welding work in a convenient and worth-while manner, as for instance with the assistance of turn-tables (see Fig. 21) such as were used in the Zieleniewski Workshops for the construction of the Jagellon Library.

In general it may be said that the number of riveted building constructions in Poland is greatly on the decrease. There are in fact hardly any being carried out without welding, a fact which becomes clearly visible in the following table, which covers the most important steel structures.

Large Building Constructions in Poland since 1933.

Built in		No. of storeys	Weight of steel construction	In workshop	At site
1933	Postal Savings Bank in Warsaw . .	6	700 t	welded	riveted
1933	Prudential Building in Warsaw . .	16	1100 t	welded	riveted
1934	Billeting Fund Building in Warsaw	6	500 t	welded	welded
1934	Customs House in Gdynia		250 t	welded	welded
1934	Central Station in Warsaw . . .		under construction	mainly riveted but some welding	riveted
1935	Jagellon Library in Cracow . . .	8	500 t	welded	welded
1935	Market Hall in Katowice	$l = 39{,}5$ m $h = 19{,}5$ m	400 t	welded	riveted
1936	Communal Savings Bank in Chorzòw	8	180 t	welded	welded
1936	Postal Savings Bank in Poznań . .	5	400 t	welded	welded
1936 unfin.	Post Office in Warsaw	5	500 t 1st sect.	welded	welded