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Matthew Clark and the Origins of Russian Structural Engineering 1810-40s: an introductory biography

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Unlike the history of architecture, the history of structural engineering and industrial archaeology have not proved very popular among Russian experts and readers. This gap in Soviet knowledge was pointed out by the English historian, John James. He became the first West European expert to take on the task of analysing the development of Russian structural engineering. The material collected and published by him is not only a most important, basic source of information, but also an incentive to others to carry on further detailed researches using the abundant material which can be found in the Soviet archives.[1] This article develops the theme of Anglo-Russian engineering that was first explored by him.

In the wide, cosmopolitan group of engineers who took an active part in the construction of the classical buildings of central St Petersburg in 1810-30, a major part was played by Matthew Clark (1776-1846). Unlike the majority of British expert engineers who came to Russia at the same time as he, Matthew Clark can be truly ranked alongside the leading St Petersburg architects of the Age of High Classicism – Carlo Rossi and Vasilij Stasov. In fact, he became the first professional structural engineer in the history of St Petersburg to devote his work to iron construction for civic buildings. One can find Clark's name mentioned in the vast majority of Soviet architectural publications and works on local history, but none of these publications contains data about the life of Matthew Clark and his engineering activities; this essay attempts to fill that gap.

Clark's Engineering Apprenticeship

Information about the birth and early years of Matvej Yegorovich Clark is very fragmentary and lacks documentary evidence. According to the service records of the time, Matthew (Matvej, in Russian) Clark was born in Great Britain around 1776.[2] His father George (Yegor) Clark came to Russia with his family in 1786 as part of a large group of experts who accompanied the Scottish businessman, engineer and ironfounder, Charles Gascoigne. In Russia, George Clark (who died in 1804) worked as a surveyor of mines at the Olonetz Ironworks in Karelia belonging to the Mining Department.[3] Matthew Clark and his brother Vasilij (known as Lieut-Colonel Clark the First) worked in the same department.[4] The presence of the vast Clark family in Russia can be traced until the end of the nineteenth century. The existence of many different service records and family documents in the St Petersburg archives often makes it difficult to find the right information on the biography of Matthew Clark.

The rapid advancement of Matthew Clark during his first years of employment took place at the plants and factories run by British engineers who came to Russia at virtually the same time as Clark's father. In 1792, the 16-year old Matthew began his career, which lasted for more than 50 years, in Russian state enterprises. At first he worked at the Kronstadt Ironworks, at that time run by Charles Gascoigne. Three years later, the young 'casting, locksmith and pattern master' Clark was transferred to the Alexandrovskij Cannon-Manufacturing Factory in the Olonetz province, not far from its main city, Petrozarodsk. In 1801, Clark was appointed the 'locksmith, machinery and blacksmith master' at the St Petersburg State Ironworks, which had recently been reconstructed by Gascoigne. This was situated about four kilometres along the Peterhoff highway. In a year Clark was transferred to the Izhorskij Admiralty Factory in the St Petersburg suburb of Kolpino, as a 'casting, cannon, pump and camboose master.'[5] In the beginning of the nineteenth century, the Izhorskij Factory was run respectively by Charles Gascoigne and Alexander Wilson.[6] Here, at one of the biggest and most advanced ironworks in Russia, Matthew Clark worked for more than ten years. In 1808 he was awarded his first prize from the Emperor – 1.000 roubles.

In 1811, Clark returned to the Mining Department from the Admiralty Department as a supervisor at the same St Petersburg Ironworks. Such career advancement was proof of his successful initial work in St Petersburg. In 1818, he was appointed as Hüttenverwalter (administrator) of the tenth rank and in 1819, the Oberhüttenverwalter of the eighth rank. Within a year he was awarded the Order of St Anne of the third degree for his work in organising the steam powered saw-mill at one of the military establishments.

Between Ironwork and Architecture — Clark's Early Works in Engineering

Clark's early works in engineering construction and artistic casting date from the end of the 1810s. In fact, his appearance on the St Petersburg architectural scene coincided with the introduction of new construction materials – forged iron and cast iron. His extensive experience with iron allied him with the leading St Petersburg architects in this totally new area of construction.

The construction in 1817 of the decorative gateway 'To my Dear Colleagues' in Ekaterininskij Park (part of the Tsar's summer residence Tsarskoye Selo) may be regarded as Clark's first contribution to St Petersburg architecture. The original plans, drawn up by the architect Stasov, provided for the use of cast iron in the construction of the gateway. The production and assembly of this structure, which weighed over 100 tons and used eight 6-metre high metal columns took about four months to complete.[7] Beginning with this project, the theme of metal triumphal arches and follies became one which was continually used in Clark's work. The building of Baron A.A. Arakcheev's residence – Gruzino – on the river Volkhov became one of his most impressive creations and was eventually completed by Stasov and Clark in the early 1820s. The small Andreevskij temple in the shape of an Ionic portico, made of cast iron (1820-21) and the four-tiered steeple, finished with an iron-framed and plated spire, on a base of cast iron columns (1824-5), became the dominant features of this architectural complex.[8]

One of the most significant works of early Russian metal architecture was the interior of the archives in the Main Headquarters in St Petersburg. This was Clark's first co-production with the other leading architects of High Russian Classicism, Carlo Rossi. The reconstruction of the three dwelling houses in the

Palace Square as the new complex of the Main Headquarters took place in 1819-23. The rectangular building of the former 'German' theatre (17.3 metres x 32.5 metres) was adapted as the 'fire-proof' archives. Unlike the monumental composition of the facades, in this project Rossi turned to the new St Petersburg forms of architecture in his metal frame construction. This accorded well with the unusual functional concept of the hall (Fig.1). The three-tiered frame, made of prefabricated cast iron columns, served as the support for the main perimeter gallery, made in the shape of a spiral ramp. The wrought iron shelves, holding documents, stood on it. The central nave of the hall (span 9 metres) had semi-circular arches, and the space under the galleries consisted of cast iron beams carrying cylindrical vaults.[9] The cast iron rafters, safes and parts of the prefabricted columns were

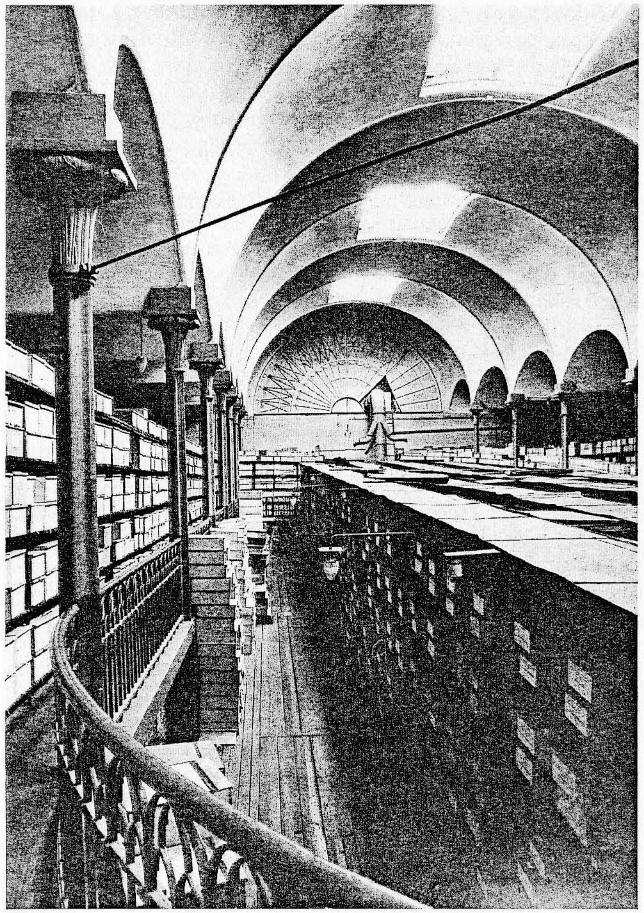


Fig. 1: The archives in the Main Headquarters, St. Petersburg (1819-23) photographed in 1990.

made by Clark at the St Petersburg State Ironworks. The cast iron boards of the inclined gallery floor were produced at Petrozavodsk. On the completion of the work Clark was awarded the Order of St Vladimir (fourth degree) for the 'excellent diligence and outstanding skill in constructing the cast iron archives in the Main Headquarters building'.[10]

A new, enlarged version of the cast iron gateway was erected in Pavlovski Park in 1826 with the architect Carlo Rossi. The Doric six-column portico of the Nicholas Gates (16.8m x 10.7m), crowned with a gigantic eagle, took six weeks to make and twelve days to assemble. A year earlier, Clark was commissioned to make the cast iron figures of lions and winged lions for two pedestrian suspension bridges across the Ekaterininskij Canal (engineer W. Traitteur, sculptor P. Sokolov). These romantic sculptures, each made in two halves, successfully decorate the structure of the supporting cast iron frames. Clark's works in decorative metal continued in his construction of a group of metal horses on top of the arch of the Main Headquarters building (1827-8, architect C. Rossi, sculptors V. Demut-Malinovskij and S. Pimenov). The originally planned cast iron figures were replaced by the more light-weight, beaten copper sculptures with iron carcasses and reinforcement.

For Clark, as well as for many other representatives of the 'empiric' school of engineering during the European Age of Enlightenment, the continuous search for new forms in their creative work was essential. For example, in April 1820, Matthew Clark and William Griffith developed a device which produced lighting gas from oil, and soon obtained a monopoly for using it throughout the whole of Russia for ten years. Clark's drawings show the device which, in fact, was the prototype for the cylindrical gas holder.[11] In 1824 Clark's companion, Griffith, was replaced by the energetic John Rotton, who established the first gas and water supply companies in St Petersburg.[12]

But the main areas in which Clark worked during the 1820s were still mechanics, metallurgy and artillery. In 1823, he was appointed to the post of 'military establishment mechanic' and received the rank of Berghauptmann of the sixth grade. In the following year he was given the task of 'organising the artistry, mechanics, ironwork and general design at the St Petersburg Arsenal'. Then, in 1825, he was awarded a life-long pension of 4.000 roubles per annum for his outstanding work in constructing the new steam engine at the Emperor's Mint in St Petersburg.[13] Almost straight after this he was elected a member of the Mining Scientific Committee. In 1827, in addition to his many other duties, Clark was appointed as the mechanic at the St Petersburg Arsenal and Okhta Gun-Powder Factory with a salary of 3.000 roubles per annum. Soon he was given the Order of St Vladimir (third degree) for his 'excellent work and useful inventions in the improvement of the artillery department.'[14]

The Alexandrovskij Ironworks — St Petersburg's Leading Iron Construction Manufacturing Centre

The increased need for iron construction caused the Russian government to carry out an administrative reform in the state ironworks and to build a new one on the left bank of the river Neva, in the village of Alexandrovo not far from St Petersburg.[15] In December 1826, Clark was made the director of this works. He took part

in the construction of the new premises from April 1825 until the end of 1827. Judging by the fact that he was awarded the Diamond Order of St Ekatarina in February 1828, we may suppose that his attention to detail in the building of this ironworks was meticulous. His time at this establishment marked the most successful and fruitful period of Clark's career. His company soon became not only the main manufacturer of iron structures but also the home of many innovative experiments with the new types of metal construction.

The first experiment of this type was the unique iron roof of the Aleksandrinskij Theatre (1828-32). The Rossi/Clark design for the new Emperor's theatre involved the integration of four practically independent parts.[16] The successful 'transference' of the well-known practice in bridge construction of forming an arch without a tie-beam, standing on stone buttresses, to the construction of roofs on public buildings may be seen as a peculiarity of this work. The building's pitched roof was supported by circular arches (29.16 metres span, rise of vault 10.1 metres) with crossed lattices. The auditorium ceiling and scenery workshop floor were supported by wrought iron arches (21 metres span), consisting of three arches of variable curvature. The scenery workshop was roofed with lattice trusses of 22 metres span. The fly gallery was roofed with similar triangulated trusses of 10.4-10.6 metres span; supported by raking cast iron cantilevers[17]. (Figs. 2-5)

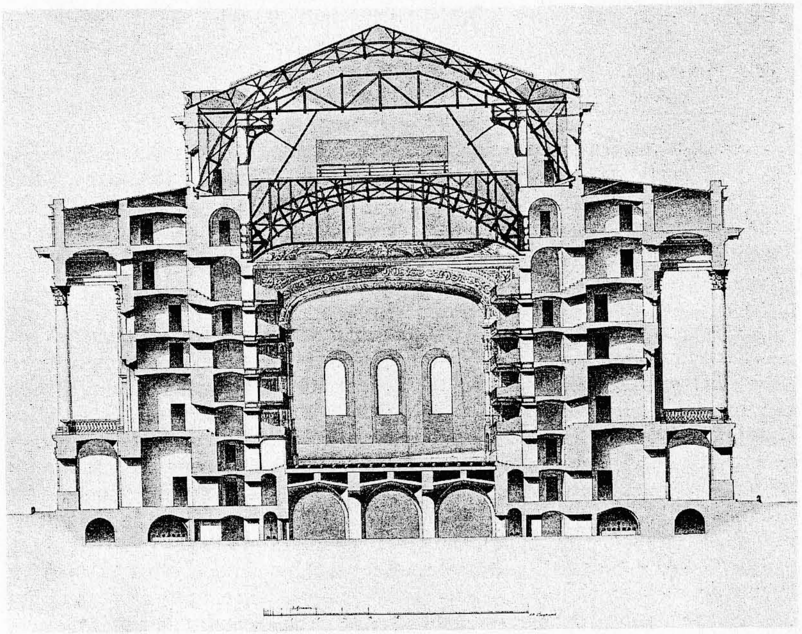


Fig. 2: Aleksandrinskij Theatre, St. Petersburg (1828-32), section at the proscenium opening (Museum of the Academy of Fine Arts, St. Petersburg).

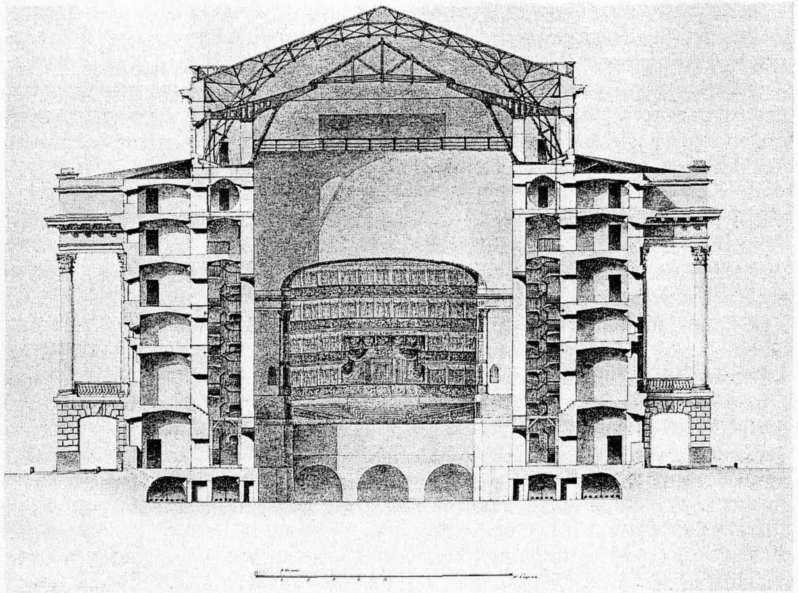
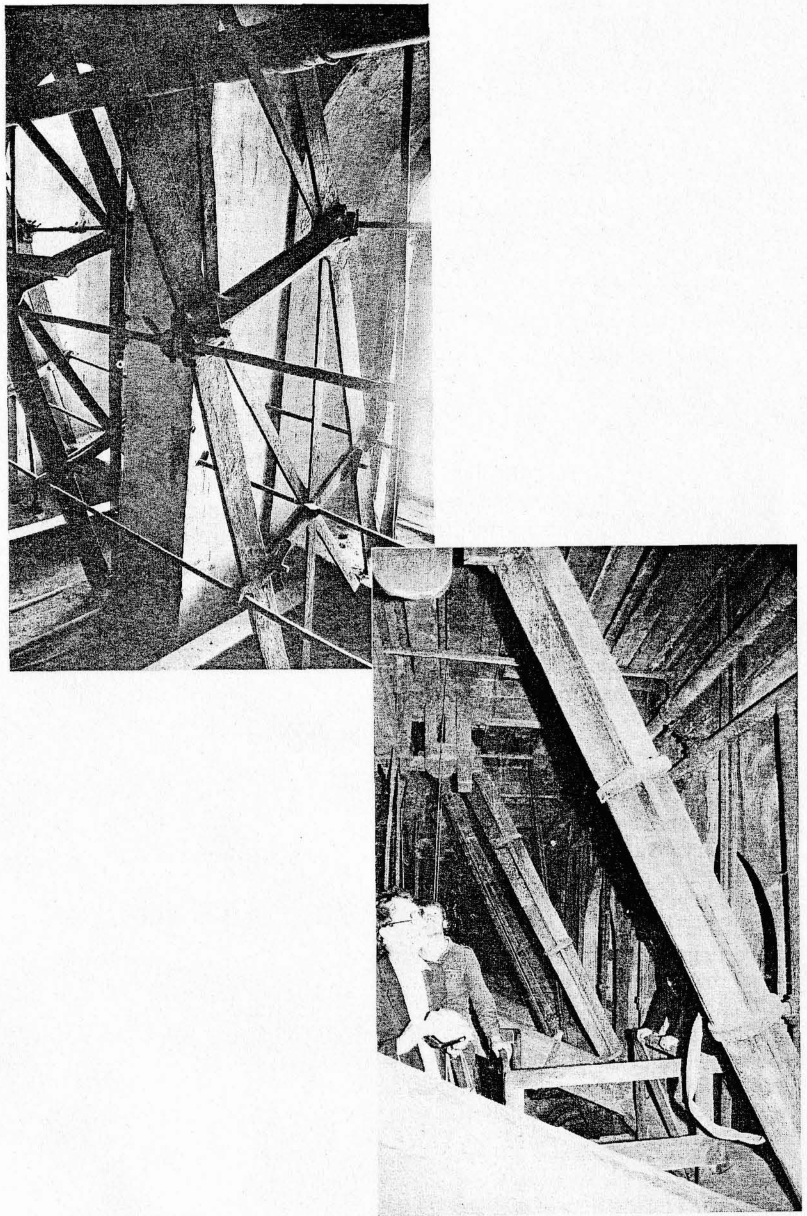


Fig. 3: Aleksandrinskij Theatre, section through the stage area showing the fly gallery (Museum of the Academy of Fine Arts, St. Petersburg).

The lack of experience in the construction of wide span iron roofs caused uncertainty about the strength and stability of the new building, with the result that construction was temporarily halted in July 1829. The engineer-general P.D. Bazaine, the chairman of a specially appointed commission, did not agree with the Rossi/Clark plans and proposed his own method of roofing, using a system of detachable cast iron arches with crossed tie-beams.[18]

The correspondence between Clark and Bazaine which took place around November/December 1829 forms a very interesting example of the intense engineering debate between a representative of the old 'empiric' and new 'analytical' schools of European engineering practice in the 1820s.[19] At the same time, it shows how closely connected St Petersburg engineering was with that in Europe. Bazaine, substantiating his methods of arched roof structures, referred to the 'honorable writer Tredgold's' researches in the area of cast iron structures. He quoted the arch bridges in the Royal Park in Paris; cast iron bridges in Berlin and Potsdam; bridges at Bermut and Cysyllte, and bridges across the Ellesmere Canal in England.[20] However Rossi, who was absolutely convinced he was right, wrote the following well-known letter: '... Clark, since it is I who am entirely responsible for the fact that this roof is totally safe and that the whole construction is of the appropriate firmness in relation to its enormous size.... if anyone should come to harm from an iron roof of this kind, may I as an example to others be hanged from one of the beams of the theatre's roof... If this humble request is not acknowledged, I



Figs. 4-5: Aleksandrinskij Theatre, part of the lattice arch of the main roof structure and one of the raking cast-iron struts supporting the roof over the fly gallery, photographed in 1985.

will not be able to proceed with the construction of the afore-mentioned building without the loss of my reputation...'[21]

The discussion was closed with the decision to approve the first Rossi/Clark project with the obligatory testing of each arch with a 41-ton weight on the specially built wooden testing ground. These were the first ever trials of iron constructions by applied weights to take place in Russia. The tests were finished on 14 April 1831 and on 26 December all the roofing elements were put in place. More than 160 years' use of the building has justified the adoption of the design chosen by Clark.[22]

A rather less successful attempt was made by Clark to build a light covering of wrought iron for a dome, during the building of the Trinity Cathedral of the Ismajliovskij Regiment 1828-34 (architect V.P. Stasov). All the cathedral's domes (four small ones of 11.3 metres diameter, and one central one of 26.8 metres diameter) were made with curved bar iron fins, joined to horizontal bar iron rings. The fins of this construction were stabilised by three groups of tie rods, meeting at the heavy cast iron boss which hung inside the dome. However in February 1834 there was a serious accident during the construction of the nearly finished building. The main dome was torn down in a storm. The nature of the damage – torsion around the vertical axis – was what one could have expected. The method that had been chosen did not counteract the torsion, and its copper covering was simply not strong enough. The erection of a new dome was entrusted to Bazaine, who took peculiar revenge for his misfortune with his version of the Aleksandrinskij Theatre roof. He proposed two alternatives.[23] The proposal for a light metal dome with a greater attention to stability was rejected, since its construction was too close to Clark's idea. The dome that was finally built (24.8 metres diameter) was made from wood and was almost an exact replica (but in wood) of the famous Halle au Blé in Paris.

At the same time as the construction of the complicated metal roofs around the beginning of the 1830s, Clark renewed his partnership with Stasov in the area of triumphal arch construction. The decorative copper plates and sculptural details of the Narva Gates were manufactured at the Alexandrovskij Factory (1831-34). The principle of brickwork with additional copper plate lining was used in the construction of the gates. The Moscow Gates (1834-8) – a monumental six-columned Doric portal, made wholly from cast iron and copper – were the most interesting example of such an approach to the task (Fig. 6). The columns, situated in two rows, consisted each of seven hollow, cast iron blocks, standing freely on top of each other. The total weight of one column was 37.5 tons. The architrave, with 30 sculptures, was made as a girder with vertical supports. The whole construction was produced at the St Petersburg and Alexandrovskij Ironworks and the first detachable part of the gateway was erected in July 1836. The gateway which took two years to complete, was believed at the time in Russia to be 'the biggest cast iron construction in the world' (36.2m x 8.3m x 25m).

Along with iron construction, the Alexandrovskij works, with Clark at the head, manufactured steam engines and undertook numerous explorations and experiments in metallurgy. New machines for pumping water from the river Volkhov

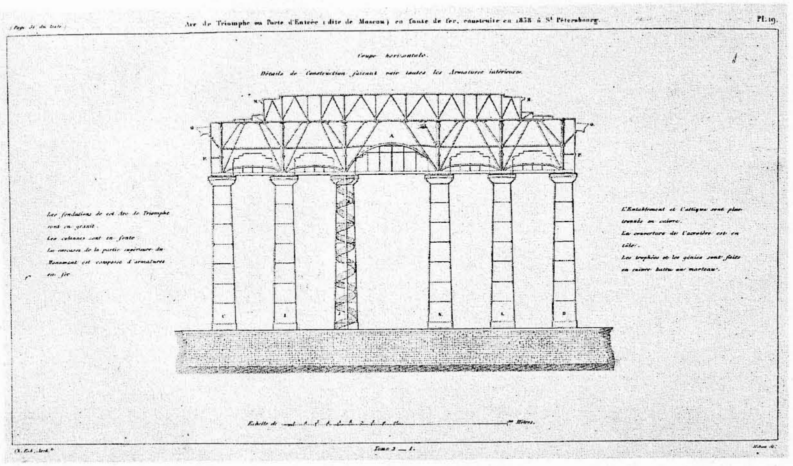


Fig. 6: The Moscow gates, St. Petersburg (1834-8). Longitudinal cross-section, from C. Eck, *Traité de l'Application du Fer, de la Fonte et de la Tôle...* (Paris, 1841).

to the new Ladozhskij Canal were made there in 1827-31.[24] Testing of Siberian cast iron also took place in 1827. Examples of English and Swedish metal were examined following a long business trip which Clark made to the foundries and arsenals of England and Sweden in 1831.[25]

The Reconstruction of the Winter Palace — Clark's Engineering Masterpiece

Clark's work connected with the reconstruction of the Winter Palace, following the catastrophic fire of December 1837, became his major engineering achievement. The area given the most attention was the roofing to the halls. The necessity for fire-proof constructions to spans of over 20 metres (quite large spans in those days in Russia) presented many new engineering problems. Their successful solution stood as an example to all young Russian engineering students.[26]

Three basic types of iron construction were used in the reconstruction of the halls.[27] Riveted thin-walled (including elliptical section) beams were applied for the spans of up to 15 metres. Triangular light rafters served for attic roofings, and two kinds of parallel chord truss were employed for wider spans.

The elliptical beams of the Winter Palace (3.43 - 15.38 metres long: 0.53 - 0.62 metres high) were the earliest thin-walled metal constructions in Russia. They consisted of two vertical 8mm metal sheets and two curved sheets of the same thickness. These sheets were joined in the middle of the beam with a 0.45cm gap using bolts, and the beams were given a camber of 0.018. Before final installation they were tested with a weight of 1.48 tons per linear metre (Figs. 7-9).

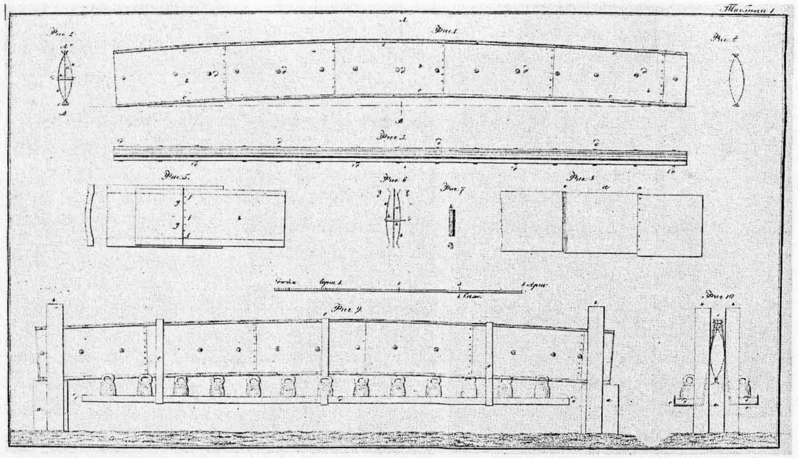


Fig. 7: Thin-walled elliptical beams at the Winter Palace, St. Petersburg (1838). Drawing from N.I. Olkhovski, *Opisanie Zelenznych Balok i Stropiel Ustroennych v Zimnem Dvortze pri Vozobnovlenii ego (1839)*.

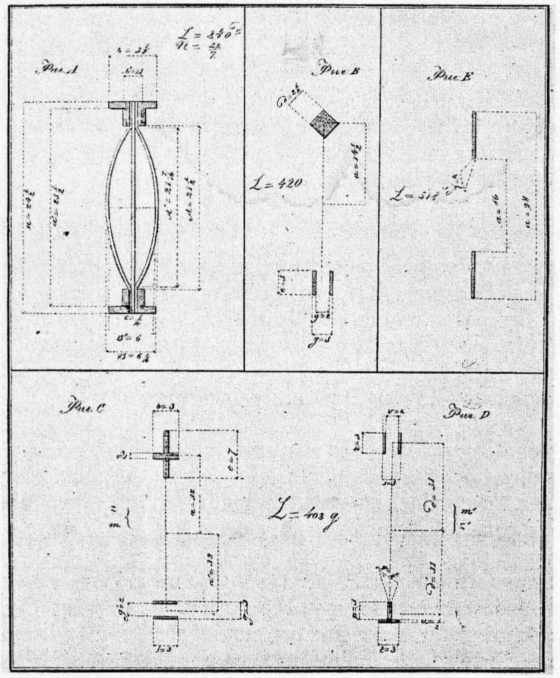


Fig. 8: Thin-walled elliptical beams at the Winter Palace. Drawing showing calculations for the moment of inertia, from *N.I. Olkhovski*.

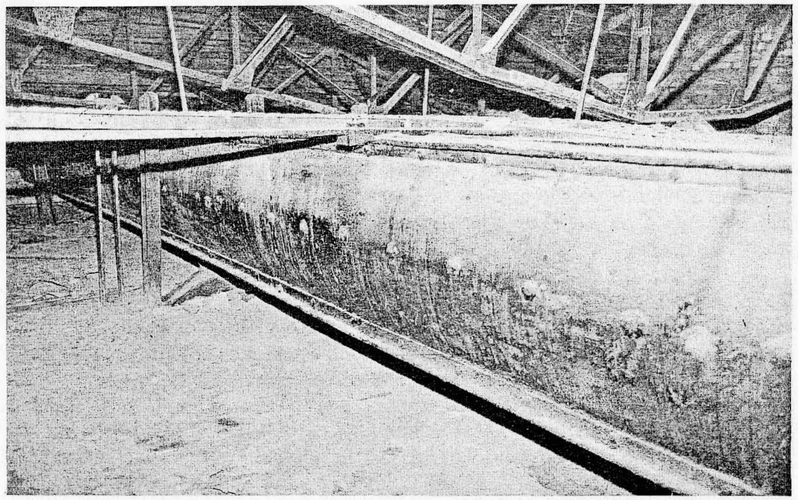


Fig. 9: Thin-walled elliptical beams at the Winter Palace, photographed in 1989.

The system of trusses with a tensile lower chord (of spans up to 21.3 metres) was also an innovation in Russian engineering. Various roofs at the Winter Palace constructed by Clark early in 1838 demonstrate the static principles of one of the most popular types of nineteenth-century truss, known as the Wigmann-Polonceau truss (Fig.10).

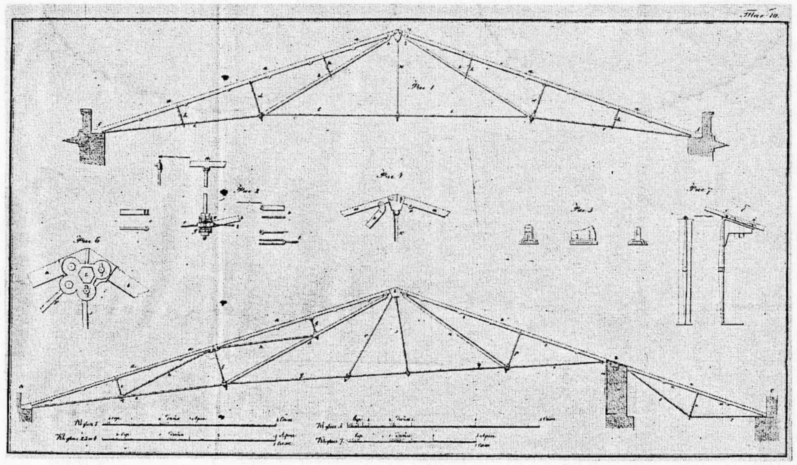


Fig. 10: Trusses with tensile lower chord, as used in the roofs of the Winter Palace, from *N.I. Olkhovski*.

The planning, testing and construction of the roofing to the large and small avant-halls, the Concert Hall, the Emblem Hall and St George's Hall proved to be the most labour intensive and time-consuming part of the works to the Palace. Many engineers and architects submitted proposals for these works – P. Bazaine, A. Wilson, M. Clark and A. Roller – as well as their foreign counterparts – Eck, Witt, Zeifert, Laves and Jasmund.[28] The special committee involved thanked all those who made submissions but rejected them, having already made its decision. The main favourites were the designs of Clark and Wilson. In February 1838 final approval was given for Clark's project and by September that year the ironwork was being erected over the four large halls of the Palace.

The structure devised by Clark (20.5 metres span, 1.8 metres in height) consisted of a form of parallel-chord truss. The lower chord with channel-shaped cross-sections was composed of two iron bands 1 inch thick, connected with yokes and wedges. The bands of the upper chord, by contrast, formed a cruciform section. The chords were joined by vertical posts. The truss also had an arch and chain located between the main chords as bracing. The arch was composed of two bands one inch wide mounted vertically adjoining the supports of the lower chord. The chain suspended in the joints of the upper chords was fixed to the latter by means of vertical adjusting bolts that created a prestressing in the truss. As a whole Clark's structure was a complicated combination of parallel chords and arch and tension members (Figs. 11-13).

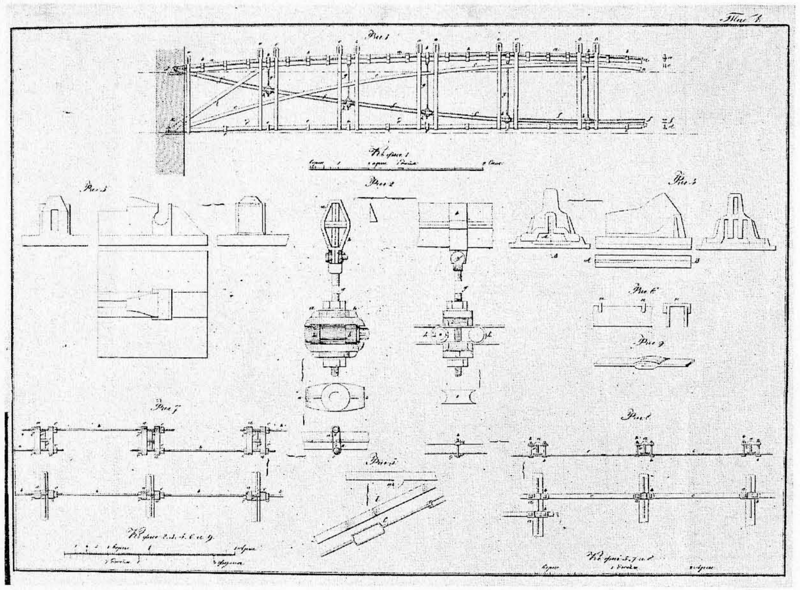


Fig. 11: Parallel-chord truss over the large halls of the Winter Palace, from *N.I. Olkhovski.*

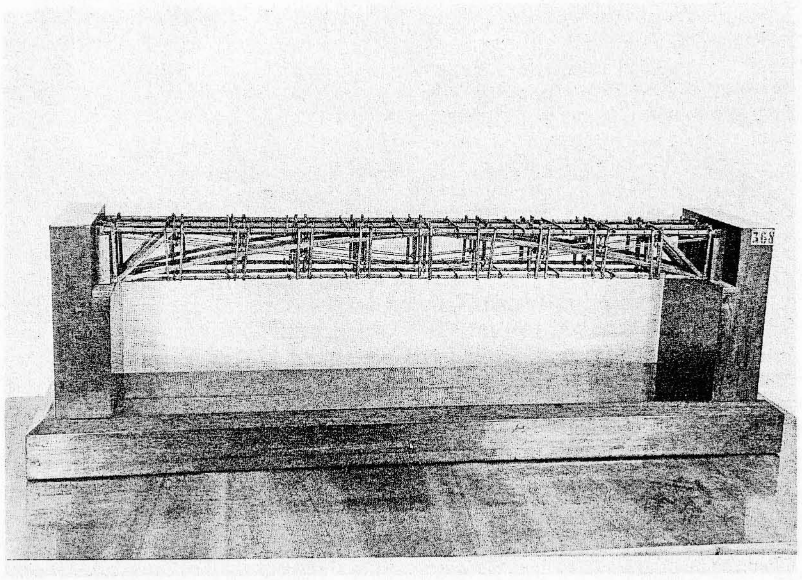


Fig. 12: Original model for the parallel-chord trusses at the Winter Palace (Museum of Railway Transport, St. Petersburg).

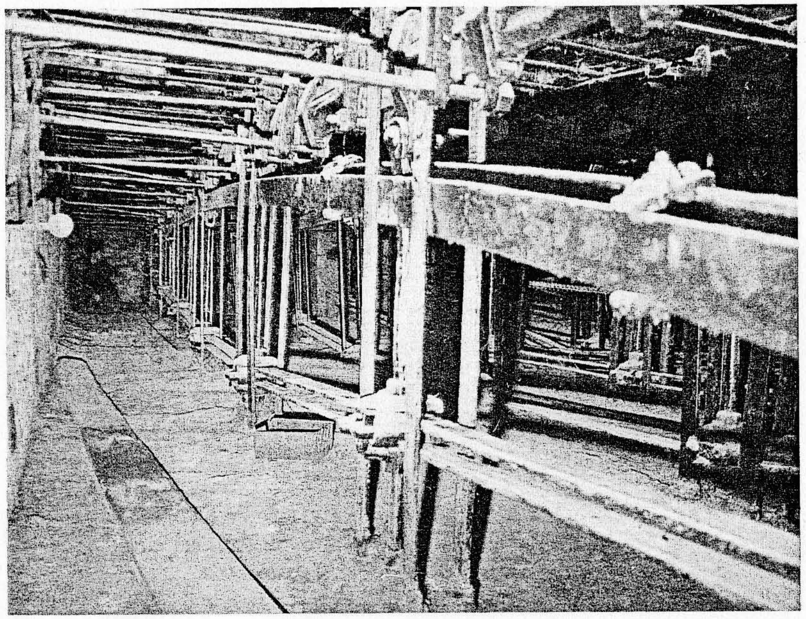
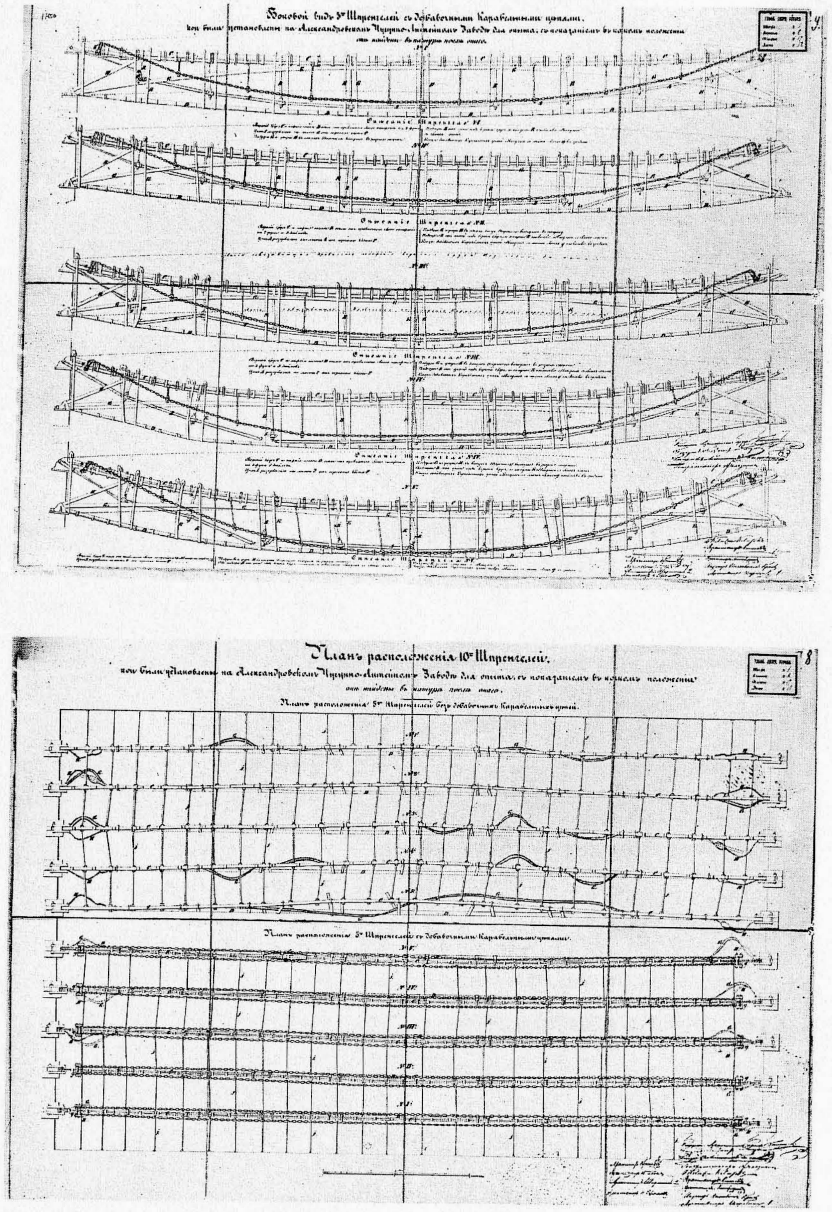


Fig. 13: Parallel-chord truss over the Armorial Hall at the Winter Palace, photographed in 1986.



Figs. 14-15: Drawings showing the testing of the chain-reinforced parallel-chord trusses (Archive of the State Hermitage, St. Petersburg).

In the 1830s it was quite difficult to test the strength of these structures using Navier's techniques. The only alternative way to verify Clark's thinking was to apply full-scale tests, as had been done at the Aleksandrinskij Theatre. The tests on the structure of the Winter Palace roofs form a major episode in early Russian engineering. The results were precisely noted on special record sheets in many volumes; all now stored in the archives of the State Hermitage (Figs. 14-15). All the works connected with the erection of the new metal roof structures of the palace were completed by autumn 1839.

St George's Hall, which was the largest, was the only one of the large halls where trusses of the kind described were considered inappropriate due to the low ceiling. Clark developed for this hall a roof based on iron I-shaped beams (21.3 metre span, 0.8 metre height). This roof unexpectedly failed in August 1841. In answer to the Emperor's immediate enquiry, Clark declared that he 'did not feel at all to blame, since all the beams and fastenings were not broken, but bent, which proved that high quality ductile metal had been used, instead of brittle metal'[29]. This response clearly shows that even he, the manager of the most advanced Russian ironworks, was not quite sure of the quality of the wrought iron. Pointing out the 'plastic' nature of the damage, Clark endeavoured to remove the suspicion of having used materials of inferior quality. He obviously did not consider that the faults could be attributable to his materials, but that the drawbacks lay in the structure made for those materials.

The accident in St George's Hall led to doubts as to the reliability of the truss constructions which had been previously built over the other large halls. In November 1841, comparative testings of ordinary trusses against trusses reinforced by English anchor chains, took place at the Alexandrovskij Factory. These trials showed that the existing roof constructions did not need any further measures to increase their strength. The final doubts concerning the advantages of such truss systems were removed and Clark was put in charge of erecting a new roofing of similar structural type.

The new structure over St. George's Hall (21.3 metres span, 2.9 metres height) was markedly different to the typical roofs over the Neva suite of halls. It was essentially a catenary structure supporting two chords (Figs. 16-18). The slightly curved upper chord, made up from rolled iron T-sections, was propped on tapered rods, and was also supported by raking struts. The lower chord, formed from horizontal iron bands, was suspended from the arch, and it carried the ceiling of the hall below. The top chords had lateral bracing between them, and were covered with iron sheeting for the full length of the roof space.

The design and construction of this new structure above St. George's Hall (1841-42) was one of Clark's best engineering achievements. In it the complicated, composite roof structures over the Neva halls were transformed into a simple, statically clear structure, carefully engineered with a close attention to every detail.

Clark's Unexpected Dismissal

In April 1840, Clark agreed to manufacture and test the iron construction of the new

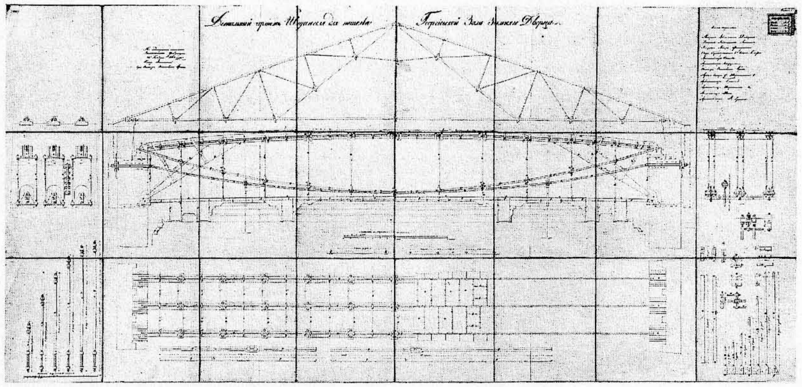


Fig. 16: Roof over St. George's Hall of the Winter Palace, 1841-2 (Archive of the State Hermitage, St. Petersburg).

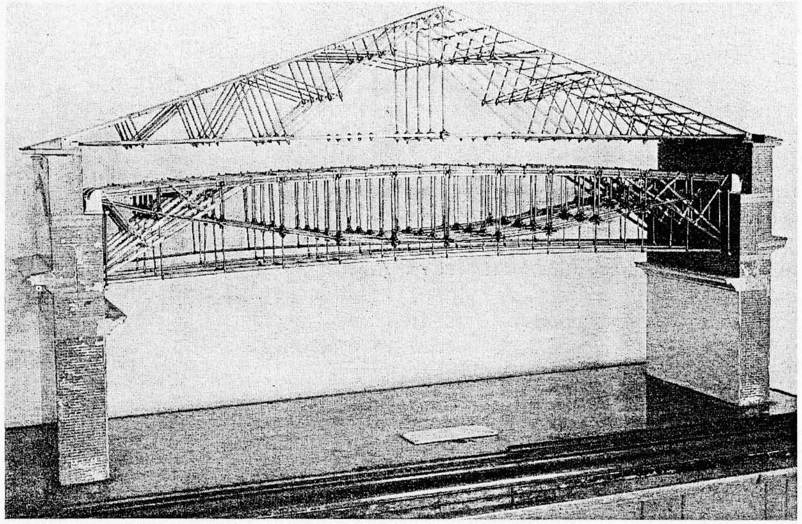


Fig. 17: Model of the roof over St. George's Hall, made in 1861 (Museum of Railway Transport, St. Petersburg).

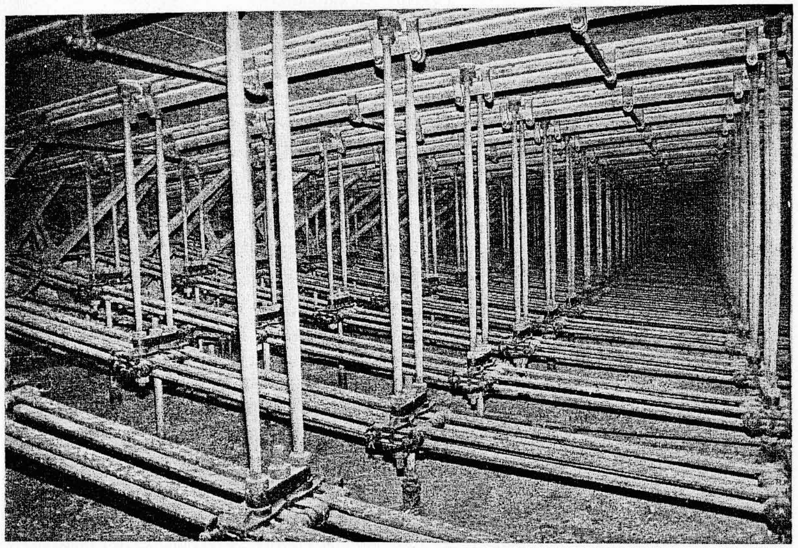


Fig. 18: The catenary arch trusses above St. George's Hall, photographed in 1986.

Mariinskij Palace on Isaak Square in St Petersburg, 'as it had been done in His Majesty's Palace earlier'.[30] On this occasion his usual insistance on taking full responsibility for the strength and accuracy of the work turned out to be fatal. Unexpected and not yet fully explained circumstances made this commission the last in his career.

The architect A.I. Stakenschneider provided for the installation of 384 beams of two types: from iron bars and iron sheets.[31] Soon after the works got under way, he began to complain about the slow production rate at the Alexandrovskij Factory. Clark, on the other hand, claimed that he had not received the necessary drawings. The work was not completed by the promised date – June 1841. In August of that year the beams of St George's Hall failed, causing Clark to devote all his time to repairing the damage. Probably as a direct result of this accident, another special commission had a close look at the construction of the Mariinskij Palace beams and noticed that many of them had become crooked and lacked cross connections.

In October 1841, the commission asked Clark to present his drawings of the beams. At the same time the commission called for Rossi, who was ordered to inspect the Palace's constructions and was allowed to dismantle and cut the beams if necessary. In spite of Clark's requests that the beams be tested first, in April 1842 Rossi insisted on the dismantling and cutting down of several sections. The results of this test confirmed his suspicions. In some of the beams, pieces of old iron were used instead of the new, specially-made iron which had been provided by the State.

The official reason for this serious malfaisance was the unscrupulousness of the two boiler section masters, who used old iron instead of new.[32] However, Clark's full responsibility for the work called for swift and strict measures of punishment. On 27 May 1842 Clark was dismissed from his post as the director of the Alexandrovskij Works.[33] He was asked to repair all the damaged parts of the roofs at his own expense. In order to guarantee this order, all Clark's private property was held in ransom. In November 1842, Clark was completely discharged from the works on the Mariinskij Palace. The work was finished by Rossi, who replaced 119 beams that had been installed earlier.[34]

After his dismissal, Clark was attached to the Administrative Department of the Corps of Mining Engineers. In April 1846, following a request by Tsar Nicholas I, it became clear that 'Obersberg Hauptmann of the 4th rank Clark, after his dismissal from his post as director of the Alexandrovskij Works never did and now has no occupation in this department.' In response to this statement, there followed an Imperial order to dismiss Clark totally from state employment.[35] After much correspondence, Clark was awarded a pension of 1.254 roubles a year.[36] However, he was not able to use this relatively modest pension. The former Alxandrovskij Works manager died in St Petersburg on 24 September 1846 at the age of 70.[37]

Conclusion

The iron structures of the 1820s and 1830s were part of the 'prestigious' and 'representative' architecture of St Petersburg, as a rapidly expanding European capital city. The use of large sums of state money and cheap serf labour facilitated the introduction of St Petersburg's iron architecture.[38] The most significant contributors to the development of early Russian iron constructions must undoubtedly include the name of Matthew Clark. Trained as an iron founder, he appears to have been practically the only representative of the English experimental school of engineering in St Petersburg who was able to compete successfully with the brilliant engineers of the French analytical school, employed in the Russian Institute of Engineers of Ways of Communication. Throughout his career, Clark personified the main achievments of the European engineering school whilst pointing the way to further principles in the development of Russian iron constructions. Such principles included the transition from arches to trusses with parallel chords and later to lenticular beams: also the development of systems of thin-walled beam sections. These structural innovations were accompanied by a wide use of iron for decorative works and sculptural monuments. Clark's main engineering works have survived to the present day and are unique, though not very well-known, monuments of the European engineering design of the first half of the last century.

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29. L.M. Baranovitch *Istorija Vosstanovlenija Zimnego Dvortza i Zarstrovanie Imperatora Nicolaja I 1838-39 (St. Petersburg, 1857).* M.E. Saltykov-Shchendrin State Library Manuscript, Inventory 380, file 105, pp.39-41.
30. The palace of the great princess Maria Nicholaevna, built by A.I. Stakenschneider 1839-44. Stakenschneider graduated from the St Petersburg Academy of Fine Arts (1822), and from 1825 worked with Monferrand on the construction of St Isaac's Cathedral. In 1837-8 he made a study trip to France, Italy and Great Britain. He was the architect of many major houses of the period 1830-60, as well as public buildings such as railway stations.
31. ZGIA SSSR, 482-3-136 (Reimbursement to the heirs of Clark for works at Mariinskij Palace, 1842-86).
32. ZGIA SSSR, 482-3-136, pp.10-11.
33. After his dismissal, Clark's position as Director of the Alexandrovskij Ironworks was taken by Col. Fullon of the Corps of Marine Engineers. In the late 1840s the factory was taken over by the railway department and its production totally reorganised. In Soviet times the factory was subject to high security, so until now local archive material has not been accessible to researchers.
34. ZGIA SSSR, 482-3-136, p.23, verso.
35. ZGIA SSSR, 44-1-472, p.7.
36. Clark was awarded the normal pension for officers of his rank.
37. ZGIA SSSR, 560-35-882, p.14 (Concerning the deposits of Matthew Clark in the State Treasury, 1887).
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The Design of Structural Ironwork 1850-1890: Education, Theory and Practice

STANLEY SMITH

The mid-nineteenth century was a period when a series of changes took place in the construction industry, especially in that part of the industry concerned with the design and erection of iron structures. Apart from the introduction of new materials, and the need for new building types, there were influential changes that occurred in the way designers evisaged the scope of their work in this field which led to an increasing specialisation of activity and the proliferation of professional organisations intended to serve the interests of specific groups. In addition, alternative views were developing about the provision of education and training for designers and what should be offered to new entrants to the engineering design professions. Another major area of activity was the attempt to apply the principles of scientific investigation to explain the performance of structures and to develop theories that could be used as the basis for design.

It has been suggested that changes in the practice of engineering generally had by 1890 led to the development of a 'scientific engineering', founded on the application of science and mathematical analysis.[1] By considering the writings and comments of some of the mid-century designers this paper attempts to establish if such a development took place in the practice of structural design in the second half of the nineteenth century. To do this, attention has been focused on four specific areas. First, on the specialisation that took place within the civil engineering profession, coupled with the growth of provincial engineering societies; second, on the published material intended to assist structural designers, its content and intended readership; third on the attitudes towards education and training that were expressed by designers in public and finally, on mid-nineteenth century views about the importance of practice in relation to theory.

Specialisation and Structural Design

Today a structural designer can be defined with general agreement as 'one who is competant to design stable and economical structures of different kinds to meet the requirements for which the structures are needed.' But it was not until 1908 that there was a specific professional institution to pursue the interests of the structural engineer.[2] In the nineteenth century, structural design of ironwork formed part of the wider activities of the civil engineer, whose needs were catered for by the Institution of Civil Engineers, founded in 1818. It was not until attempts were made to obtain a Royal Charter in 1828, that it was considered necessary to define what an engineer was or did. The Council requested Thomas Tredgold to prepare such a description and this was entered in the minutes on 4th January, 1828 and eventually, in an abridged form, included in the Charter. The work of the civil engineer was seen as concerned with, 'The art of directing the great sources of power in nature for the use and convenience of man', and as described by Tredgold, the