



The Paton WELDING JOURNAL

Issue
05
2019

Published Monthly Since 2000

English translation of the monthly «Avtomaticheskaya Svarka» (Automatic Welding) journal published in Russian since 1948

EDITORIAL BOARD

Editor-in-Chief

B.E. Paton

Scientists of PWI, Kyiv

S.I. Kuchuk-Yatsenko (*vice-chief ed.*),

V.N. Lipodaev (*vice-chief ed.*),

Yu.S. Borisov, G.M. Grigorenko,

A.T. Zelnichenko, V.V. Knysh,

I.V. Krivtsun, Yu.N. Lankin,

L.M. Lobanov, V.D. Poznyakov,

I.A. Ryabtsev, K.A. Yushchenko

Scientists of Ukrainian Universities

V.V. Dmitrik, NTU «KhPI», Kharkov

V.V. Kvasnitsky, NTUU «KPI», Kyiv

E.P. Chvertko, NTUU «KPI», Kyiv

Foreign Scientists

N.P. Alyoshin

N.E. Bauman MSTU, Moscow, Russia

Guan Qiao

Beijing Aeronautical Institute, China

M. Zinigrad

Ariel University, Israel

V.I. Lysak

Volgograd STU, Russia

Ya. Pilarczyk

Welding Institute, Gliwice, Poland

U. Reisgen

Welding and Joining Institute, Aachen, Germany

G.A. Turichin

St. Petersburg SPU, Russia

Founders

E.O. Paton Electric Welding Institute, NASU

International Association «Welding»

Publisher

International Association «Welding»

Translators

A.A. Fomin, O.S. Kurochko, I.N. Kutianova

Editor

N.G. Khomenko

Electron galley

D.I. Sereda, T.Yu. Snegiryova

Address

E.O. Paton Electric Welding Institute,

International Association «Welding»

11 Kazimir Malevich Str. (former Bozhenko Str.),

03150, Kyiv, Ukraine

Tel.: (38044) 200 60 16, 200 82 77

Fax: (38044) 200 82 77, 200 81 45

E-mail: journal@paton.kiev.ua

www.patonpublishinghouse.com

State Registration Certificate

KV 4790 of 09.01.2001

ISSN 0957-798X

DOI: <http://dx.doi.org/10.15407/tpwj>

Subscriptions

\$384, 12 issues per year,

air postage and packaging included.

Back issues available.

All rights reserved.

This publication and each of the articles contained

herein are protected by copyright.

Permission to reproduce material contained in this journal must be obtained in writing from the Publisher.

CONTENTS

SCIENTIFIC AND TECHNICAL

- Krivtsun I.V., Demchenko V.F., Krikent I.V., Kovalenko D.V. and Kovalenko I.V.* Effect of current and arc length on characteristics of arc discharge in nonconsumable electrode welding 2
- Kvasnytskyi V.V., Kvasnytskyi V.F., Matviienko M.V., Buturlya E.A. and Yermolayev G.V.* Stress-strain state of welded and brazed assemblies from dissimilar materials with soft interlayer at thermal loading 13
- Borisov Yu.S., Borisova A.L., Grishchenko A.P., Vigilyanskaya N.V., Kolomytsev M.V. and Vasilkovskaya M.A.* Structure and phase composition of ZrB₂-SiC-AlN plasma coatings on the surface of C/C-SiC composite material 18

INDUSTRIAL

- Gruzevich A.V. and Derecha D.A.* Gas-powder spraying as a high-efficient method of increasing the operation reliability of power equipment 28
- Yurzhenko M.V.* Peculiarities of technology and modern trends in the field of butt welding of polyethylene pipes (Review) 36

NEWS

- «Kyiv Technical Fair — 2019» 43

- CALENDAR OF MAY 45

KYIV TECHNICAL FAIR

The XIth International Specialized Exhibition «Kyiv Technical Fair — 2019» took place on April 2–5 in Kyiv at the International Exhibition Center. The International Exhibition Center is an organizer of the Exhibition. The main aim of the Exhibition is demonstration of the best achievements of science, technology and equipment, necessary for the innovative development of Ukrainian economy as well as assistance in establishing business, economic and trade relationships between domestic enterprises and countries of near and far abroad. Specialized Exhibition permits the enterprises to become acquainted with the world novelties in their field and demonstrate own developments, check compatibility of their products. Kyiv Technical Fair is a logical continuation of the International Industrial Forum, the largest trade show of Ukraine, which has been hold in the last week of the November by the International Exhibition Center for more than 17 years.

Topics of the Exhibition included demonstration of the achievements in the field of machine building, metallurgy, welding, cutting, 3D technologies, metal-working, diagnostics and control automation, surface treatment, manufacture of instruments, engines, casting equipment, pumping equipment, non-metallic materials in industry, which were presented by companies from 12 countries.

The visitors had a possibility to get acquainted with a wide spectrum of the products of different enterprises under conditions of healthy and fair competition; possibility to be consulted directly by manufacturer and ask all the questions of interest.

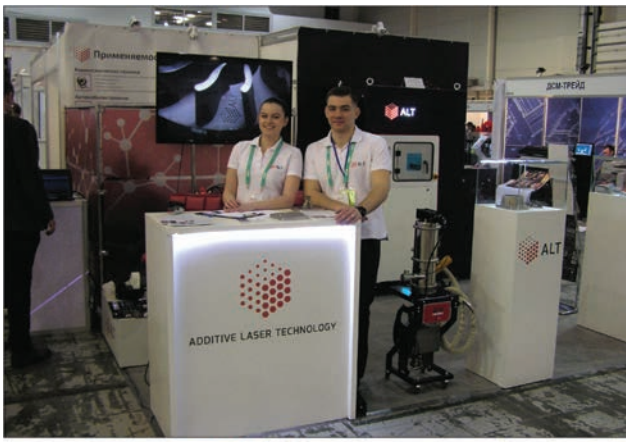
Each day was bright and full of events. In addition to novel technological developments the visitors also would remember education seminars and conferences, which took place in the open conference floors and halls. The specialists of leading companies of the branch shared their experience with colleagues, told about the peculiarities and perspectives of development of Ukraine on the world market.

The Exhibition gave a possibility to manufacturing companies and customers to meet under competitive conditions and make decisions based on particular criteria, see the equipment personally, test its operating capacity, directly communicate with corporate CEOs.

Visitors and participants had large interest to the seminar on 3D printing hold on April 4 in open air discussion area. The next reports were presented:

- «3D printing with metallic alloys. Technology of layer-by-layer laser melting as a main tool of modern machine-building», Additive Laser Technologies of Ukraine LLC, Dnepr. The Company proposes technologies and equipment for manufacture of products from metallic alloys using 3D printing method; complex innovative solutions for laser additive manufacturing; production of 3D printers based on technology of direct laser sintering (DMLS); development and manufacture of commercial prototypes and parts of





gas turbine engines including manufacture of metallic products of complex geometry.

- «*Application of 3D printing in medicine*», Viva Art LLC, Kyiv. The Company specializes in sales of professional printers for 3D printing and all necessary materials for establishment of own production of 3D models; offers services on 3D printing: printing from plastic, color printing with white mineral and cobalt-chromium. Scanning of small objects as well as human sized scanning.

- «*Commercial technologies of 3D printing — polymers, metals and ceramics*». Smart Print Company, Kyiv is a leading company in Ukraine on 3D printing technology and accredited supplier of SC «Ukroboronprom». The company fulfils individual and serial orders on 3D printing.



- «*Simufact Additiv — 3D modelling of processes of metal printing*», Engineering Company «Technopolis», Kyiv. It is a system integrator and authorized partner of the leading developers of engineering software.

- «*3D printing for commercial enterprises*», Imatek-Esko LLC, Kyiv. The Company is an exclusive representative of 3D Systems Inc. Company (USA) in Ukraine. Since 2005 it has been implementing the solutions based on 3D printers, 3D scanners and 3D printing services. It works with enterprises and companies in the field of motor car construction, architecture, medicine; sales of large-format printers and scanners of ROWE (Germany) and Context (Denmark) companies and program solutions for automation of document flow at enterprises.

By tradition Aramis LLC, Vitapolis LLC, Triada Svarka LLC, Fronius Ukraine LLC took part in the Exhibition. They propose equipment for welding and cutting, consumables and services for integration of commercial robotic welding complexes.

E.O. Paton Electric Welding Institute publishing house on its booth presented the journals, books, thematic collections and proceedings of the conferences published in 2018–2019. As always visitors of the Exhibition demonstrated high interest to «The Paton Welding J.», a leading Ukrainian journal in the field of welding, cutting, surfacing, spraying and 3D technologies.

Dr. A.T. Zelnichenko, PWI

Calendar of May

MAY 1, 1893 Opening of Chicago World Exhibition where N.G. Slavyanov received the Gold Medal for the method of electric welding under a layer of crushed glass. In addition, visitors saw an amazing item — 12-sided glass 21 mm high from steel casting. The electric arc was used for elimination of casting flaws in it, which the metallurgists believed to be natural. In 1895 Slavjanov's method was used for casting ingots from crucible and hearth steel of 100–800 pounds (1600–12800 kg) weight at the factory. In Perm Slavyanov began applying his own newest method for correction of casting flaws, repair operations with parts of locomotives, steam engines, gears and artillery guns



MAY 2, 1969 Ocean liner «Queen Elizabeth 2» went on its first voyage Southampton — New York. For 35 years it was the flagship of the British Shipping Company «Cunard». The all-welded structure of the ship hull was divided into 13 waterproof transverse bulkheads. The outdoor deck, which is wood sheathed, was fastened on welded-on studs. As regards aluminium decks, because of application of thin material, the «springing» effect appeared when walking on the ship. This was largely overcome by cross-welding stiffeners on larger areas of the deck.



MAY 3, 1973 One day before the completion of the 108-storey building of Sears-Tower — a skyscraper in Chicago, USA, it becomes the tallest building in the world at that time (442.1 m). It is the hallmark of Chicago. Construction of such a building structure is a challenge for the construction and welding companies. About 76000 t of steels were used in construction. Lincoln Electric Company participated in the project as a construction partner. Its design contained 268 km of the main welds. Both electric arc and electroslag welding was used in construction of the building.



MAY 4, 1777 Birthday of Louis Jacques Thénard (1777–1857), French chemist, Member of Paris Academy of Sciences (1810), its President in 1823. Louis Jacques Thénard is the author of numerous works in the field of chemistry and chemical technology. As the first of all the kinds of investigations, he studied conversion of electric energy into thermal energy — conductor heating by flowing current, which was conducted in 1801. Investigations, initially performed by Louis Jacques Thénard, form the base of many kinds of welding technologies.



MAY 5, 1961 Mercury-Redstone-3, the US first manned suborbital flight, began. During the fifteen minute suborbital flight by Mercury Program astronaut Alan Shepard piloted the single-seat space vehicle Freedom-7, made in the form of a capsule. The cockpit material was a titanium-nickel alloy, its volume was 1.7 m³. The astronaut was in the cradle, and was wearing a spacesuit during the flight. Flash-butt welding was used in manufacture of the ship hull. The equipment was provided by Sciaky Company.



MAY 6, 1912 Birthday of Y.G.Derevyanko (1912–1994) — engineer-shipbuilder, Deputy Chairman of the State Committee of the USSR Council of Ministers on Shipbuilding, Deputy Minister of the USSR Shipbuilding Industry. In the pre-war years he supervised design and retrofitting of a test submarine with a welded hull. During the war, he was the Chief Designer and Chief Engineer of the shipyards in Leningrad, where the designs of self-propelled pontoons and tenders were developed and their building was ensured under his leadership for the Ladoga «Road of Life». Construction of welded sea hunters of BMO type and armour sea boats was conducted simultaneously.



MAY 7, 1950 In May 1950, E.O. Paton supervised development of the design and technology of construction of Europe's largest all-welded bridge across the Dnieper in Kiev (now called the E.O. Paton Bridge).



*The material was prepared by the Steel Work Company (Krivoy Rog, Ukraine) with the participation of the editorial board of the Journal. The Calendar is published every month, starting from the issue of «The Paton Welding Journal» No.1, 2019.

MAY 8, 1915

Birthday of V.E. Moravsky (1915–1990) — representative of the Paton school. He laid the foundations for application of the new promising process of joining metals — capacitor-type welding. He devoted more than 40 years to studying the theoretical problems related to capacitor discharge, as well as solving technological tasks and development of equipment for capacitor-type and laser microwelding. Investigation results were realized in many plants of the former Soviet Union.



MAY 9, 1981

The sculpture-monument «Motherland», the largest statue in Ukraine (17th in the world), was opened on Victory Day. The figure of a woman holding up the shield and sword is faced with stainless steel sheets. The Statue height from the pedestal to the tip of the blade is 62 m, absolute height is 102 m, its weight is about 500 t. For the first time in the USSR, the sculpture of such a scale was manufactured at the Kiev Parizhskaya Kommuna Plant with technical support of PWI. More than 30 km of welds were made during its construction.



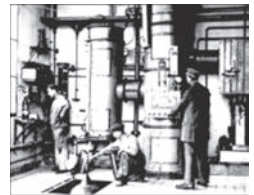
MAY 10, 1842

Birthday of D.A. Lachinov (1842–1902), Russian physicist and electrical engineer. The scientist proposed an industrial method of synthesis of hydrogen and oxygen through water electrolysis. In his patents D.A. Lachinov considered making and proposed the design of baths with unipolar and bipolar electrodes. In 1887 D.A. Lachinov, together with N.N. Benardos, performed underwater carbon electrode arc cutting in the laboratory for the first time in the world.



MAY 11, 1915

Adolph Messer (1853–1921) receives one of his patents for welding. Adolph Messer began producing acetylene generators and lighting installations in the town of Höchst, not far from Frankfurt-on-Main, starting his own company. In 1903 the Company developed the first cutter, using oxy-acetylene mixture. In the period from 1924 to 1950, production of electric welding equipment was developed and set up. At present the Messer Group Company employs about 4700 staff at 120 plants, it has developed more than 150 applied technologies and produces more than 130 gases and gas mixtures.



MAY 12, 1903

Karl von Linde (1842–1934), German engineer and scientist, developed and patented the technology of cooling and separation of gases, actively applied in welding technology, particularly in autogenous processes. In addition, Karl von Linde founded the Linde Company in 1878, which actively studied the technology of arc and plasma welding. Investigations related to mixing of oxygen and nitrogen led to introduction of the acetylene torch in 1904.



MAY 13, 1940

World's first experimental flight of Vought Sikorsky VS-300 helicopter (S-46) — the first test helicopter designed by I.I. Sikorsky (1889–1972), who was an outstanding helicopter designer, scientist, inventor and philosopher. He flew his first rotorcraft in Kiev in 1910. In 1941 by an order from the US Army, I.I. Sikorsky designed a two-seat helicopter for communication and observation. It was the world's first helicopter, which was put into mass production and the only helicopter during the Second World War. All the main load-carrying elements of the hull structure were welded.



MAY 14, 1968

Karl-Heinz Steigerwald built and patented the first electron beam chamber for metal processing. In 1963 Steigerwald founded Steigerwald Strahltechnik GmbH Company. The Company supplies vacuum installations, based on a universal concept. Chambers of different dimensions, fitted with modular mechanical and electronic equipment, are combined with electron beam generators of different power. The main application is welding large items with complex geometry of the weld or processing zone.



MAY 15, 2006

Cloud Gate sculpture was opened. It is located in the business quarter of Chicago, USA. Its author is the Indian-born British artist Anish Kapoor (born in 1954). The sculpture consists of 168 stainless steel plates, welded together and polished so well that its exterior has no visible welds. The dimensions of the sculpture are 10 (height), 20 (length) and 13 (width) m, its weight is about 100 t. Welders used hybrid laser-arc welding. Cloud Gate is one of the most famous and recognizable monuments of our time. It is believed that the sculpture form was inspired by a mercury drop.



MAY 16, 1901 The Third Arctic Expedition on «Yermak» ship began. The world's first icebreaker of Arctic class of 15000 t capacity was laid down in New Castle on the stocks of Armstrong Whitworth English Company by an order from Russia. In keeping with Admiral S.O. Makarov's idea, in addition to the conventional three stern propellers, the ship also had a bow propeller designed not only for drawing, but also for ice separation. Testing showed that this function was not fulfilled, and the yard received an order to replace the bow propeller by a wheel. The icebreaker bow part was dismantled, and a new one was welded in its place. The icebreaker demonstrated excellent seaworthiness and has operated for many years in heavy ice conditions.



MAY 17, 1892 Birthday of K.V. Petran (1892–1976), outstanding engineer, developer of a series of unique electrodes UONI-13 with calcium fluoride coating, for welding and surfacing. For more than 75 years now the electrodes of this series have been extensively applied in many industrial sectors of the CIS countries in welding critical structures.

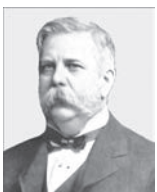


MAY 18, 1992 G.A. Nikolayev (1903–1992) died. He was a Soviet scientist, academician, Rector of N.E. Bauman MHTS, Hero of Socialist Labour. G.A. Nikolayev was the first to establish the main characteristics of vibration strength of welded structures and developed the specifications for their design. His work formed the scientific base for widespread introduction of welding instead of riveting in the structures of industrial facilities, in manufacture of boilers and carriages in the USSR.

MAY 19, 2008 The first flight of Sukhoi Superjet 100, developed by Sukhoi Civil Aircraft Company (Russia), took place. EBW KL-138 machine (PWI development) for electron beam welding was purchased for fabrication of the welded beam of a titanium pylon of this aircraft. A feature of this machine is the possibility of cosmetic smoothing of the root part of welds, also in difficult-of-access or remote locations. For this purpose the electron beam is rotated through 90°.



MAY 20, 1890 One of George Westinghouse's patents on welding was published. He was a US industrialist, engineer and entrepreneur, founder of Westinghouse Electric Company. His firm was one of the pioneers in development of welding consumables and apparatuses. In 1909 he created a direct current generator, making application of welding more accessible in many respects.



MAY 21, 1866 Birthday of Jakob Knappich — one of the founders of KUKA Systems GmbH Company. In 1889 Johann Josef Keller, together with Jakob Knappich, founded the acetylene plant for manufacture of inexpensive systems for lighting buildings and streets, household appliances and automobile headlights. Development and production of equipment for resistance welding began in 1936. In 1956 KUKA manufactures the first automatic welding lines, and supplies the first line for multispot welding for Volkswagen AG Company. Today the Company is one of the major suppliers of flexible automated solutions, including welding robots.



MAY 22, 2012 Opening of Tokyo Skytree — TV tower in Sumida district (Tokyo, Japan). It is the world's tallest TV tower of 634 m height and the second in height construction in the world after «Burge-Halifa». The entire structure of the tower consists of «lattice» elements, each of which is a combination of triangles, as part of other components. These elements are connected through branch joints and pipes. All the structures are joined by welding directly to the main support, without application of any other fastening systems or methods. This type of connection has a very simple appearance and high seismic resistance.



MAY 23, 1949 Veljekset Kemppi Oy Company was established in the city of Lahti (Finland). In mid-1960s Veljekset Kemppi Oy Company marketed its first MIG/MAG welding machine. In 1990 Kemppi became the world's first manufacturer of welding machines, which received the ISO 9001 certificate. The Company was the first in the world to create an inverter power source, and became the first manufacturer applying digital welding technology.



MAY 24, 1900 Russian cruiser «Aurora» was launched. The history of creation of this ship begins from riveting technology. After many years of berthing at Petrograd embankment as Museum-monument, Aurora came into disrepair. It was decided to replace the damaged elements of hull structures. Riveting was not applied at «restoration», otherwise there may have been not enough time before the ship's anniversary. Welding technology with simulation of rivet joints came to the rescue, which was used to make the repair.



MAY 25 (Friday), 2018 On the last Friday of May all the welders celebrate their professional holiday — the Welder's Day. The welder profession has been part of our life since ancient times. And today it is practically impossible to find a structure, which would be made without welding.



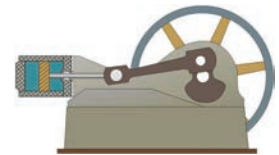
MAY 26, 1970 Tu-144 air liner exceeded the symbolic limit of 2 Mach, flying at an altitude of 16300 m at the speed of 2150 km/h. Soviet Tu-144 became the first type of supersonic air liners, which were used for commercial traffic and went supersonic. 20 % of the air liner structure was made of titanium. Ailerons made from titanium alloys were located along the entire trailing edge of the wing. Application of titanium alloys in the structure required development of new machine tools and welding equipment. These problems, together with A.N. Tupolev EDTB, were solved by specialists of TsAGI, CIAM and other organizations.



MAY 27, 1934 Birthday of V.M. Kudinov — representative of the Paton school. The scientist performed research connected with physico-mechanical phenomena at explosion treatment of metals. V.M. Kudinov supervised performance of a complex of fundamental research, associated with elaboration of the physical theory of the phenomenon of wave formation in explosion welding. This research was the base for distinguishing a separate class of welding processes, which were called structural explosion welding, performed on parts and items. In the field of explosion cutting, he performed developments of the design of elongated cumulative charges, their optimization and creation of a safe technology of their manufacture.



MAY 28, 1896 N.G. Slavyanov (1854–1897), Russian engineer, inventor of the method of electric arc welding of metals, submitted an application for the invention, and soon was granted the privileges for the «Method of Electric Compaction of Metal Castings». In 1888 Russian engineer N.G. Slavyanov applied arc welding by metal electrode under a layer of flux in practice for the first time in the world. In the presence of a State Commission, he welded a crankshaft of a steam engine in one of the shops of Perm cannon factories. Engineer Slavyanov called his invention «Electric Casting of Metals».



MAY 29, 1829 Humphry Davy (1778–1829) died. He was an English chemist, physicist and geologist, one of the founders of electrochemistry. He obtained the electric arc, regardless of V.V. Petrov, but somewhat later (1809). Discovery of the electric arc was attributed to Humphrey Davy for some time, and it was known under the name of Voltaic arc. Davy pushed together two sharpened carbon electrodes, connected to poles of a battery, consisting of 2000 cells. The charcoals glowed red, owing to huge heat release. When Davy removed their tips from each other, the current was still transmitted across the air gap, spreading a blinding light, which was called Davy's light or Voltaic arc.



MAY 30, 2012 Stojkiy destroyer was launched. This project is one of the most recent developments of Russian shipbuilding. First cutting was used to make parts of the required shape, and then welding was applied to join the hull sections. Modern welding equipment for automatic submerged-arc, semi-automatic gas-shielded, argon-arc and manual electric arc welding was used in its construction.



MAY 31, 1920 Matsu was launched — a battleship of the Imperial Japanese Navy, second ship of Nagato type. Nagato type ships are the first battleships fully designed and built in the Japanese shipyards. They were based on the concept of high-speed battleships. In keeping with the most recent engineering achievements, the relatively new technology of arc welding was extensively used at construction of the ship, ensuring the durability and strength of the armor. In particular, this technology was used to additionally strengthen the lower part of the armour belt.

