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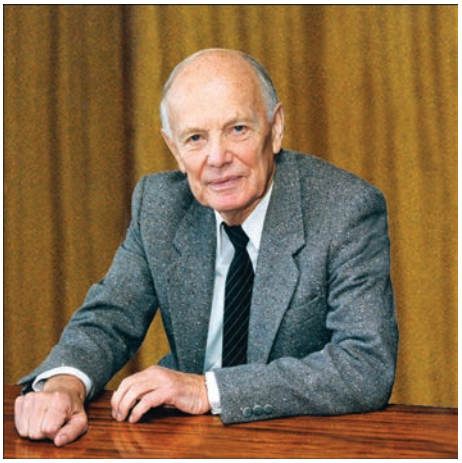
Plenary Papers for International Conference «Consumables for Welding, Surfacing and Coating Deposition and 3D Technologies», Kyiv, PWI, 4–5 June 2019

Dear Ladies and Gentlemen, Colleagues!



It is a great pleasure for me to welcome all the participants and guests of the International Conference devoted to problems urgent for modern welding production — materials for welding, surfacing, coating and 3D-technologies.

The range of problems and tasks chosen for discussion during the Conference, information on the recent achievements in this field, as well as familiarization with the samples of welding consumables from local manufacturers, presented in the exhibition, will promote strengthening the scientific and business contacts, and further development of research and applied work in the considered areas.

Traditional fruitful cooperation of science and production, constant scientific support by the E.O. Paton Electric Welding Institute and active position of welding consumables manufacturers allow providing high quality, and wide demand for domestic welding consumables, both in the internal and external markets. Evidence of this is the fact that during the years of independence Ukraine managed to prevent expansion of foreign manufacturers in the Ukrainian market. More over, Ukrainian specialists helped establishing a number of welding consumables productions in many countries of post-Soviet space. Unlike Ukrainian economy as a whole domestic manufacturers of welding consumables ensure positive foreign trade balance.

Among the new tasks facing specialists — manufacturers of welding consumables — we should mention organization of manufacturing of consumables for welding titanium and aluminium alloys, materials for application in additive technologies and robotic complexes.

On behalf of the Conference Organizing Committee, I would like to express my sincere gratitude to all the institutions, enterprises, organizations and specialists, whose active support enabled conducting this event.

I am confident that consideration of the questions to be discussed during the Conference, sharing information about the recent achievements in this field, establishing new scientific and business contacts will allow us making our contribution to reviving and enhancing the business activity of our country.

I wish fruitful work, great achievements, welfare and strong health to all the Conference participants.

Academician B.E. Paton

Electrode manufacturing at PPWE of the E.O. Paton Electric Welding Institute

Pilot Plant of Welding Equipment (PPWE) manufactures a wide range of professional welding equipment, and now The Plant is its leading manufacturer in the territory of Ukraine and CIS countries.

In order to widen the range of manufactured products and strengthen its market positions, PPWE management took the decision to master production of coated welding electrodes. After a long preparation process, at the beginning of April, 2016, electrode manufacturing was started under PATON™ trade mark. Modern technologies and strict incoming inspection of raw material quality are used in the new production section, and a professional expert team is continuously following development of welding consumables manufacturing with the purpose of timely introduction of innovations.

Pilot Plant of Welding Equipment produces electrodes by the classic formulations of demanded electrode grades: ANO-21, ANO-36, ANO-4, UONI 13/45, UONI 13/55, MR-3, special electrodes for surfacing T-590, cast iron welding TsCh-4, high-alloyed steel welding OZL-8 and TsL-11; as well as electrodes of ELITE series by improved formulation: Elite ANO-36, Elite ANO-21, 7018 Elite.

Thus, the range of PATON™ coated electrodes now looks as follows:

Elite series

- UNIVERSAL (RUTILE, WITH IRON POWDER);
- 7018 (BASIC, WITH IRON POWDER);
- Elite ANO-36 (RUTILE-CELLULOSE WITH 8 % CELLULOSE CONTENT);
- Elite ANO-21 (RUTILE-CELLULOSE WITH 6 % CELLULOSE CONTENT);
- Elite MD6013 (RUTILE).

Classic series

- ANO-36 (RUTILE-CELLULOSE WITH 8 % CELLULOSE CONTENT);
- ANO-21 (RUTILE-CELLULOSE WITH 6 % CELLULOSE CONTENT);
- ANO-4 (RUTILE);
- MR-3 (RUTILE);
- UONI-13/55 (BASIC).

SPETsELEKTRODY series

- T-590 for surfacing;
- OZL-8; TsL-11 for welding stainless steels;
- TsCh-4 for welding cast iron.

The most well-known and accepted group of electrodes of E46 type includes electrodes of ANO-4, MR-3, ANO-21, ANO-36 grades and other welding electrodes.

Over the recent years rutile-cellulose electrodes of ANO-21 and ANO-36 grades, made by PWI formulation, became the most widely accepted. By their purpose and applications, they are designed for manual arc welding at direct or alternating current of conventional and critical structures from low-carbon steels, supplied to DSTU 2651/GOST380 (St0, St1, St2, St3 of all groups A, B, C and all degrees of deoxidation — «KP»(rimmed), «PS»(semi-killed), «SP»(killed)) and to GOST 1050 (05kp(rimmed), 08kp(rimmed), 08, 10kp(rimmed), 10ps(semi-killed), 10, 15kp(rimmed), 15sp(semi-killed), 15, 20kp(rimmed), 20sp(semi-killed), 20), in all positions (except for vertical downward for 5.0 mm electrodes).

Formulations and manufacturing technology of these electrode grades, corresponding to the requirements of GOST 9466–75 by their composition and mechanical properties, are very broad, that sometimes allows the manufacturer maneuvering under the conditions of tough competition, without going beyond the GOST requirements. Therefore, the main quality indices of welding electrodes from different manufacturers, and even from one manufacturer taken separately, can be somewhat different by their welding-technological characteristics. The change of welding characteristics of the electrodes is also influenced by the ability of each

manufacturer to develop their own specification, which later on allows using new components and technological operations in electrode manufacture.

PWI PPWE took a number of measures to improve the quality of manufactured products. They include: modification of the formulations applied in manufacture of the main electrode grades, for improvement of welding-technological and consumer characteristics, introduction of advanced innovation developments (application of a complex ferroalloy modifier from one of the world's best manufacturers); supply diversification and geographic expansion of the known and new raw materials, also from foreign countries (cellulose — Switzerland, potassium-sodium lump — Germany, mica — India, etc.); toughening both incoming and outgoing inspection of the quality of raw materials and products; redesigning and improving the quality of packing materials with application of three layer packing, that guarantees preservation of welding-technological properties of the electrodes all the way from the Plant to end user.

Application of new kinds of raw materials allowed considerable improvement of welding-technological characteristics of the electrodes that expanded their application both in the industrial sector and for household purposes. When upgrading the formulations, a lot of attention was given to their ecological safety, sanitary-hygienic characteristics and safety for welder's health.

In 2017, within the strategy of development of this area, the technology park for electrode manufacture was complemented by a modern automatic line of the capacity of 12 t per shift. In the same year 2017 CE certificate was obtained, which confirmed the product compliance with EC norms, and deliveries to the markets of the European countries were started. Today PATON™ electrodes are supplied to the markets of more than 25 countries all over the world — from Latin America to South Korea.

Despite the short term presence in the welding electrode market PATON™ welding electrodes managed to prove themselves and become an indispensable assistant in welding operations in different areas: construction, machine- and ship-building, agriculture, fabrication of different metal structures, etc. And electrodes of Elite series, manufactured by the improved formulation, became widely accepted for welding operations by ordinary users to solve household tasks, due to their insensitivity to the quality of the surfaces being welded, easy initial and secondary ignition, as well as stable arcing.

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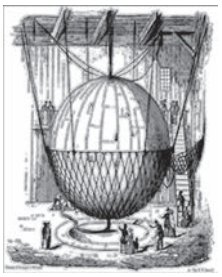
Calendar of June

JUNE 1, 1925 At the beginning of June, the company «Chrysler», an American automotive company, was founded. From the very beginning of its foundation the company used welding in cars manufacturing. Since 1930, «Chrysler» begins to use new welded structures for cars which were assembled from steel beams welded-on to body panels. A high reliability of cars brought fame to «Chrysler» and its models of the 1930s became the most sold ones.



JUNE 2, 1844 At the outskirts of Paris, Edmond Marie-Mong tested the first in the world aeronautical metal structure. The copper sphere was manufactured of welded copper sheets of 0.1 mm thickness. However, the primitive technology of forge welding caused serious damage to the project. On thin copper sheets the holes, deformations and cuts spontaneously appeared, resulting in leakage of hydrogen. Gas escaped through tiny holes with a hiss and, therefore, the launching failed. However, despite the failure, the metal structure of Edmond Marie-Mong inspired many engineers and enthusiasts. Inventors of metal vehicles patented in eager rivalry their projects in Europe and America.

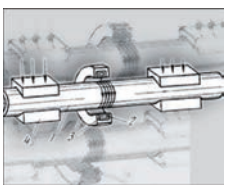
JUNE 3, 1951 In early June, at the E.O. Paton Electric Welding Institute of the Academy of Sciences of the UkrSSR a special wagon-laboratory was created, equipped with models of the latest automatic welding equipment and demonstration devices, which, as a mobile laboratory, was sent to the enterprises of the Urals to promote automatic welding technologies and to render assistance in their implementation.

JUNE 4, 1958 In summer of 1958, the first Soviet (third in the world) nuclear-powered submarine was put into service. Back in the early 1930s in the USSR and in the United States the creation of radically new submarines with nuclear-powered plants was started. In the list of necessary qualities of the new submarine, the depth of immersion of 300 m was mentioned. The immersion to such a depth exceeded by several times all the previously achieved records. After a series of experiments, the required properties and the required quality of welded joints were obtained.

June 5, 1934 The solemn commemorations of crew of the icebreaker «Chelyuskin» were held. During an unsuccessful voyage and a following days-long drift, the crew noticed one important technical detail. When the ship hull was squeezed by ice, the rivets could not withstand the pressure and flew out from the ship board like bullets. After the wreck of «Chelyuskin», crushed by ice, the designers began to refuse from rivets in favor of welding. As experience showed, the ship hull became lighter and the labor intensity during building decreased by one third. Welding began also to be widely used in ship repair.

JUNE 6, 1927 The scientist and engineer V.P. Vologdin (1883–1950) in his short handwritten note «The use of electric arc welding during construction of bridges and large iron structures» proposed the idea of construction of an all-welded bridge. In 1928, he designed and constructed an all-welded bridge at the Shkot peninsula in Vladivostok. Four welders welded a bridge with a span of 25 m just only for 20 days, saving 25 % of metal as compared to the riveted structure. In 1929–1931 he constructed two more all-welded bridges, including a heavy-type bridge with a span of 36.6 m and total weight of 300 tons.

JUNE 7, 1977 At the beginning of June 1977, the company «Kemppi» manufactured the first in the world inverter-type power source «Hilarc-250», assembled on the base of the so-called quick-response thyristors. «Quick-response thyristors» allowed converting a direct current into alternating one at the frequency of 2–3 kHz. Thus, the first inverter power sources for welding appeared. Unlike conventional rectifiers, where the transformer operates at an industrial frequency of 50 Hz, in inverter rectifiers it began to operate at a frequency of 2 kHz or higher. The increase in the operation frequency of a welding transformer can significantly reduce its weight and dimensions.



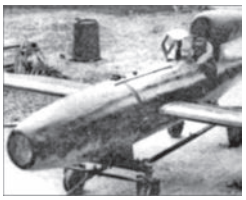
JUNE 8, 1946 The idea of applying the high-frequency currents for welding of metals was for the first time proposed in 1946 by Soviet specialists headed by A.V. Ulitovsky. In the 1950s in the Soviet Union and abroad, intensive investigations began on the development of technology and equipment for high-frequency welding of pipes, and a little later, also for cable sheaths and profiles.

*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.

JUNE 9, 1959 The first nuclear-powered strategic submarine of the US Navy of the type «George Washington» with ballistic missiles on the board was launched. In the submarine hull behind the deckhouse a 40-meter missile compartment was «inserted», in which 16 missile launchers were located. To create a missile compartment, the submarine structure was divided in half, and then a compartment for ballistic missiles was «inserted» into it. After assembly of the missile section, all parts of the submarine were welded together. The general layout of the submarines of type «George Washington» with vertical launching tube, located behind the deckhouse, was very successful and became a classic scheme for underwater strategic missile-carriers.

JUNE 10, 1931 Date of birth of E.M. Esibyan (1931–2015). His research activities are related to the development of transistor-type power sources for a low-ampere arc supply in argon and putting devices AP-4 into serial production at the Simferopol Electric Machine-Building Plant. Also, E.M. Esibyan was involved in the development of the first in the world practice power sources and plasmatrons for air-plasma cutting of metals, the organization of large-scale production of installations «AVPR» and «Kiev-4» and their implementation at the machine-building plants in Ukraine.

JUNE 11, 1997 An official presentation of the first eight multifunctional fighters Su-30K was held at the Indian Air Force's airbase in Lohegaon near the city of Pune (Maharashtra). They were manufactured under the contract in India and, before that, successfully completed a number of test flights. To create this type of aircraft, a special installation KL-132 (developed by the E.O. Paton Electric Welding Institute) was used for electron beam welding of the jet engine AL-31F components at the plant of the «HAL» company (Koraput, India).



JUNE 12, 1944 The fascist Germany began bombing of London and other British cities with V-1 flying bombs «V-1». Their mass production during the World War II became possible due to the application of welding, with the help of which the spherical cylinders for compressed air, required for engine operation, were manufactured. The fairing and body lining were made of aluminum alloys. The structures of fuselage, wings, stabilizer and other assemblies were manufactured of low-carbon steel using spot welding, mainly with hand tongs.

JUNE 13, 1901 In the middle of 1901, the first acetylene-oxygen welding torch was designed by French engineers Edmond Fouche and Charles Picard. Its design has not fundamentally changed until nowadays. The development of acetylene generators led to an increase in their reliability, and in 1960, the industrial application of this type of welding in the construction of gas pipelines, technological equipment and other structures began.

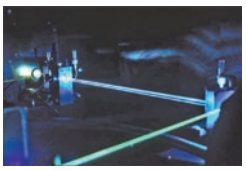
JUNE 14, 1952 The construction of USS Nautilus (SSN-571), the first in the world nuclear-powered submarine, began. It was adopted by the US Navy on September 30, 1954. On August 3, 1958 «Nautilus» reached the North Pole and became the first ship in the history of mankind, which passed this point of the Earth on its own power. In the United States, to manufacture the first nuclear-powered submarine «Nautilus» the company «General Dynamics» used different joining technologies, mainly submerged arc welding and oxyacetylene welding.

JUNE 15, 1911 After repair, the armored cruiser «Men» was repeatedly put into service. The ship conducted combat training and made voyages along the east coast of the United States. During its repair, the autogenous welding was used as one of the first precedents in the US military shipbuilding. As for the very first cases, they occurred in 1906–1908 in Genoa and Marseilles. There, the autogenous welding was used to repair boilers and other equipment of ships. During that period, about 80 vessels passed a similar repair procedure.

JUNE 16, 1965 From the Baikonur Cosmodrome the first launch of the «Proton-K» rocket-carrier was successfully realized. The «Proton-K» rocket-carrier belongs to the heavy class and became the main means for the cargo delivery to the orbit. In the engine design the welding was widely used. In particular, in the main lines of the rocket there are 11connectors in total. The oxidizer tank of the load-carrying structure is welded and made of aluminum alloy. It consists of a smooth cylindrical shell of a sectional type, reinforced with frame rings and two spherical bottoms. The shell of the oxidizer tank is smooth and welded from three sections.

JUNE 17, 1911 A unique solution for development of welding electrodes was found by A. Stromenger. As a chemist and organizer of the analytical laboratory in London, he was well aware of the properties of different materials and suggested the company «Tudor» to apply a coating of blue asbestos containing compounds of iron and sodium impregnated with silicate. This cord was wound on a metal rod. Also, over this coating a thin aluminum wire was wound. Such a structure of the electrode coating provided protection of the weld pool and metal of electrode drops from atmospheric air due to the formation of slag. Already in the middle of 1911, under the name «Quasi-arc», these electrodes began to be used in the repair of trams and ships.

JUNE 18, 1970 Since 1969, the Publishing House «Naukova Dumka» began to publish a series of one-volume editions of selected works of famous Ukrainian scientists. The works of V.I. Vernadsky, D.K. Zabolotny, A.A. Bogomolets were published. In the summer of 1970, a collection of selected works of E.O. Paton (more than 400 articles) was published on such topics as: span structures of bridges, welded structures, welding technology and shapes of welded structures.



JUNE 19, 1941 Date of birth of AG. Grigoryants, Doctor of Technical Sciences, Professor, Head of the Bauman Moscow State Technical University, a specialist in the field of laser engineering and technology. His activities are focused on strength, welding deformations and stresses. Also the publications of Grigoryants on the application of laser radiation energy in medicine are known.

JUNE 20, 1939 The first ever flight of German jet aircraft «Heinkel He 176» was performed. This is the first aircraft in the world, driven by a fluid-fuelled jet engine. In the design of the aircraft the welding was widely used. In the course of the works, it turned out that in welding of wing structures the serious technological problems appear. Then, a different wing was designed and manufactured, made by the usual scheme with two longerons, and welding at the critical place was decided to be removed. The wing consoles with an area of only 5.4 m^2 and a span of 5 m had a very high load, being almost 300 kg/m^2 at 1620 kg take-off weight.

JUNE 21, 1956 In the USSR, the R-5M missile was added to the armament. That was a Soviet single-stage liquid-propellant ground-based medium-range ballistic missile with a nuclear warhead. The tanks of the rocket represented thin-walled load-bearing structures joined by welding, for manufacture of which an aluminum alloy was used. A special attention was paid to the quality of the tank welds: manual (acetylene-oxygen) welding was replaced by argon-arc welding, while the longitudinal welds of the shells and welding of the bottoms were done by automatic machines, and welding-on of connecting pipes and flanges was done manually, but also by argon-arc welding. This improved the quality of welded joints and their anti-corrosion properties.

JUNE 22, 1957 In the USSR, the R-12 missile was launched. That was a Soviet liquid-propellant single-stage ground-based ballistic missile with a flight range of up to 2,000 km. The oxidizer tank of the rocket, made of AMg-6 alloy, had a complex structure and consisted of two compartments: the upper and the lower ones, separated by a common hemispherical bottom. The cylindrical frame rings of the compartments are smooth, welded and consist of rings formed by welding of rolled sheets with thickenings in the places of welding. The rocket parts were joined using automatic welding in argon. Namely, the missiles R-12 became the cause of the Caribbean crisis, when in the frames of the «Anadyr» operation they were deployed in Cuba.

JUNE 23, 2009 The type-45 destroyer «Daring», a modern destroyer with a guided missile weapon was transferred to the British Navy. This type of ships was produced since 2003 for the British Navy. Due to the automation of welding process from «Gullco International (UK) Limited» it became possible for a short time to provide joining of parts of two-phase steel in the structures of the «Type-45» ships. Also, welded tractors were applied, which significantly reduced the time and costs of welding. This had a positive effect on the quality of welds and the time of their completion. In that project, automation of welding process from «Gullco» brought more than 50 % savings in time and costs.

JUNE 24, 1924 The English experimental all-welded self-propelled barge «Fullagar» with a length of 46 m and a displacement of 398 tons slammed into the rocks, but, despite deformation of the bottom, it remained afloat. The vessel was designed by J.S. Goodwin. He took into account all the features of welding, including welding stresses, which were reduced due to holes in gussets and floors. The hull of the vessel was assembled according to the old method: by bolts, which were removed after welding, and the holes were rewelded. The commission came to the conclusion that a riveted vessel with such damages would have sunk, and the mark «experimental» was removed. Namely this event was widely publicized and made welding to be a popular technology in shipbuilding.

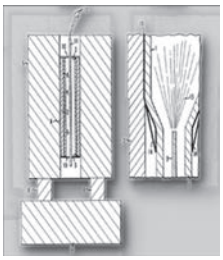
JUNE 25, 1919 The first flight of the aircraft «Junkers F-13» took place. That was the first in the world all-metal transport aircraft, designed in Germany at the end of the World War I. Among the several options, a scheme of a monoplane with a low wing was adopted for the further development. This scheme has become a classic one for the most subsequent airliners. The design of «Junkers F-13» was based on welded duralumin pipes, covered with corrugated duralumin lining. This created a very strong structure. The plane was easy in maintenance and could be equipped with wheels, skis or floats for landing on the water. The airliner was on service in all the continents and in all the climatic zones.

JUNE 26, 1824 Date of birth of William Thomson, Lord Kelvin (1824–1907), a British physicist and mechanic. He is known for his works in the field of thermodynamics, mechanics and electrodynamics. He proposed an absolute temperature scale (1848), gave one of the formulations of the second law of thermodynamics (1851), and introduced the concept of energy dissipation. Later, these laws formed the basis for many designs of equipment, including welding one. In 1856, William Thomson, during his investigations, fused the bundles of wires in a box with coal, passing electric current through the wires. Thus, for the first time, he performed a butt welding.

JUNE 27, 1940 The battleship of the American armed forces «Iowa» started its building. In total, it was planned to build six ships of this type. In 1939, the US government issued an order for the construction of «Iowa» and «New Jersey». It should be noted that the construction of battleships was conducted at an unprecedented pace. Electric welding was used, which was not typical for that time. Using automatic welding machines during construction, the workers were able to accelerate and simplify the process of building ships. The first pair of ships of this series was put into service in 1943. Among those ships the place of a flagship was taken by the battleship «Iowa». It was distinguished by a larger conning-tower.

JUNE 28, 1935 One of the patents for welding of «Pullman-Standard Car Manufacturing» (USA) was registered. Back in 1929, the company received quite satisfied results in arc welding of thin armor plates, and in 1931 an all-welded armored vehicle was designed and manufactured there. In February of 1933, the first armored train left the workshop of the same company.

JUNE 29, 1796 Date of birth of P.P. Anosov (1796–1851), a Russian mining engineer, metallurgical scientist, a major organizer of the mining industry. P.P. Anosov, who worked at the Zlatoust Metallurgical Plant for more than 30 years, is the author of different grades of steels, including damask steel, for the production of unsurpassed cold arms. He developed a hammer for peening of ball iron. According to the results of his investigations, different methods were proposed to improve the quality of metal and to produce bimetal by a forge welding.



JUNE 30, 1961 One of the largest American chemical companies «DuPont» registered the first ever patent for explosion welding. The investigations of explosion welding began in the 1950s in different institutes and organizations. In the World War I, cases of the shell welding-on to the armor were noticed. However, this knowledge was not in demand. Only in 1961 at the same time the reports about explosion welding of metals appeared in the USSR and the USA. This technological process allowed producing bimetallic billets and products of practically unlimited sizes from different materials and alloys, including those, welding of which is difficult or impossible using other methods.