

deformed uniformly, as much as possible, over the entire surface area to minimise residual distortions of large-size flat pieces. At present, metal shot is considered to be the best material for supports. It provides a lower level of residual distortions compared to other materials. However, further decrease of residual distortions is still a topical problem.

Another pressing problem is the possibility of evacuation of explosion chambers. It is reported that evacuation improves the quality of explosion welded joints. At the same time, it makes design of the explosion chambers more complicated and more expensive, and reduces their productivity.

In the future, application of special workshop automated explosion chambers will lead to increase in output of thin-sheet bimetal for its subsequent utilisation to manufacture elements of machines and devices, as well as bimetal of any combination and thickness, including for further rolling.

1. Banker, J.G. (2009) Industrial applications of explosion welding (Review). *The Paton Welding J.*, **11**, 42–46.
2. (1992) *Unified safety regulations in explosion operations*. Kiev: Normativ.
3. Bogrovsky, Ya., Fruchek, M., Korzun, M. (1976) Some problems related to increase in explosion effects. In: *Proc. of 3rd Int. Symp. on Application of Explosion Energy for Fabrication of Metallic Materials with New Properties by Welding, Cladding, Hardening and Explosion Compacting of Powders* (Marianskie Lazni, 19–22 Oct., 1976), 515–522.
4. Kudinov, V.M., Palamarchuk, V.I., Gelfond, B.E. (1977) Damping of shock waves by foams. In: *Application of explosion energy in welding technique*. Kiev: PWI.
5. Gurin, A.A. (1978) *Control of shock waves in explosion operations*. Moscow: Nedra.
6. (1974) *SN 453–73: Recommendations on designing of shelters located in mine working*. Moscow.
7. Krupin, A.V., Soloviov, V.Ya., Popov, G.S. et al. (1991) *Explosion treatment of metals*. Moscow: Metallurgiya.
8. Bazhin, I.I., Stukalov, N.G., Chebanov, Yu.I. (1970) Experience of designing of vacuum chambers in units of the workshop type. *Impulsnaya Obrab. Metallov Davleniem*, Issue 1, 84–87.
9. Krivtsov, V.S., Borisevich, V.K. (2007) State-of-the-art and prospects of application of pulse power sources for technological processes of materials treatment. *Aviats.-Kosmich. Tekhnika i Tekhnologiya*, **47**(11), 10–17.
10. Demchuk, A.F., Isakov, V.P. (2006) *Metallic explosion chambers*. Krasnoyarsk: RIO KrasGU.
11. Nikolaenko, P.A. (2010) *Stress-strain state and strengthening of metallic explosion chambers*: Syn. of Thesis for Cand. of Techn. Sci. Degree. Moscow.
12. (2009) Moscow Regional Shared-Use Explosion Center of the Russian Academy of Sciences (SUEC). *The Paton Welding J.*, **11**, 77.
13. Willian, F., Howel, G. *Explosive welding device*. Pat. 3848794 USA.

## *From the history of welding*

# TO 130th ANNIVERSARY OF THE FIRST METHOD OF ARC ELECTRIC WELDING

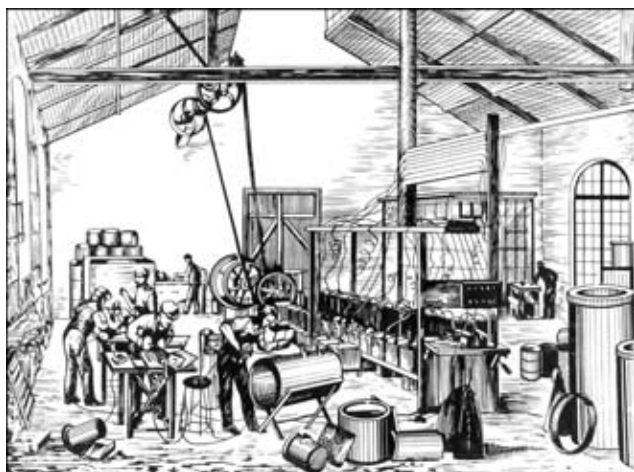
*In 1881 the electrical engineers, who came to Paris to attend the International Electrical Engineering Exhibition, watched Nikolas de Benardos, colleague of P.N. Yablochkov, the famous inventor of «Russian light», performing brazing-welding of different exponents by heating parts using electric arc in the laboratory of N.I. Kabat. In a facsimile list Benardos noted that projects and inventions from Nos. 21 to 39 (1877–1881) were made in St. Petersburg; 40 to 42 – in Zakaspijsky region, where the company of Yablochkov implemented the electricity, and 48 to 54 – in Paris. No.46 stated «Electric brazing of metals, electrogefest». The considerable part of this list contains inventions in the field of electric engineering: corrugated batteries, electric arc lamp, candlestick for the candle of Yablochkov with automatic switch of a current, battery of powder of crystal lead, commutator for filament lamps, etc.*

The life and activity of the inventor of the first method of a new type of joints attracted attention after 50 years when the arc welding turned into the leading technology of manufacturing the critical metal structures due to efforts of many inventors, scientists, rationalizers.

Nikolay N. Benardos was born in July 26 (August 7), 1842, in the village Benardosovka (now village Mostovoe of Bratsk district of Nikolaev region, Ukraine) in the family, coming of military servants of Greek origin.

Being a child he learned at home in Benardosovka. He learned not only reading, writing and different languages, but also forgery and joinery at the splendid grandfather's workshop. He entered medical faculty of Kiev University, then he was transferred to Moscow Petrovsko-Razumovskaya Agricultural Academy.

In 1869 he left to register his mother's heritage (a land in 12 km from town Lukh of Kostroma province, Russia) and stayed there. He built a house, workshops, greenhouse, also helped in building school and drug-



Print «The first welding workshop «Electrogefest» at the works Creuzot (1890, France)

store. Being elected to the Zemstvo Assembly (elective district council in pre-revolutionary Russia) of Yurievets uyezd (district) he struggled for free education and medical care. Then he was put to prison for about a year. In newspapers he discussed problems of aeronautics, medicine, agriculture, claimed for different inventions and suddenly went bankrupt. In 1877 he moved to St. Petersburg and took a great interest in electric engineering.

Most probably that the first method of arc welding was created by Nikolay Benardos in St. Petersburg, where the laboratories and industrial facilities of the Electric Lighting Company «P.N. Yablochkov the Inventor and Co» were sufficiently equipped for manufacturing batteries with corrugated plates suitable for welding, controllers of welding current, water rheostats, holders, etc. He brought to Paris a ready-made equipment and mastered technology. However, he started patenting his invention only in 1885 and within three years he was granted patents of many European countries and the USA. The reason for delay was paying a great fee and need in funds for realization (implementation) of invention. If the service within a short term (1–3 years) was not established, the patent would be abated. That is why most inventors were unhurried to register their developments.

In 1884 the mansion «Privolnoe» with all premises in Lukha, mortgaged in a hypothecated bank, was sold to pay for the debts. The rest of money Benardos used for patenting in Russia (including also electric arc welding). The patenting abroad was financed by a merchant S.O. Olshevsky, who became a co-owner of the patents.

The solemn procession of «Electrogefest» was described in many books and articles. However some adventurers took a possession over the patents of Benardos and his model workshop of welding works, the first in the world created by him and the society «Electrogefest» (on operation and implementation of electric welding and other inventions) in 1885. The owners of the society did not wish to spend money to improve welding and Nikolay Benardos continued improving the equipment, torches, devices and welded

joints for his own money. The possibilities of welding as an independent operation in modeling are disclosed in the patent of Benardos titled as «microcasting» or «metallic modeling». To enhance quality of weld metal he applied magnetic control, flux-cored wire, shielding gas and other. Hoping to receive a governmental order he developed a project of repair of the Tsar Bell (Moscow Kremlin) and a rise to the bell-tower.

Since the beginning of 1883 Benardos worked in London and other cities of Great Britain, improving equipment and process of welding. Already in the late 1880s the equipment and technology for arc welding were implemented in different fields of industry in France, Spain, Great Britain, Germany, the USA and other countries.

At the end of 1890s the health of inventor became worse, he passed a long treatment in Moscow, lived with his son and then decided to settle in Kiev province in the village Byshev near Fastov. Being on the summit of glory the famous inventor left without a penny. Sometimes the seriously ill Nikolay Benardos could not afford his daily bread, but as soon as he got money he spent them on different materials and started working on the new invention. In 1902 the house and household premises were set on fire by some peasants from neighborhood. All the drawings, documents, mockups were burnt. After the fire he moved to Fastov where he worked at the boiler works and locomotive depot. In September 8 (21), 1905, Benardos died. Nobody knows about the place of his burial. Neither magazines nor newspapers informed about the death of the author of more than two hundred inventions and projects in the field of electrical engineering, electric technologies, agriculture, military affairs, transport, aeronautics, household, building and medicine.

Basing on the documents prepared by the E.O. Paton Electric Welding Institute, UNESCO included the historic event — «100-anniversary of invention of welding by Benardos» to the «Calendar of memorable dates in 1981» on the representation of Ukrainian SSR.

On May 18–21, 1981 the solemn meeting and scientific conference were held in Kiev. In Fastov the monument was unveiled and in Pereyaslav-Khmelniysky the museum was opened. The similar events were held on June 11–13, 1981 in Ivanovo and Lkh. The information about Benardos in a form of a post stamp and special envelopes was enlisted to descriptions of philatelic catalogues of the world. The movie about Benardos was many times demonstrated by the Central TV. Many scientists supported the idea of holding the conferences «Benardos readings» every two years in Ivanovo, Kiev and Nikolaev in turn. The scientific magazines of many European countries published articles about the history of inventing the electric welding. And in 1985 in Great Britain the large International Conference took place devoted to the hundred anniversary of granting the first patent in the world on electric welding to Benardos.

*Prof. A.N. Kornienko, PWI*