Comprehensive testing of this method in welding of copper and copper with steel, multilayer surfacing on copper and steel, bronzes of the BrAMts9-2, BrKMts3-1 types under the fluxes of AN-26P, AN-20P, AN-60, AN-348-A, OSTs-45 grades showed that application of combined shielding provides dense welds and deposited metal in all cases.

The method of combined shielding has passed the industrial tests in welding of copper with steel under flux as applied to the manufacturing of blast furnace tuyeres with thickness of edges being welded of 5–10 mm, and also in deposition of bronze on steel under flux on circumferential surfaces with the purpose to increase the operability and service characteristics of bimetal products, that allows it to be recommended for the industrial implementation.

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HALF-CENTURY ANNIVERSARY OF THE FIRST EXHIBITION OF ACHIEVEMENTS OF WELDING PRODUCTION

A.N. KORNIENKO

E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

50 years ago (since 12 July till 3 October, 1960) the exhibition «Implementation of advanced welding technology into national economy of the USSR» took place in Moscow at the Exhibition of Achievements of National Economy in the pavilion «Machine building» at the area of above 6000 m^2, where more than a thousand of exhibits (full-scale specimens, mockups and posters) was shown. According to the scales of demonstration of development of welding production in the single country the exposition had no equals. By that time in the USSR not only world-famous methods of welding and related technologies were successfully applied, but also a number of principally new methods of joining were developed. Therefore, it can be considered that the exposition illustrated the world level of welding technology for the end of the first half of the XX century. It was namely the period when welding became the most widely applied in mak-

ing the permanent joints. In the 1930s the welding production made the great contribution into the industrialization of the USSR. In the USA and a number of other countries the welding also continued to replace riveting in machine building, industrial building in spite of depression and delayed rates of economic development.

During those years the fundamentals of welding were based. In particular, under the leadership of Evgeny O. Paton the methods of calculation and designing of sub-assemblies of welded structures were developed, the strength of welded specimens was studied, high-quality electrodes for manual arc welding were manufactured, the development of high-efficient method of automatic submerged arc welding was finalized and its implementation at the plants of the USSR started. During the years of the Great Patriotic War the specialists of the Electric Welding Institute at the evacuation to the Urals developed first in the world the automatic submerged arc welding of armored steels, proved experimentally the presence of arc discharge under flux, new designs of welding heads were created on the basis of discovery of self-adjusting of arc processes, dozens of installations for welding the components of tanks, aircraft bombs were designed and mounted. In other countries, the same as in the USSR, implementation of welding accelerated the production of armament, transport vehicles, construction and restoration of metallic structures.

In the postwar period the rates of development of welding preserved. The Electric Welding Institute started conversion of the submerged arc welding. Already in 1944 the works on mechanization of welding processes in site, widening of application of the automatic welding in different fields of civil production began, two-arc welding at high speeds was suggested, mobile welding tractor-automatic machines, hose semi-automatic machines and other were offered. In that period Evgeny O. Paton laid grounds of combining the theoretical and experimental research works with applied developments which led to foundation of investigations of a principally new class, i.e. purposeful fundamental studies.

The works, carried out at the E.O. Paton Electric Welding Institute, promoted the facilitated acceleration of restoration of destroyed industry of the country, first of all metallurgy and fuel-power complex. The technologies of pipes production and construction of pipelines, large-block building of ships, production and repair of railroad transport were developed. For the first time in the world the automatic submerged arc welding of vertical welds was performed, implemented into the building of blast furnaces, bridges and other structures, the production of tanks of flat panels was created, the assembly-welding automatic machines for manufacturing mining cars, standpipes, miner's lamps, etc. were designed. The remarkable achievement of the E.O. Paton Electric Welding Institute, awarded by Grand Prix at the International Exhibition in Brussels (1958), was the development of electroslag welding, the technology of joining metals (steels, aluminium, copper, titanium and their alloys) of unlimited thickness. Basing on this technology the electroslag surfacing and remelting were developed. The world achievement became the development at the E.O. Paton Electric Welding Institute of a circumferential transformer for the flash-butt welding in the field conditions of rails, butts of pipes including main pipelines of large diameter. At the end of the 1940s TsNIITMASh, E.O. Paton Electric Welding Institute, NIAT, IMET and a number of other institutes developed for the first time in the world the arc welding in CO_2, the implementation of which allowed considerable mechanization of welding production of steel structures. To manufacture critical products of non-ferrous metals the arc welding in ar-

gon, plasma welding, ultrasonic, friction, electron beam, diffusion, magnetically-impelled arc butt welding and other were used. New technological possibilities of gas-plasma treatment, in particular, cutting were achieved due to the works of such organizations as VNIIAVTOGEN and VNIIESO.

It should be noted that before the organizing of exhibition the USSR leaders studied the status of welding science and technology. On June 5, 1958 the Decree of Central Committee of Communist Party of the Soviet Union and Council of Ministers of the USSR «About the further implementation of welding technology into the production» outlined the main trends in the development of welding in the USSR for seven years. For the first time welding was recognized as an independent type of production, the state planning of production of welded structures and level of mechanization of welding works were established. On 23–24 February, 1959 the first session of the Council on coordination of research works in the field of welding, which included 70 leading specialists of the country, scientists and managers of production, took place in Kiev under the chairmanship of Boris E. Paton. 15 commissions on different problems of welding science and technology were organized which began to conduct independent operative work on coordination. The July plenum of Central Committee of Communist Party of the Soviet Union of 1959 outlined the building of specialized welding plants in different regions of the country. On 13 July, 1960 at the next plenum B.E. Paton presented the paper «Welding, its importance in industry and construction and prospects of its further development». The exhibition served as visual illustration of the paper made on behalf of all welders of the country. It consisted of the following chapters: introduction, welded structures, automatic and semi-automatic submerged arc welding, welding in shielded gases, power sources for arc welding, surfacing, electroslag welding, flash-butt welding, innovative methods of welding and cutting, welding consumables, gas-flame treatment, mechanization of assembly-welding works, inspection of welded joints and welding consumables. The achievements were demonstrated by the enterprises of 43 councils of national economy of all regions of the country, 18 ministries, establishments and committees, 22 scientific and research, design and technological organizations. At the exhibition one could get acquainted with innovative technological processes, equipment, rational welded structures, automation and mechanization of assembly-welding, surfacing and other works.

In the section «Welded structures» on the example of crane beam of Chelyabinsk plant of metal structures the advantages of welding in comparison with riveting were shown. In the exposition the mock-up of two-tier stand was shown for manufacture of flat sheet panels, coiled into a coil in accordance with the Paton method of industrial manufacturing of large tanks. The gasholder at the stage of manufacturing using method of coiling was presented at the exhibition. This method allowed several times reducing the time of site works, decreasing the total cost of tanks construction. Besides, the technology of manufacturing of flat-coiled pipes of strips welded on edges was developed. Liquid or gas, supplied among the strips under pressure, form the cylindrical shape of the pipe. Thus, in Tatarstan

the laying of 100 km of pipelines of these pipes allowed saving more than thousands of tons of metal and reducing the cost of construction by 1700 thousand roubles. The results of implementation of new welding technologies of critical engineering products were presented at the exhibition. The unique sample of welded structure was also the exhibition pavilion itself, the dome of which consisted of rings connected between each other in the meridian sections by stiffeners.

One of the most metal-intensive branches is ship building where large block method of building is widely used. At the exhibition the single sub-assemblies, mockups of atomic ice-breaker «Lenin», large-tonnage tankers, dry cargo ships and others were presented.

Electroslag welding was already applied in the 1950s for manufacture of high-capacity power units, forge-press, hoisting-transport and other equipment, equipment for chemical, nuclear and other branches at the Novo-Kramatorsk plant, Taganrog plant «Krasny Kotelshchik», Uralmashzavod, Leningrad Metal plant and other plants and organizations, which presented over 80 exhibits-products and mockups.

CO_2 welding found the wide spreading in our country. The high economic effect of the process was proved by mockups and full-scale samples of products of automotive industry, turbo-generator and turbo-motor plants of Kharkov, Novosibirsk, Leningrad, shipbuilding yards of Kherson and Nikolaev, other machine- building plants, mockups and units of blast furnaces, industrial constructions, etc. In the demonstration of achievements in this field of welding technology more than 30 organizations took part, including NIAT, VNIIESO, E.O. Paton Electric Welding Institute, TsNIITMASh, NIIKhIMMASh.

Maximum mechanization of assembly-welding works in transport machine building, boiler, instrument industries, and also in a number of other branches was provided due to application of all methods of resistance welding. A wide application of repair technologies of restoration of worn-out parts using hardfacing was also reflected at the exhibition. In this section a series of special surfacing mechanized equipment attracted attention. With the development of new types of machinery and more strict requirements to the quality of materials and their joints an attention to related processes and special electric metallurgy was intensified. Surfacing and other technologies of deposition of coatings belong to the methods allowing considerable increasing of service properties of parts and mechanisms.

The successful implementation of new technological processes became possible due to an abrupt increase of production of the modern welding equipment. In the section «Power sources for arc welding» many types of welding transformers, mechanic converters of direct current and semi-conductor rectifiers, developed by VNIIESO, E.O. Paton Electric Welding Institute, NIAT, plant «Elektrik» and other were presented. Hundreds of models of machines for arc welding, machines for resistance welding, machine-tools, holders, different machines of welding stations and other equipment were widely presented. At the exhibition the E.O. Paton Electric Welding Institute presented a welding tractor TS-32 with a sliding water-cooled copper shoe, providing a forced formation of a lower weld bead; tractor TS-33 for automatic welding of butt and fillet welds of aluminium of thickness of up to 40 mm using semi-open arc along the layer of flux with universal set up for layout of a weld between the wheels and near the tractor (including also circumferential welds on the vessels of diameter of 1000 mm and higher); rails machine A-372r and magnetically-walking machine A-501M, which were successfully demonstrated in Brussels and New York; gun A-564 for stud welding under flux in lower, vertical and overhead positions; universal tractor TS-17M, semi-automatic machines PSh-5 and other. Semi-automatic machine A-547r of the E.O. Paton Electric Welding Institute was designed for CO_2 welding of metal of small thickness in all spatial positions using wire of 0.6–1.2 mm diameter at currents of 20–200 A. A set was demonstrated, consisting of a hose holder, feed mechanism together with a wire reel in a common casing, control panel, gas equipment and rectifier VS-200. For resistance spot welding the E.O. Paton Electric Welding Institute developed small-sized tongs K-165 with a built-in transformer, suspended machines for flash-butt welding of rails (K-155) and pipes (KTSA-1). A large amount of versatile and specialized machines and tongs for all methods of resistance welding was presented by VNIIESO and plant «Elektrik». Other technological processes were also provided by high-efficient equipment. According to technical data the domestic equipment was not inferior to the best foreign models, and design solutions were the basis for the development of the new equipment.

The exhibition attracted attention of specialists of many branches of industry, demonstrated high level of welding production in the USSR and had considerable influence on the further development of welding.