

Mechanisation and Automation at the Turn of the 20th Century

Abstract: The article presents the history of the mechanisation and automation of arc welding at the turn of the 20th century, including Benardos' and Slavyanov's first welding machines and the first related patents.

Keywords: mechanisation, automation, welding

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...providing human masses with necessary goods, using the work performed by machines, rather than by humans, is a good thing. Because of the fact that such provision is performed by machines, mechanisation is positive and following its history resembles a quest through the success and happiness of mankind. (Aleksander Bocheński, Wędrówki po dziejach przemysłu polskiego. KAW, Warszawa 1987)

The above-presented universal message refers to all manufacturing technologies, from those enabling the making of simple goods of everyday use to those applied in order to create the most complex structures. In welding engineering, mechanisation started as early as in the late 1890s and was concerned with electric welding.

Similar to metal arc welding invented in 1888 [2] by Nikolay Slavyanov (patented in 1890) [3], electric carbon arc welding, patented in 1885 by Nikolay Benardos and Stanisław Olszewski was manual [1]. Having obtained their patents, the aforementioned inventors became involved in works aimed to improve the above-named welding methods. As a result, N. Benardos designed two welding machines featuring automatic arc control (Fig. 1) [1], whereas N. Slavyanov developed a station enabling the semiautomatic feeding of a wire to the welding area (Fig. 2)

[2]. The aforesaid station consisted of a differential controller (1), a rocker (3) and an electrode feeding system (5). At one end the rocker was provided with two pairs of rollers (7), whereas the other end of the rocker was provided with a counterweight (4). The central part of the rocker was connected to the controller (1) by means of a bar (2). The controller was a solenoid, the winding of which was gradually connected to the welding circuit, whereas the core was connected with the rocker and pulled away a spring. The rocker was provided with a bolt having a driving roll and a handwheel (6) fixed to its ends. The semiautomatic welding machine was suspended over an element to be welded (workpiece) and an approximately 2 metre long electrode (8) was placed on the roller. By turning the handwheel, the electrode was moving closer and the controller spring was wound up. As the

electrode melted, arc voltage increased, welding current decreased, the spring started to overcome the attractive force of the solenoid, the bar moved backwards and the end of the rocker with the electrode moved closer to the workpiece. From time to time, the electrode was moved closer manually, by using the handwheel (and turning the roller) (7) [3].

It is assumed that mechanised welding was implemented in the early 1920s. However, already in October 1913, William L. Callahan and Joseph W. Raynor of the C&C Electric&Manufacturing Company, New Jersey filed a patent for an automatic arc welding machine (Fig. 3) and received related patent no. 1.262.749 [4]. Two years later, Otis Allen Kenyon patented an automatic welding machine (Fig. 4), where the electrode was fed mechanically to the welding zone [5]. Paul O. Noble [6], commonly recognised as the pioneer of automation, filed a patent for his

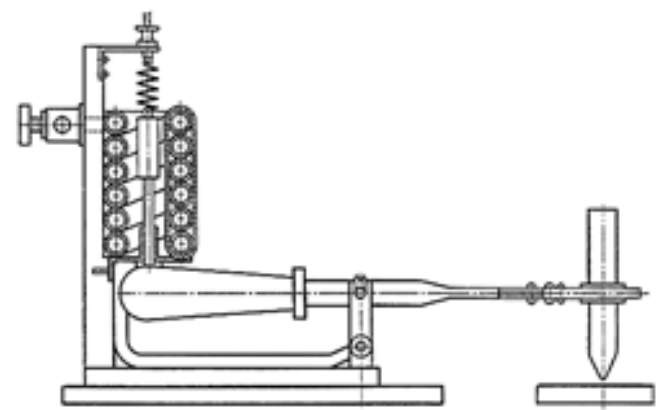
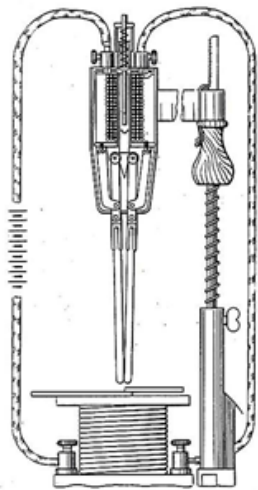


Fig. 1. N. Benardos' arc welding machine featuring automatic arc control [1]

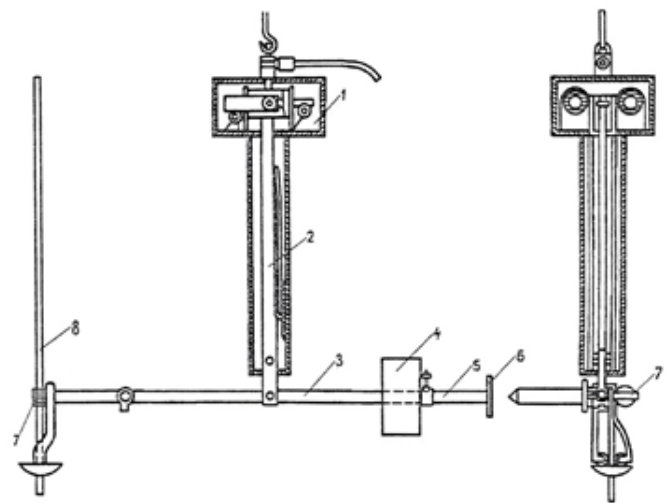


Fig. 2. Schematic diagram of Slavyanov's semiautomatic gas metal arc welding machine [1]

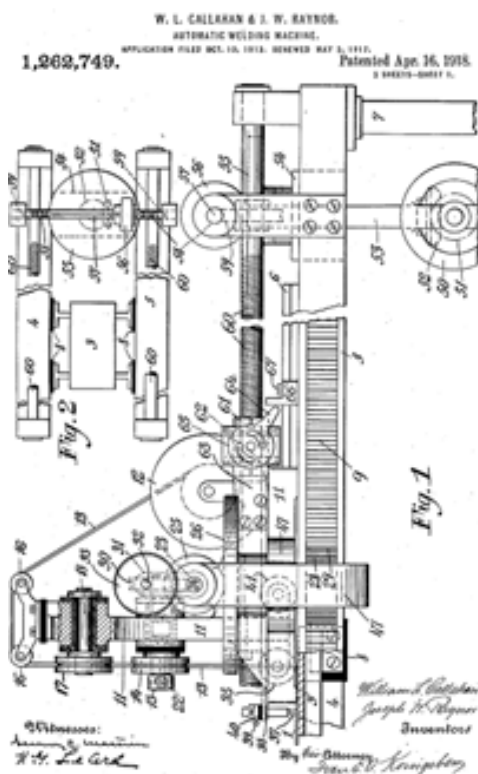


Fig. 3. Automatic welding machine developed by W.L. Callahan and J.W. Raynor; patent no. 1.262.749, 5 V 1917 [4]

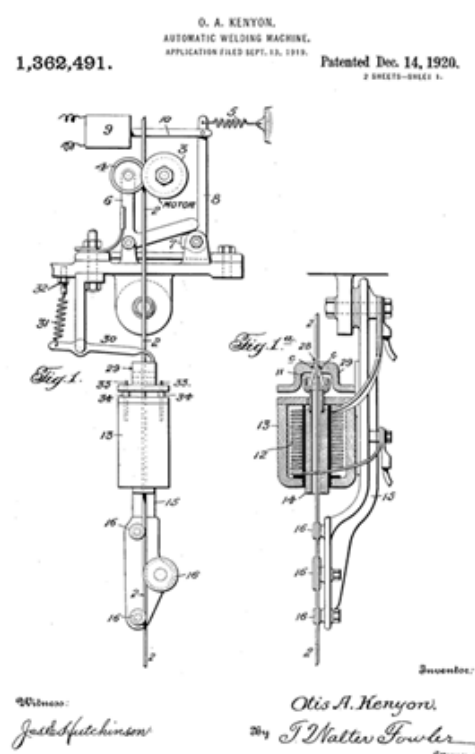


Fig. 4. Automatic welding machine developed by O. Kenyon; patent no. 1.362,491, 14.12.1920 [5]

gas metal arc welding machine in July 1921 and received related patent no. 1.508.711 three years later (Fig. 5) [7]. In the aforesaid welding machine, arc voltage was used to control the DC powered feeding of the electrode wire.

In the same year, in the Soviet Union, Dymitr A. Dulchevsky presented an arc welding machine featuring the automatic feeding of the wire. In 1925, D. A. Dulchevsky presented a machine enabling the automatic adjustment of arc and the feeding of the electrode (Fig. 6) [2, 8]. The above-named automatic welding machine was primarily used in railway applications (for surfacing).

The automatic welding machine developed by D.A. Dulchevsky was powered by a three-phase motor (900 rpm). In relation to the normal length of arc, the effect of spring (12) and that of electromagnet (13) were counterbalanced and lever (11) adopted a position corresponding to the position of clamping ring (5). The above-presented case did not trigger the feeding of the electrode. When the welding circuit was open, the voltage of the idle state of the generator was higher than the normal voltage of arc and electromagnet (13) attracted the lever more intensively than spring (12). The right end of the lever lifted, the axis of clamping ring (5) moved downwards and the feeding of the electrode (leading to the shortening of arc) was initiated. During the short closure of the circuit of electromagnet (13), welding arc connected in parallel was nearly inactive. Spring (12) made the right end of lever (11) move downwards, the axis of clamping ring (5) moved upwards and the lifting of the electrode (leading to the extension of arc) was initiated. The electrode feeding rate was adjusted through changes in eccentricity. An increase in eccentricity was accompanied by an increase in the electrode feeding rate. Likewise, a decrease in eccentricity was accompanied by a decrease in the electrode feeding rate [8]. At the turn of the 1930s, the electrode was fed to the welding zone using an automatic head (Fig. 7) [1].

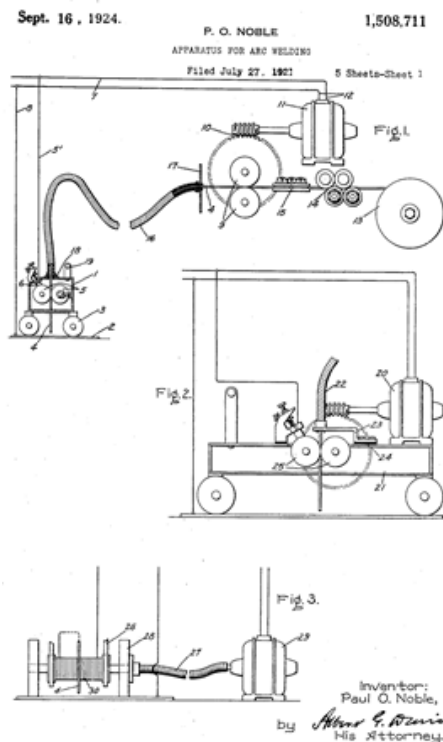


Fig. 5. Automatic welding machine developed by P. O. Noble; patent no. 1.508.711, 16.11.1924 [7]

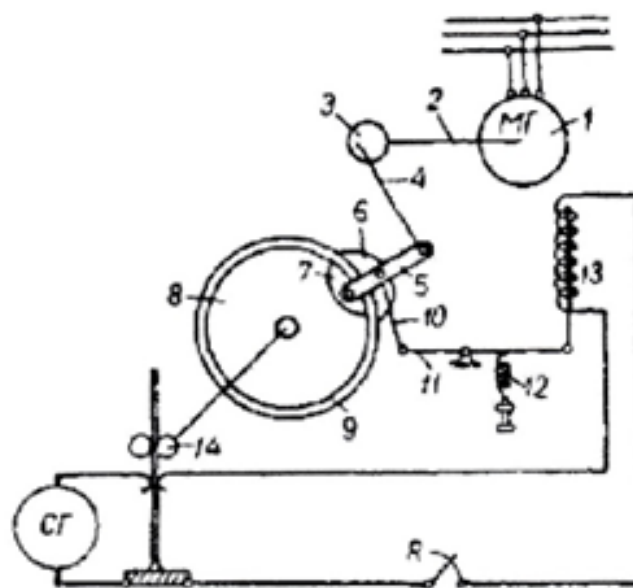


Fig. 6. Automatic welding machine developed by D.A. Dulchevsky [8]

Designs of welding heads depended on types of electrodes (Fig. 8) [9]. Heads used in machines provided by Polski Przemysł Elektryczny "ELIN" (Polish Electric Industry) enabled the use of carbon electrodes, diameters of which were restricted within the range of 8 mm to 15 mm, metal electrodes, whose diameters were

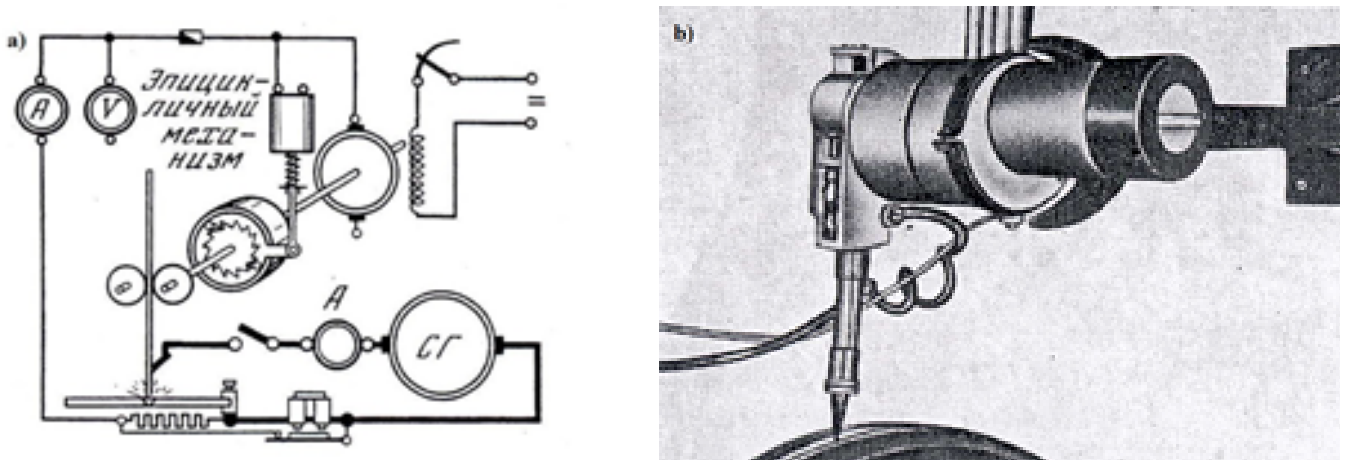


Fig. 7. Automatic welding head: a) schematic diagram, b) main view [1]

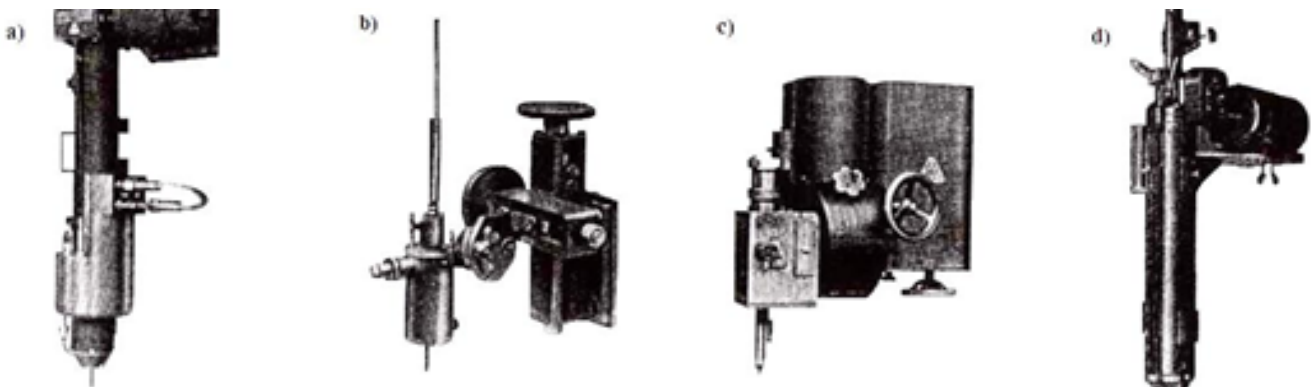


Fig. 8. Welding heads [9], a – automatic welding head, b – semiautomatic welding head, c – welding head for uncovered electrodes, e – welding head for covered electrodes

restricted within the range of 3 mm to 6 mm and covered electrodes, diameters of which were restricted within the range of 6 mm to 12 mm [10].

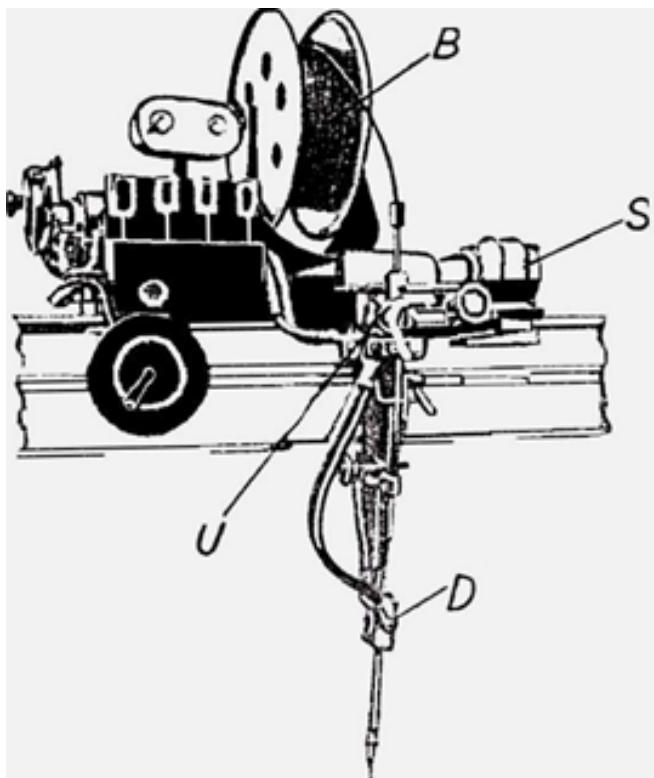


Fig. 9. Automatic electric welding machine [11]

During automatic welding with the wire (Fig. 9), the wire was unwound from drum (B) and passed through torch (U) supplying current to the electrode. The torch was powered by a DC motor (S). The rate of electrode extension from the torch depended on arc voltage and was adjusted so that the length of arc was constant. When head (D), provided with the device unwinding the wire, was moved along the weld, the process was semiautomatic. When the movement of the head was driven mechanically, the welding process was fully automatic [11]. Usually, in automatic welding machines the electrode moved in a rectilinear manner. However, there were also automatic welding machines where a workpiece rotated along its axis and the electrode did not move (i.e. its position was fixed) (Fig. 10) [9]. All of the above-presented solutions were concerned with machines for unshielded arc welding. Welds made using the aforesaid method were characterised by unsatisfactory quality resulting from significant porosity.

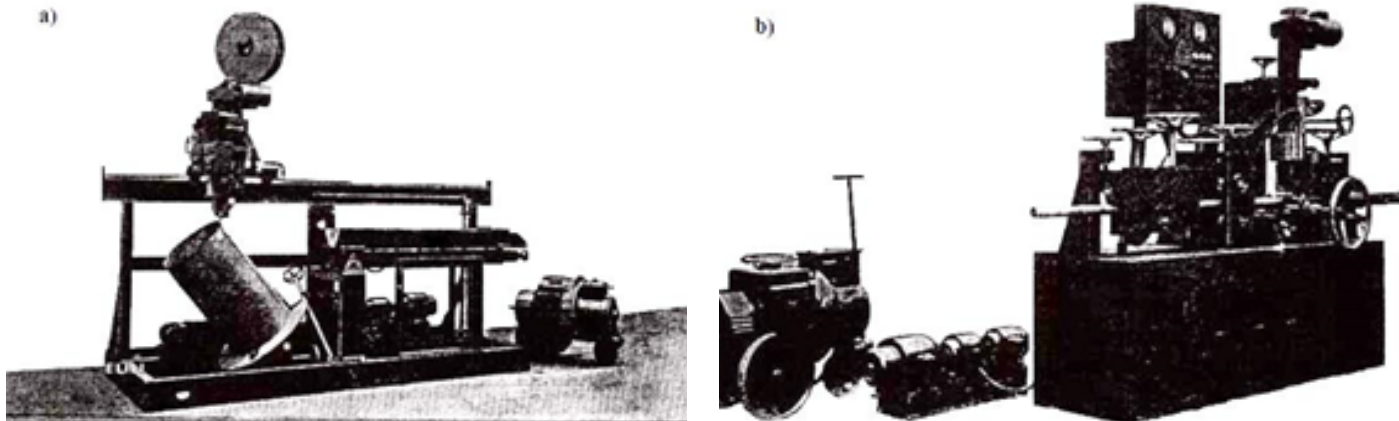


Fig. 10. Automatic welding machines for rectilinear and girth welding (a) and for the welding of tubes (b) [9]

Because of this, D.A. Dulchevsky suggested the shielding of arc and welding area against air access using charcoal, sawdust, soot and starch-based powder [12]. His development was concerned with manual welding and only the early 1940s saw the beginning of the automation of this process [13]. The remaining methods, i.e. metal active gas and metal inert gas welding processes, were developed and implemented subsequently [14].

Presently, welding processes are predominantly mechanised and automated, with many of them being fully robotic.

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