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(54) **METHOD AND DEVICE FOR PROCESSING OF ARTICLES.**

(57) The invention relates to combined methods of processing metal and alloy articles as well as to devices for implementation of these methods. A method for processing articles comprises evacuation of the space between the article (7) and electrodes (3-6) or feeding a working medium between them, as well as generation of an electric discharge in said space. Immediately after the treatment of the article (7) by electric discharge, the article is subjected, additionally, to plastic working, the vacuum or the working medium being maintained in the working zone. Plastic working is effected by rolling, drawing or spinning. A device for implementing the method comprises a chamber (1), an evacuation system (2), electrodes (3-6) located inside the chamber (1) and a power source (8), one output of which is connected to the electrodes (3-6) and the other one to the current leads (9, 10) of the article (7) to be processed. The device further comprises a working organ, for example rollers (13, 14) intended for plastic working of the material of the article and located inside the chamber (1) after the electrodes (3-6) along the technological path, as well as a means for relative movement of the article (7) and the working organ (13, 14). The working organ (13, 14) may, at the same time, serve as the current lead of the article (7) and as an element of the vacuum lock system. The invention can be used in the engineering industry and in metallurgy for finishing or intermediate processing of rolled steel, wire, pipes and other articles, as well as for application of coatings and obtaining multilayer materials.

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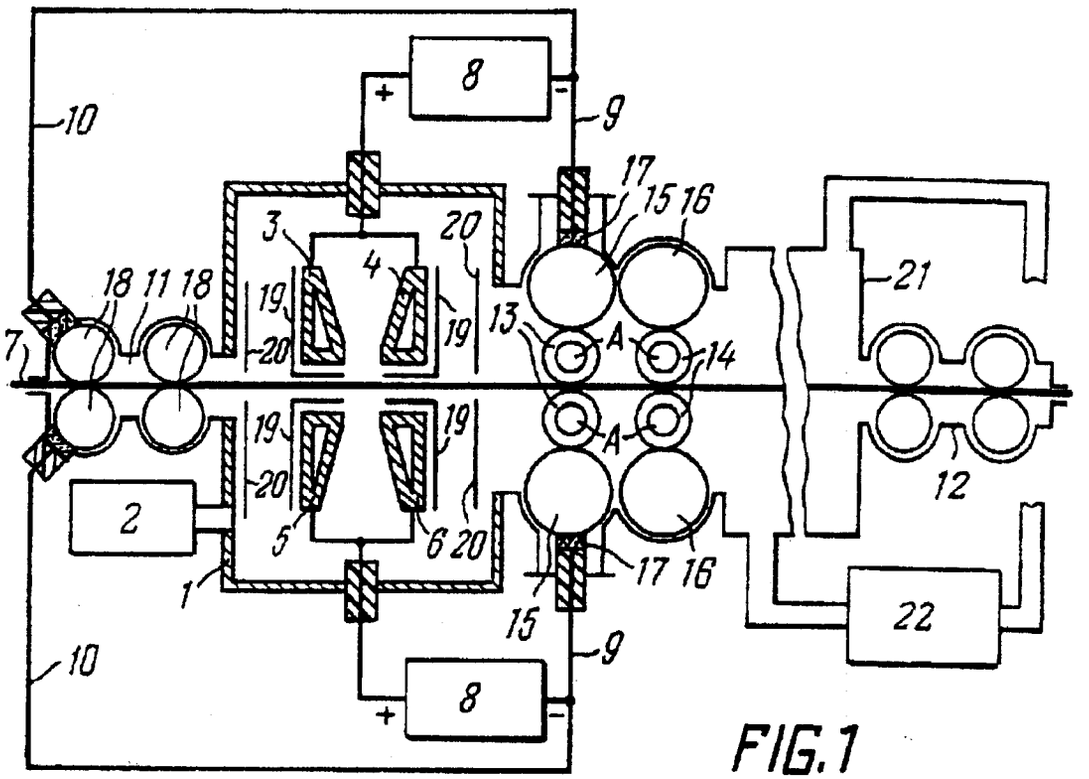
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FIG.1

This invention relates to combined electric discharge machining and mechanical working of metal and alloy articles methods and more particulary to methods of articles processing and also devices for implementation of this methods.

BACKGROUND OF THE INVENTION

At present in industry for manufacturing of steel strips and sheets it is being used a method including the following production operations : hot rolling of blanks, cleaning of rolled stock surface from scale with pickling, cold rolling of grinded strip, annealing, repeated chemical treatment, grinding, polishing and rolling a strip into roll or cutting it by sheets (Nippon Steel Corporation. Stainless steel. Sheet and Strip. Cat. No. EXE 317 - pp.1Ø-11- Japan - 17p. - Feb. 89).

This method allows to produce the high quality articles, but using in it operation of article surface cleaning by means of chemical treatment is leading to environvent contamination and for its implementation it is necessary to use large-scale pickling and rinse bathes, devices for drying of pickled strip and purification works. Moreover, after pickling it is necessary to carry out a mechanical grinding of rolled stock surface for reduce of its roughness, that increse the process labour input.

Recently at the various engineering fields some successfuly began to use the methods of articles machining and particulary cleaning its surface by means of electric discharges.

It is khown the method of articles processing in which subject to processing article is being installed between two electrodes allocated at a chamber and under the reduced pressure there are excited the glow electric discharge between the electrodes. Being into glow discharge the article is being subjected by ion bombardment that lead to cleaning and activation of its surface (USSR Certificate of authorship Nr 322420). This process is being characterized by uniformity of article surface cleaning, but its productiviy is very small owing to low value of coefficient of atomization of materials into glow discharge and besides this it doesn't provide removal the fins from article surface.

From known designs the more similar to applicating invention on engineering meaning and achieving result are the electric discharge machining method and device that paticulary can use for cleaning a surface from scale (Application EP Nr 9Ø3Ø81Ø5.7). The known method consists in that machining article and least one electrode are connected to power supply and in the gap between at least part of article and at least one electrode is created the medium pressure of 1Ø Pa maximum, is excited the arc discharge between article and at least one electrode and said article is being moved relative zone of discharge localization and/or this zone relative article. For different kinds of electric discharge machining there were developed the various techniques of moving of electric arc spots on article.

The device for implementation of this method includes at least one electrode, power supply, one of lead which is connected to at least one electrode and other lead connected to at least one current lead of machining article and/or to at least one other electrode, and means for creating between at least part of article and at least one electrode a low pressure or protective medium.

The replacement in technology of steel strips and sheets production, that has been described in first of above-mentioned analogs, of pickling by electric discharge machining, that is discribed in later of enumerated analogs, allows to provide ecological cleanness of process and reduce the dimensions of applied equipment. But machined by discharge surface has a roughness of R_{max} ~ 2Ø ... 12Ø mkm, that not always can be accepted. Because this in some cases after machining in discharge also, as after pickling, it is necessary to carry out a mechanical grinding of pickled surface, that increase process labour input and power consumption for machining. Moreover, with discharge machining a article is being heated and it is necessary to cool its during long time into protective medium in order to avoid repeated oxidation already cleaned surface, that increase operating cycle and decrease the productivity of used devices of batch-operated or lead to increase of continuous-acting installations dimensions and result of this is increase of power consumption for evacuation of this installations and upkeeping into its the protective medium.

SUMMARY OF THE INVENTION

Accordingly the present invention aims to provide method and device for articles processing in with, owing to use the new combination of various kinds of machining and also new combination of device assemblies and its optimal design, should be achieved the nesessary quality of machined articles, high productivity and ecological cleanness of process.

The arisen problem is being solved in that in method of articles machining, being that at least two electrode or machining article and at least one electrode is connected to power supply and within the gap between at least part of article and at least one electrode it is created a vacuum or working medium, it is excited a electric discharge between electrodes or between at least part of article and at least one electrode and at least part of article is machined by means of this discharge accordingly

the invention, and after the machining of article by means of electric discharge it is made up the additional plastic working of article, or of at least part of article, that was machined with electric discharge.

Accordingly the present invention the article surface heating under the machining by means of electic discharge is used for achievement of first technical positive effect, namely reducing of article material deformation resistance within the zone of its plastic working and providing the necessary ductility. Owing this with joint using of machining operations with dicharge and pressure it is being achieved the second possitive effect, namely multiple reducing of article surface roughtness after working with considerably more low power consumptions for achievement of this effect in comparison with any other operations of surface finishing (mechanical grinding and polishing, electrochemical polishing and so on).

It is worth while to make up the plastic working directly after the article machining by means of electric discharge, that prevent the article cooling between these process operations and intensify the effect of their joint using.

At the same time within the zone of plastic working it is created the vacuum or protective medium that elimimates a interaction with medium of article material heated into process of its machining by means of electric discharge.

It is worth while after the plastic working to make up the repeated machining of article by means of electric discharge. This design is being used particulary if after cleaning from scale it is necessary to get mat surface of working article with more uniform and lesser in size roughtness in comparison with that after primary working. This is being achieved by means of finishing machining of article by electric discharge with lesser values of dischagre current and/or time of machining in comparison with that of primary machining.

It if preferably after the repeated machining of article by eclectric discharge to make out the repeated plastic working of its material. In come cases it provide the achievement of better quality of machined articles in comparison with that of single machining by discharge and by pressure.

In other cases it is worth while to alternate the article machining by means of electric discharge with plastic working of its material. This permit to eliminate the overheating of article into discharge and optimize its material temperature under the plastic working.

It is worth while to make up the plastic working as a rolling. The best results this technique give with working of semifinished items, that was primary produced by rolling, for example, strip or shapes.

In other particular cases of realization of invention it is worth while to make up the plastic working by means of drawing. This technique gives the best result with semifinished items, that has been primary produced by drawing, for example, wire.

In some cases it is preferably to make up the plastic working by revolving around article surface by rollers or small balls. This technique is optimal with working of areas of article surface which is difficult of acces including inner surfaces of hollow articles.

Moreover, accordingly invention the arisen promlem is being solved by that device for making up of method of articles machining, including at least one electrode, power supply, one of leads which is connected to at least to one electrode and other lead is connected to at least one current lead of machining article and/or at least to one other electrode, and means for creation between at least part of article and at least one electrode a vacuum or working medium according invention, is provided with at least one working member for working of article material by pressure, and with means for relative movement of article and at least of one working member for plastic working, and at least one working member for plastic working is allocated along the technological process behing of at least one electrode.

This mutual arrangement of part of applicating device allow under the joint using it with applicating method to work very different articles having both outer and inner working surfaces and with achievement of specified by method positive effect.

It is worth while that means for creation between at least part of article and at least one of electrode a vacuum or working medium should include a chamber connected with system of evacuation or/and feeding of working gas, and at least one electrode should be allocated within chamber or be at least a part of it. This allow to machine within above-mentioned chamber the articles mostly with outer machining surfaces, namely sheets, wire and others.

At the same time at least one working member for plastic working is preferably to make up in a shape of rollers connected with drive. This shape of working member allows after article machining by discharge to make out working of its material by pressure by means of rolling, that is the most advisable under the working of semifinished items, that was produced before this by rolling, for example strip or shapes.

In other particular cases it is preferably that at least one working member for plastic working should be produced in shape of reducing die, allocated in alighment with working article. This allow by the best way to machine accordingly applicating method the semifinished items, that was produced

before this by drawing, for example, wire.

It is preferably that at least one working member for plastic working should be allocated within a chamber, that allow to keep up in zone of plastic working a rare or protective medium and thereby to eliminate an interaction with medium of article heated material.

At the same time an apparatus can be provided at least by one vacuum lock for charge into chamber and dicharge from it the working articles, that allows to make out the working as a continuous or semi-continuous process.

It is preferably that under the working of continuous articles, for example rolling or wire, at least one working member for plastic working should be installed in zone of discharge of article from chamber and simultaneously should be an element of vacuum lock. This allows to simplify the device design owing to decrease a number of its structural elements with making up by the other elements of several functions.

It is worth while that in zone of discharge of article from a chamber should be installed at least two working organs for plastic working and in the gap between wich is created an additional cooling chamber, connected with means for feeding of protective gas. This arrangement allows to effective lower article temperature before discharge into atmosphere and thereby prevent interaction its material with air.

At the same time at least one working member for plastic working simultaneously is an element of current lead of working article and connected to power supply lead. This design allows essentially to simplify the device design owing to elimination or reducing the number of assemblies of current supply to moving article.

It is preferably that at least one working member for working by pressure should have the cavity connected with means for the coolant supply. This allows to cool the working organ effectively and by this to remove heat from working article.

It is possible that at least one working member for plastic working should be fixed on holder having a cavity, connected with means for coolant supply.

This design is being used if owing to any cause it is unsuitable to cool the working member directly, for example, owing to occuring higher wearing it must be quick-changeable and because this cann't be installed stationary.

Under the working of hollow articles it is advisable that at least one electrode and at least one working organ for plastic working should be allocated with a possibility of introducing into article cavity, and means for creation between at least part of article and at least one electrode a vacuum or working medium should be contented the devices for sealing of article cavity and also system for evacuation this cavity or/and feeding to it a working gas. This allows to create a rare or working medium directly within article cavity and to work its inner surface without use of chamber.

With this at least one working member for plastic working can be produced in shape of one or several rollers or/and small balls expanders installed on holder that is mounted with a possibility of rotatory or reciprocal movement into cavity and in alignment with it. That design of working member for plastic working allows uniformly enough to work the inner article surfaces that mainly have a shape of body of revolution.

It is advisable that expanders should be fixed on holder by means of elastic links which create constant pressure of working member against working surface.

Moreover, the device can be provided at least by one additional electrode allocated along the techological path after at least one working member for plastic working. This design is being used particulary if it is necessary to give mat surface of working article by means of finishing working of its surface by discharge, as have been shown above.

It is advisable that device should be provided at least by one additional working member for plastic working allocating along the technological path after at least one additional electrode. With this it is preferably that electrodes and working elements should be installed with alteration along the tecnological process. This allows to eliminate an overheating of article in discharqe and optimize a temperature of its material under the plastic working.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained below by examples with references to the drawings enclosed, in which:

Fig. 1 shows schematically a device for implementation of a method of the article processing according to the invention, including an electric arc cleaning of strip rolled products in vacuum with the subsequent vacuum rolling;

Fig. 2 shows schematically a device for implementation of a method of the article processing according to the invention, including an electric arc vacuum cleaning of sheets with the subsequent rolling and electric arc re-treatment of them;

Fig. 3 shows a device to obtain calibrated strip rolled products by the claimed method, which includes an alternation of the electric arc treatment of rolled products in vacuum with the rolling in vacuum and in a protective medium;

Fig. 4 shows a device for implementation of a method, which includes the electric arc cleaning of wire in a rarefied or protective medium with

the subsequent drawing in a protective medium; Fig. 5 shows a device for implementation of a method, which includes a coat applying to inside surface of pipes in vacuum or in a working medium by the evaporation and/or sputtering in an electric discharge with the subsequent rolling of the processed surface by rollers or small balls.

VARIANTS OF IMPLEMENTATION OF THE INVENTION

Now let's consider in details a structure of claimed devices for the realizing of a proposed method for processing of articles.

The device for processing of articles, made mainly of strip rolled products, comprises a chamber 1 (Fig. 1) connected with an evacuation system 2, cooled or refractory electrodes 3,4 and 5,6 located inside the chamber 1 on opposite sides of a rolled article 7 being processed and connected to positive terminals of a power source 8 for an arc discharge, and vacuum lock systems 11,12 for entering (lock system 11) and withdrawal (lock system 12) of the rolled article 7 into/from the chamber 1, while negative terminals of the power sources 8 are connected to current leads 9,10 of the rolled article to be processed.

The device has also working organs for a pressure treatment of the rolled material 7, which are located inside the chamber 1 along the technolodical path after the electrodes 3-6 and are built in the form of working shafts 13 and 14, which are connected with a drive (is not shown on the drawing) and having cavities A connected to a facility for the cold fluid supply (is not shown on the drawing). There are alto support shafts 15 and 16, which interact with the working shafts 13 and 14 lowering their flexure.

The shafts 13 and 15 simultaneously are the elements of current leads of article being processed and have an electrical connection with the negative terminals of the power sources 8 by means of brushes 17 and the current leads 9. The current leads 10 are intended to equalize electric potential along the article surface during its electric arc treatment, and are connected to shafts 18 of the vacuum lock system 11 similarly the current leads 9. The electrodes 3-6 are partly fenced with neutral screens 19, which are intended to confine an arc dicharge on the working surfaces of these electrodes 3-6 and on processed parts of the article 7 in the areas between the electrodes 3 and 4 as well between the electrodes 5 and 6. Screens 20 which prevent the shafts 13, 15 and 18 from dusting by erosion products of arc discharge treatment of the rolled article 7, are located inside the chamber 1 between the electrodes 3-6 and said shafts 13, 15 and 18.

The shafts 13-16 are placed in a zone of output of the article 7 from the chamber 1 and are concurrently elements of the vacuum lock system, which isolates the chamber 1 from a gas cooling chamber 21 connected to unit 22 supplying a cold protective gas.

By the use of the described device, the invented method for processing of articles is implemented in the following way.

Leading end of the rolled article 7 is inserted into the chamber 1 through the vacuum lock system 11, is pulled between the electrodes 3,4 and 5,6 and between the shafts 13 and 14 into the gas cooling chamber 21, is withdrawn from this chamber through the vacuum lock system 12 and is fastened at a tractive drum (is not shown on the drawing). This tractive drum and the shafts 13,14 carry out movement and tension of rolled article in the chambers 1 and 21. The chamber 1 is pumped down by the use of system 2 to a vacuum of 10 Pa or lower. The chamber 21 is concurrently pumped down with the help of an auxiliary pump (is not shown on the drawing), after which a protective gas is carryed into the chamber 21. Circulation of protective gas and its cooling outside the chamber 21 are maintained.

Then the article 7 and the electrodes 3-6 are connected to the power sources 8, and an arc discharge between the article 7 and the electrodes 3,4 and 5,6 is excited. Excitation of the arc is carryed out by any familiar method, for example, by a breaking of contact between the rolled article 7 and auxiliary lighting electrodes placed on both sides of the article 7 (are not shown on the drawing).

Concurrently with an arc excitation, drives of the working shafts 13,14 and tractive drum are started, moving the article continuously from one zone of treatment to other. In doing so and directly after the treatment by an arc discharge, a reduction of the rolled product 7 by the cooled shafts 13,14 is carried out. Then the article is cooled in the chamber 21, is withdrawn from it through the vacuum lock system 12 and is reeled in a roll or is passed to subsequent working.

Under the burning of arc discharge upon the surface of rolled product 7 during its treatment, the cathodic arc spots move on sections between electrodes 3 and 4 on one side of rolled product 7, and between electrodes 5 and 6 on its other side; the temperature withinside of these spots reaches 3000-5000 degrees Celsium. The speed of their movement makes 0,01 to 100 m/sec, and depends on physics-chemical properties of scale material and pollutions of rolled product surface. Cathodic arc spots remove the scale and pollutions from their trajectory, bringing the surface by this way to

perfect purification from scale, but the roughness of surface is increased as a result of such treatment.

During electric arc treatment the rolled product 7 is heateg, and most heated parts of it are the surface microbulges. Therefore under reduction of jast processed by the arc of rolled product 7, in the area between shafts 13 and 14 with a size about Rmax (under one-side purification), or with a doubled size of Rmax (under two-side purification), the plastic deformation is derived mainly for microbulges material bringing to versatile decreasing of roughness of a surface being processed.

Bigger rate of reduction brings to usual rolling, but there are good possibilities for useful utilization of heat being released under electric arc treatment as well to avoid the oxidation of a surface being processed, and to reach by this way the high quality of rollled product having been treated.

The device, shown on Fig. 2, differs from that, shown on Fig. 1, in that its working chamber body consists of two parts being 23 and 24 isolated each from other. The part 23 of a chamber body at the same time is an electrode (anode) for treatment of sheet 25 by an arc dicharge under low preassure; this part is electrically connected with positive terminal of power source 26 and made to be cooled (is not shown on the drawing). Power source 26 is supplied with contactless programmed switch of positive terminals which is connected to current leads 27 and 28 of a sheet 25 being processed. It is possible to use the contactless switch being described in the upper pointed claim EP No. 9O308105.7.

Following electrode 23 which is a part of working chamber body, other part 24 of this body placed along the technological path, has working shafts 29, 30 interacting with support shafts 31 and 32, as well the additional electrodes 33,34 and 35,36. Electrodes 33-36 are connected to positive terminals of power sources 37 and intended for charge retreatment of sheet 38, which has been subjected to a plastic working by shafts 29 and 30.

The device has also the vacuum lock systems putting in operation the chambers 39 and 40 for loading of untreated and accordingly unloading of treated sheets; these chambers have storage elements 41 and 42 for sheets. Chambers 39 and 40 are separated from parts 23 and 24 of working chamber by means of locks 43 and 44, and supplied with individual evaluation systems 45 and 46. Chamber 39 has the mechanisms 47,48 for transferance of untreated sheets from storage element 41 to loading position and mechanism 49 for sheet inserting into the working chamber 23,24; chamber 40 has a mechanism 50 for sheet unloading from chambers 23,24 as well the mechanisms 51,52 for moving of treated sheets to storage element 42.

There are also the means for moving of sheets being processed relatively shafts 29 and 30. These means consist of rollers 53,54 and 55 connected with drivers (are not shown on the drawing), which are concurrently the elements of current leads of sheets being treated 25,38.

Due to the usage of this device, the invented method is realized by the following way.

Untreated sheets are loaded into storage element 41 of chamber 39, this chamber is sealed and pumped out to preassure below 10 Pa by means a system 45, after that the vacuum lock 43 is opened and chamber 39 is connected to the working chamber 23,24 where the technological vacuum is continuously maintained due to a system 2. Then one of sheets is transfered to a loading position by mechanisms 47,48 and with the help of mechanism 49 said sheet is inserted to the zone of electric arc machining inside the part 23 of working chamber.

Then a power source 26 is switched on and an arc dicharge is excited between a sheet 25 and the part 23 of a working chamber body, and cathode spots are positively moved forth-and-back along the sheet 25 according to the given program by switching negative terminals of power source 26. These terminals are connected with conductive rollers 53 and 54 by means of current leads 27 and 28. Due to the positevely movement of cathod spots, the uniform clearing of whole sheet surface is ensured without its moving.

Immediately after ending of clearing process the source 2 is turned off, and drives of rollers 53, 54, 55 as well working shafts 29,30 are turned on. The cleaned sheet is moved to shifts 29,30, is catched and reduced by them in the same manner as it was described before.

After going out of shafts 29,30 the sheet 38 comes to a zone of electrodes 33-36. Just in that moment a power source 37 is turned on and an arc discharge is excited between sheet 38 and electrodes 33,34 and 35.36. A current value of this discharge and/or a processing time are chosen in several times less then they were in clearing process of sheet 25, that obtain uniform mat surface with low roughness in cojunction with smoothing of microunevenness by shafts 29,30.

Specifically, in case of cleaning of stainless steel of class 304 with a of scale about 10 mkm, a power consumption for scaling averages 5-8 kwt hour/sq m and for dulling makes about 0,2-0,4 kwt hour/sq m. A roughness of surf ace after primary electric arc treatment (cleaning) averages 20-120 mkm, and after consequent plastic working and second arc treatment it makes about 1,25-6,3 mkm.

The sheet 38, processed in the second arc discharge, is transfered by means of rollers 55 and mechanism 50 to chamber 40, which is pumped

out with the help of a system 46, and then by means of mechanisms 51,52 this sheet is transfered to storage element 42, where it gets cold.

After the treatment of all sheets and collecting them in storage element 41, the vacuum locks 43 and 44 are closed, processed sheets are withdrawn from chamber 40 and new batch of untreated sheets is loaded into the chamber 39, after that a cycle is repeated.

The device, shown on Fig. 3, differs from other devices described above in that it is supplied with two additional working organs for plasric working of rolled material 7, these working organs are placed along the technological path after additional electrodes 33-36 and are made as working shafts 56 and 57, connected with a drive (is not shown on the drawings).

Shafts 56 together with support shafts 58 are installed in output zone of rolled article 7 from a chamber 59, and at the same time they are the elements of vacuum lock system, which separates chamber 59 from a gas cooling chamber 60, and shafts 57 together with support shafts 61,62 concurrently are the elements of vacuum lock system, which separates chamber 60 from the atmosphere.

With the help of this device a claimed method can be realized by the following way.

Rolled product 7 to be processed goes through vacuum lock system into a chamber 59, where it is processed by both the arc discharge with the help of electrodes 3-6 and by a plastic working with the help of shafts 29,30, as it was described in the first example. Than the rolled product is repeatedly rpocessed by the arc discharge with the help of electrodes 33-36 and by a plastic working with the help of shafts 56, and after that it is cooled in chamber 60 and calibrated by means of a shaft 57.

Such technical decision allows to rise a productivity of process owing to work at higher values of arc current and faster moving of a strip, keeping a strip out of overheating during the treatment in discharge. The possibility to vary the values of current of the first and the second discharge allows to optimize the temperature of rolled product 7 in zone of a plastic working and to rise a quality of processing.

The device, shown on Fig. 4, is intended for the treatment of wire 63 and differs from described before in that electrodes 64 and 65 are made as truncated cones, faced each to other by their lesses bases. Neutral screens 66, 67 and 68 are intended to confine an arc discharge on working surfaces of electrodes 64,65 and on a section of wire being processed between the screens 66 and 67.

The working organ for the plastic working of wire is made as a die 69, placed in line with a wire 63 along the technological path after the electrode 65. A holder 70 of this die 69 has cavity B, connected with the unit for the cooling fluid supply (is not shown on the drawing).

The die 69 is installed in a wire output zone from a chamber 71 and in the same time is an element of vacuum lock system, which separates the chamber 71 from a gas cooling chamber 72.

A calibrating die 73 is fastened an a cooled holder 74 and is an element of vacuum lock system, which separates a gas cooling chamber 72 from the atmosphere.

Another vacuum lock system is joined to a chamber 71 and is intended to insert a wire 63 to be processed into the chamber 71. This vacuum lock system is connected to vacuum pump 76 and contains a chamber 75, which has a calibrating dies placed in line each to other. Current leads of a wire 63 being processed have elements 77 and 78, connected to a holder 70 of the die 69 as well to the chamber 75 and to a spring-loaded brush 79.

The means for moving of a wire relatively the dies 69,73 and the electrodes 64,65 have a tractive drum 80 connected with a drive (is not shown on the drawing) as well with a reeling drum 81.

With the help of this device a claimed method is realized by the following way.

Leading end of wire 63 to be processed is sharpened and inserted into a chamber 71 through calibrated openings of a chamber 75, diameter of which is equal to diameter of untreated wire. Than this leading end is pulled through screens 66-68 and through an opening in the die 69, is inserted into a gas cooling chamber 72, is withdrawn from it through an opening in a die 73 and is fastened on a tractive drum 80. Then the chambers 71 and 75 are pumped down by means of the system 2 and vacuun pump 76, and with the help of unit 22 a protective gas is supplied into a chamber 72, providing circulation of gas and cooling of it, as it was described above. A brush 79 is connected to a wire 63, and a good electric contact between them is obtained by a spring, which is not shown on the drawing.

After this a drive of the tractive drum 80 is switched on and concurrently an arc discharge is excited between electrodes 64, 65 and an area of wire 63 being processed and placed between screens 66 and 67. Cathode spots of an arc move chaotically along a perimeter of a working part of wire and descale it. A velocity of clearing is controled by changing a current of arc discharge or by placing the additional number of working electrode units inside a chamber. Pulling a wire 63 through an electrode unit with a velocity, which corresponds to the clearing velocity, maintains an uniform clearing of wire along both its perimeter and length.

Immediately after an arc treatment of wire 63 it is reduced by a cooled die 69, and as a result of that a multiple decrease in a roughness of wire is reached. Then wire is cooled in a chamber 72 and is withdrawn from it through the opening of calibrating die 73, which gives to wire both accurate dimensions and shape. Processed wire 63 is reeled to a tractive drum 80.

The device, shown on the Fig. 5, has a hollow expendable cylindrical electrode 82 made of coating material and connected to the negative terminal of a power source 8, and two ring-shaped electrodes 83 and 84 connected to the positive terminal of said power source. Solenoids 85,86 ire placed inside she electrode 82 and are intended for creation of magnetic field, which confines a discharge on the exterior surface of the electrode 82, and in case of arc discharge moves cathode spots of the arc along said surface. Electrodes 82-84 and solenoids 85,86 are fastened on a holder 87 which is mounted with a possibility to be inserted into a cavity of article 88 being processed as well a possibility to create rotatory and/or reciprocation movement relative to the article 88 and in line with it (the law of movement is defined depending on the requirements to treatment). Rollers 90 are mounted on the same holder 87 by means of elastic members 89 and are intended for the plastic working of coating material which is applied to inside surface of article 88 by means of electric dicharge (it is possible to use small balls or small balls in combination with rollers).

There are also facilities for sealing of a cavity of an article 88 being processed, which consist of covers 91,92 and gasket 93, placed between the covers 91,92 and the article 88. The covers 91,92 are made hollow far the entry of rollers 90 and electrodes 82-84 at extreme positions of the holder 87. An isolated lead-in 94 of a holder 87 is need for sealing of the holder during its movements, and a system 95 is intended to pump out a cavity of an article 88 in the process of coat applying by means of evaporation in an electric arc or to create in this cavity a rarefied working gas medium in case of coating with the help of cathode or magnetron dispersion.

By the use of this device an invented method is implemented in the following way.

Article 88 to be processed, for example, a pipe is sealed by the covers 91,92 and gaskets 93. Then with the help of a system 95 and depending on a chosen method of coat applying, vacuum or a working medium is created in a cavity of the article 88 to be processed.

Then electrodes 82 and 83,84 are connected to power source 8, and an arc or glow discharge is excited between electrode 82 and electrodes 83,84 in the process of coating by the electric arc evaporation or cathode or magnetron dispersion accordingly. As a result of discharge, evaporation and/or dispersion of material of the electrode 82 to inside surface of an article 88 and bombardment of this surface by charged particles are carried out. When a heating of article 88 being processed is necessary, this article is connected to the positive terminal of power source 8 (is not shown on the drawing), and as a result of that, a part of dicharge current flows to the article 88 and it is heated by an intensive ion bombardment.

Rotatory and/or reciprocating movement of electrodes 82-82 is carried out by means of a holder 87, owing to which a coating applies uniformly to whole surface of the article 88.

Immediately after applying a coat and keeping both the temperature and plasticity of condensate out of lowering, the plastic working of this material is carried out by the rolling of coating with rollers or small balls. Rolling is implemented by means of the same holder 87, on which rollers/balls 90 are mounted near the electrodes 82-84, and a preassure is created by means of elastic members 89. As a result of this, the porosity and roughness of coat are decreased and a strength of coat as well a corrosion stability of some materials are increased.

Since plasma-chemical reactions of direct synthesis go in a discharge in gas medium, then there is a possibility to obtain coats with a complex structure (oxides, nitrides and so on) using various working mediums.

Use of the proposed method and device for descaling of articles allows (in comparison with existing methods) to reduce a surface roughness of processed articles by a factor of at least 10 and to decrease a power consumption for finishing of this surface by grinding and polishing to obtain a marketable appearance.

Dulling of article surface in a re-processing by electric discharge after plastic working, according to the claimed method, allows to increase the strength and adhesion of coatings applied to this surface.

Use of claimed technical decisions in the process of applying coats in an electric discharge allows to improve the coat material properties by means of lowering of porosity, increase in homogeneity and in strength, improvement of appearance, as well increase in corrosion stability in some cases.

Functional possibilities of claimed technical decisions are not limited by the described examples, because to implement this method not only vacuum arc And glow discharge can be used, but also other kinds of electric discharhes (for example spark discharge, electric arc in protective gases, and so on) can be used too.

In this case there is a possibility to solve different technical tasks connected with an electric discharge machining. For example, a plastic working immediately after action of an electric discharge allows to increase an accuracy of an electric spark treatment or to improve quality of welded joints by a reduction of porosity of weld material and deformations after welding.

Clearing and heating of surface of semifinished items for example, rolled products made of various materials, with the help of electric discharge, jointing then cleaned surfaces and carrying out a plastic working of this multilayer half-finished product, for example, by a joint rolling, it is possible to obtain high-quality bi-metal and other multilayer composit materials.

Listed advantages of the proposed invention allow to use it successfully in various fields of engineering, where an electric discharge technology is already applied, and to expand application of this technology.

INDUSTRIAL APPLICABILITY

This invention can be used in the engineering industry and in metallurgy for finishing or intermediate processing of rolled steel, wire, pipes and other articles as well for application of coatings with lesser porosity and obtaining multilayer composite materials.

Claims

1. The method for processing of articles which is implied that at least two electrodes (82, 83, 84), or the article being processed (7, 25, 69) and at least one electrode (3, 4, 5, 6, 23, 24, 64, 65) are connected to power source (8, 26), the vacuum or working medium is created in the gap between at least a part of article (7, 25, 63, 88) and at least one electrode (3, 4, 5, 6, 23, 64, 65, 82, 83 ,84), and the electrical discharge is excited between the electrodes (82, 83, 84) or between at least a part of article (7, 25, 63) and at least one electrode (3, 4, 5, 6, 23, 64 ,65), and at least a part of the article (7, 25, 63, 88) is processed by means ofthis discharge, differing in that after processing the article (7, 25, 63, 88) by the electrical discharge the additional plastic working of the article's material (25, 88) or at least a part of the article (7, 63) which has been processed by the electrical dicharge, is carried out.

2. The method according to the p.1, differing in that the plastic working is carried out at once after the electrical discharge treatment.

3. The method according to the p.1, differing in that a vacuum or protective medium is created in the zone of plastic working.

4. The method according to the p.1, differing in that the electrical discharge re-treratment is carried out after plastic working

5. The method according to the p.4, differing in that pressure re-treatment of the article's material is carried out after electrical discharge treatment.

6. The method according to the p.1, differing in that an electrical discharge treatment is alternated by a plastic working

7. The method according to the p.1, differing in that a plastic working is carried out by rolling.

8. The method according to the p.1, differing in that a plastic working is carried out by a drawing.

9. The method according to the p.1, differing in that a plastic working is carried out by a revolution around a surface with rollers and/or small balls.

10. The device for implementation of the method for processing of articles according to the p.1, containing at least one electrode (3, 4, 5, 6, 23, 64, 65, 82, 83, 84), power source (8, 26), one terminal of which is connected with it least one electrode (3, 4, 5, 6, 23, 64, 65, 82)and other terminal of which is connected with at least one current lead (9, 10, 27, 28, 77, 78) of the article being processed (7, 25, 63) and/or with at least one other electrode (83, 84), and ways for creation of vacuum or a working medium between at least a part of article (7, 25, 63, 88) and at least one electrode (3, 4, 5, 6, 23, 64, 65, 82, 83, 84), differing in that it is provided with at least one working organ (13, 14, 29, 30, 69, 90) for the plastic working of article's material (7, 25, 38, 63, 88) and ways (53, 54, 55, 80, 81, 87) for relative article moving (7, 25, 38, 63, 88) and at least one working organ (13, 14, 29, 30, 69, 90) for the plastic working, and the working organ (13, 14, 29, 30, 69, 90) is placed along the technological path after at least one electrode (3, 4, 5, 6, 23, 64, 65, 82, 83, 84).

11. The device according to the p.10, differing in that the means for creation of vacuum or a working medium between at least a part of an article (7, 25, 63) and at least one electrode (3,

4, 5, 6, 23, 64, 65) contain a chamber (1, 59, 71) connected with the working gas pump out and/or feed system (2), and at least one electrode (3, 4, 5, 6, 64, 65) is placed inside the chamber (1; 59, 71) or is at least a part of it (23).

12. The device according to the p.10 or p.11, differing in that at least one working organ for the plastic working is made as the shafts (13, 14, 29, 30) connected with a drive.

13. The device according to the p.10 or p.11, differing in that at least one working organ for the plastic working is made as a die (69) placed in line with an article being processed (63).

14. The device according to the p.11, differing in that at least one working organ (13, 14, 29, 30, 69) for the plastic working is placed inside the chamber (1, 59, 71).

15. The device according to the p.11, differing in that it is supplied with at least one vacuum lock system (11, 12, 39, 40, 75) for the loading of the articles being processed (7, 25, 38, 63) in the chamber (1, 59, 71) and for the unloading from it.

16. The device according to the p.15, differing in that under the processing of continuous articles, for example, rolled products (7) or wire (63), at least one working organ (13, 14, 56, 59) for the plastic working is installed in the article's (7, 63) exit zone of a chamber (1, 59, 71) and simultaneously is an element of the vacuum lock system.

17. The device according to the p.16, differing in that at least two working organs (56, 57, 69, 73) for the plastic working are installed in the article's exit zone of a chamber, and an additional cooling chamber (60, 72), connected to the means (22) for a protective gas feeding, is made between the said working organs.

18. The device according to the p.10, differing in that at least one working organ (13, 29, 30, 69) for the plastic working simultaneously is an element of a current lead of the article (7, 38, 63) being processed and connected to terminals of power souce (8, 37).

19. The device according to the p.10, differing in that at least one working organ (13, 14) for the plastic working has a cavity (A) connected to the means for the cooling fluid feeding.

20. The device according to the p.10, differing in that it least one working organ (69) for the plastic working is fastened an the holder (70), which has a cavity (B) connected to the means for the cooling fluid feeding.

21. The device according to the p.10, differing in that under processing of hollow articles (88) at least one electrode (82, 83, 84) and at least one working organ (90) for the plastic working are placed with a possibility of entering into the article's cavity (88), and means for creation of vacuum or a working medium between at least a part of article (88) and at least one electrode (82, 83, 84) contains facilities (91, 92, 93) for a hermetic sealing of the article's cavity (88) and a system (95) for pumping out this cavity and/or for feeding a cooling gas into it.

22. The device according to the p.21, differing in that at least one working organ for the plastic working is made as one or several rollers and/or small balls (90) fastened an the holder (87), which is mounted with a possibility of rotatory and/or reciprocating movement in the cavity (88) of an article and in line with it.

23. The device according to the p.22, differing in that rollers and/or small balls (90) are fastened an a holder (87) by means of elastic members (89).

24. The device according to the p.10, differing in that it ii supplied with at least one additional electrode (33, 34, 35, 36) placed along the technological path at least after one working organ (29, 30) for the plastic working.

25. The device according to the p.24, differing in that it is supplied with at least one additional working organ (56, 57) for the plastic working, placed along the technological path after at least one additional electrode (33, 34, 35, 36).

26. The device according to the p.10, differing in that the electrodes (3, 4, 5, 6 and 33, 34, 35, 36) and working organs (29, 30 and 56, 57) for the plastic working are installed in an alternating order along the technological path.

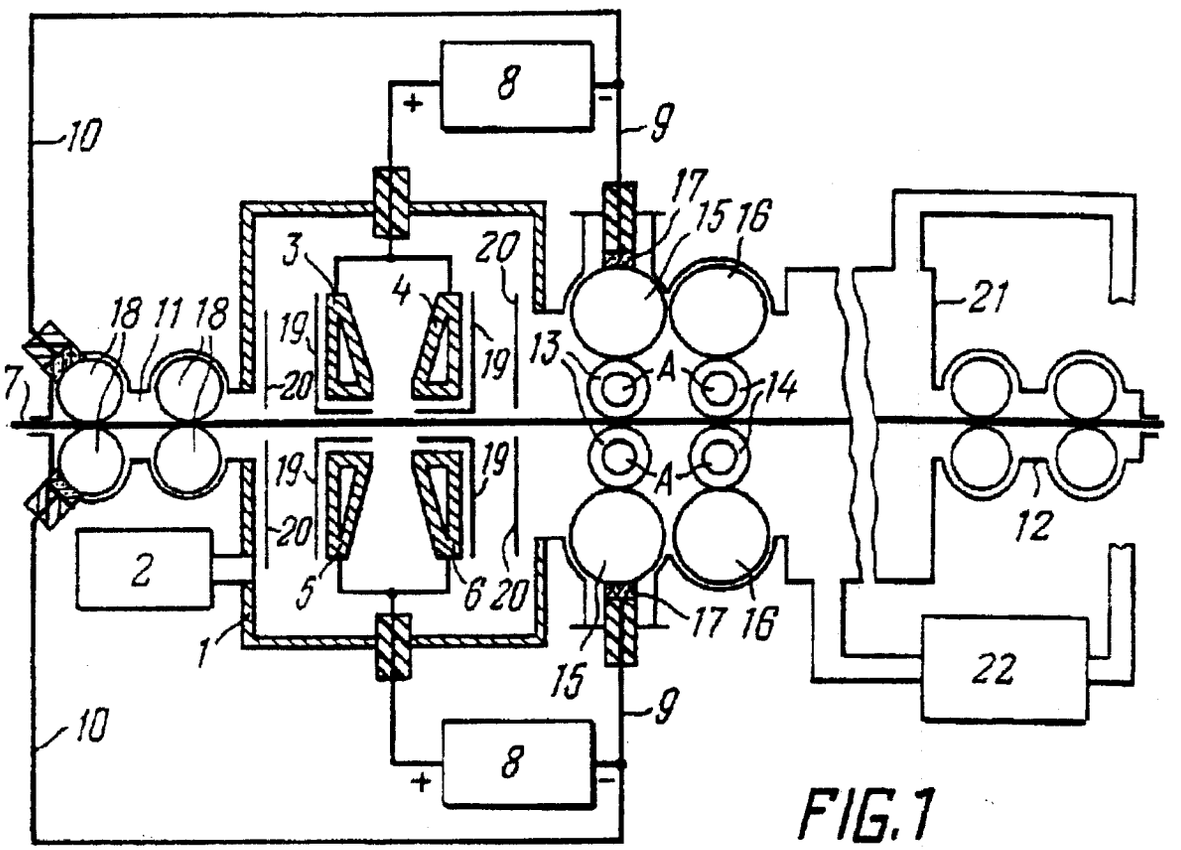
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FIG.1

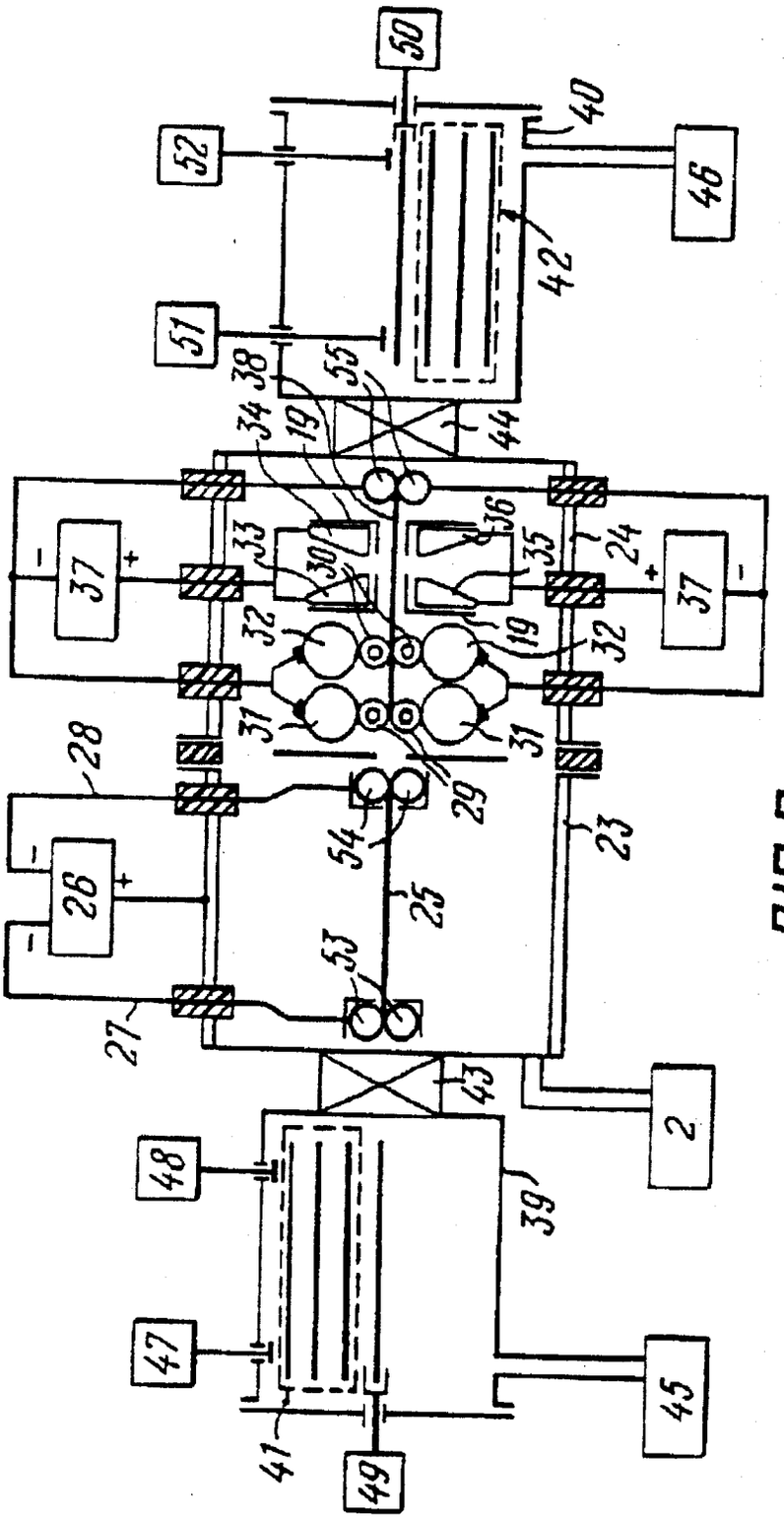
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FIG.2

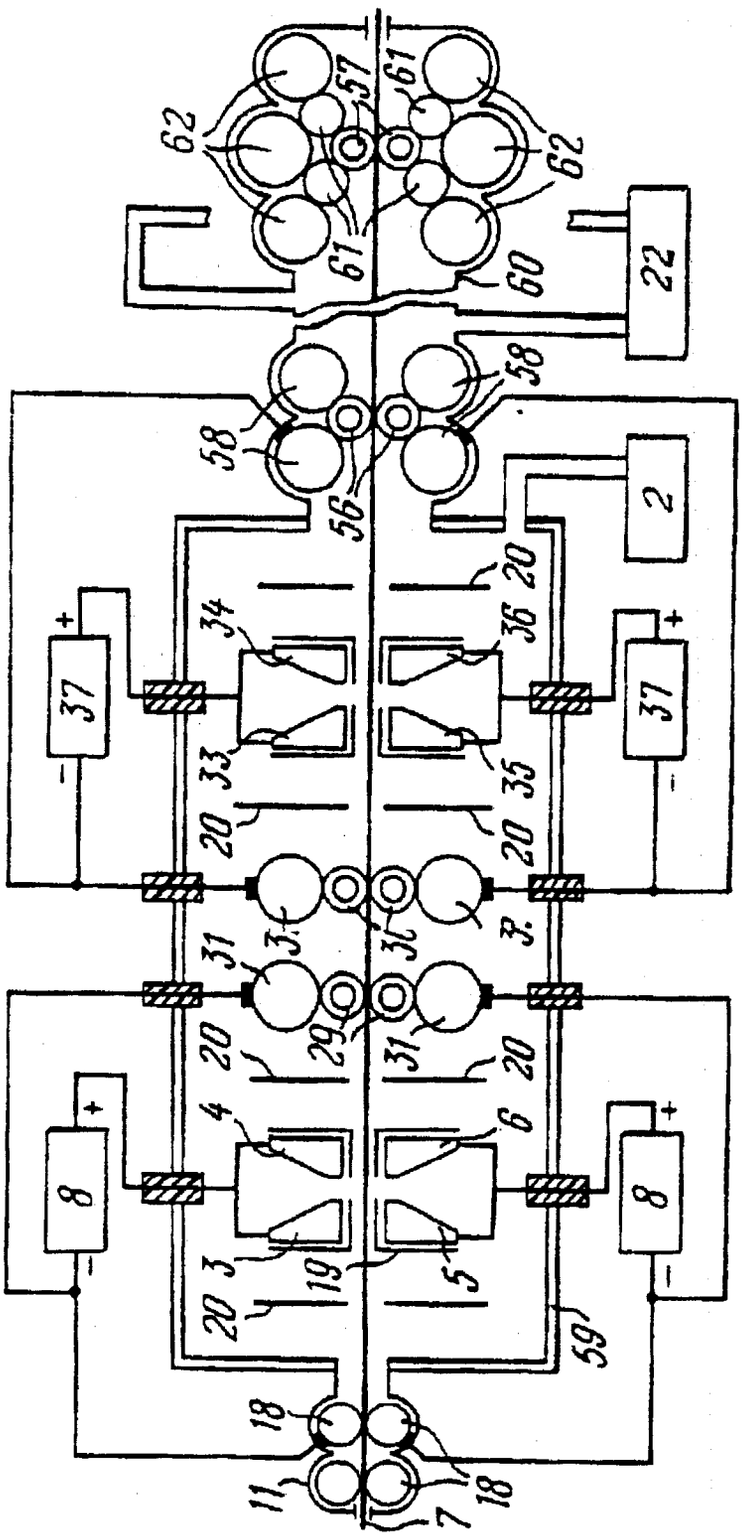
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FIG. 3

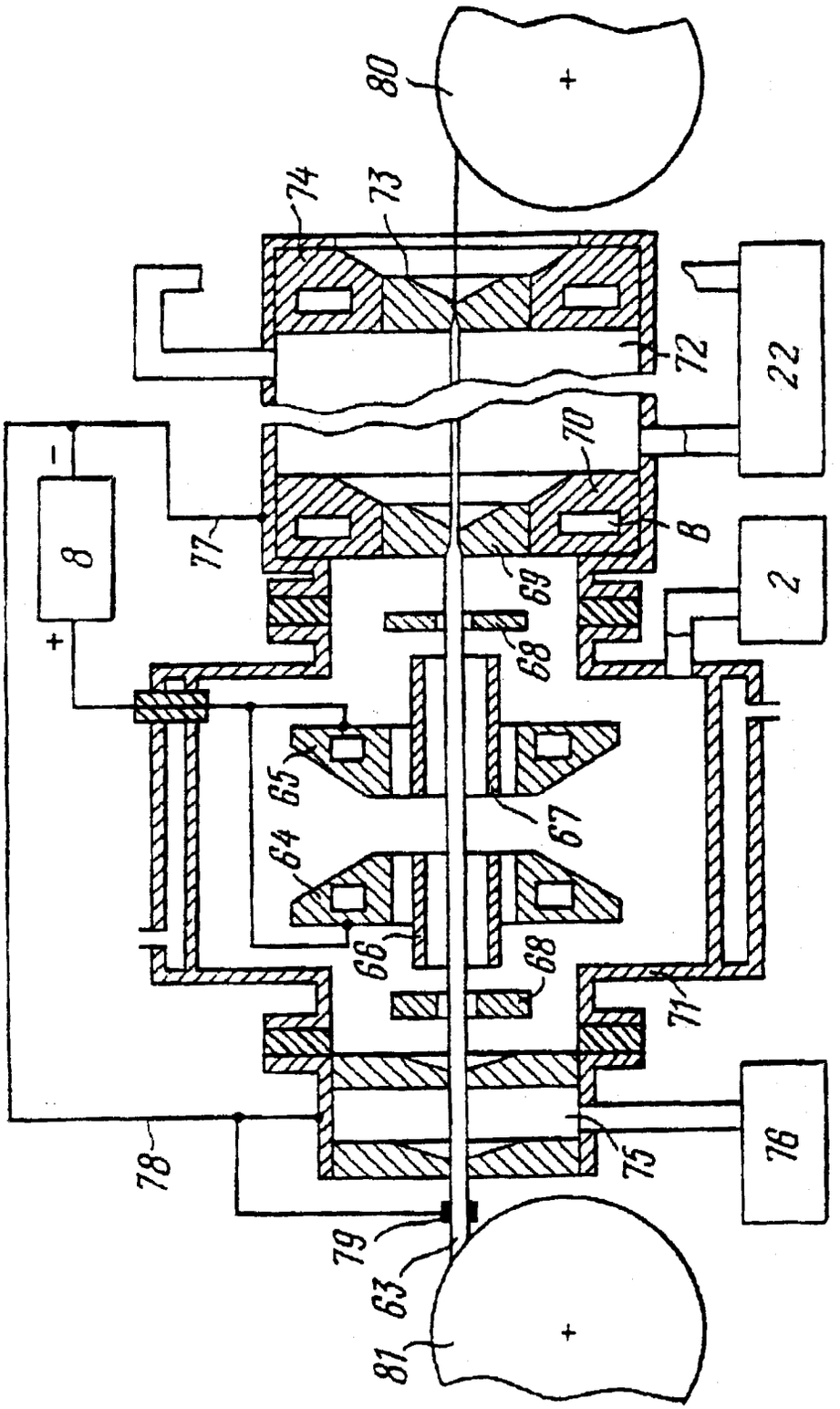

FIG. 4

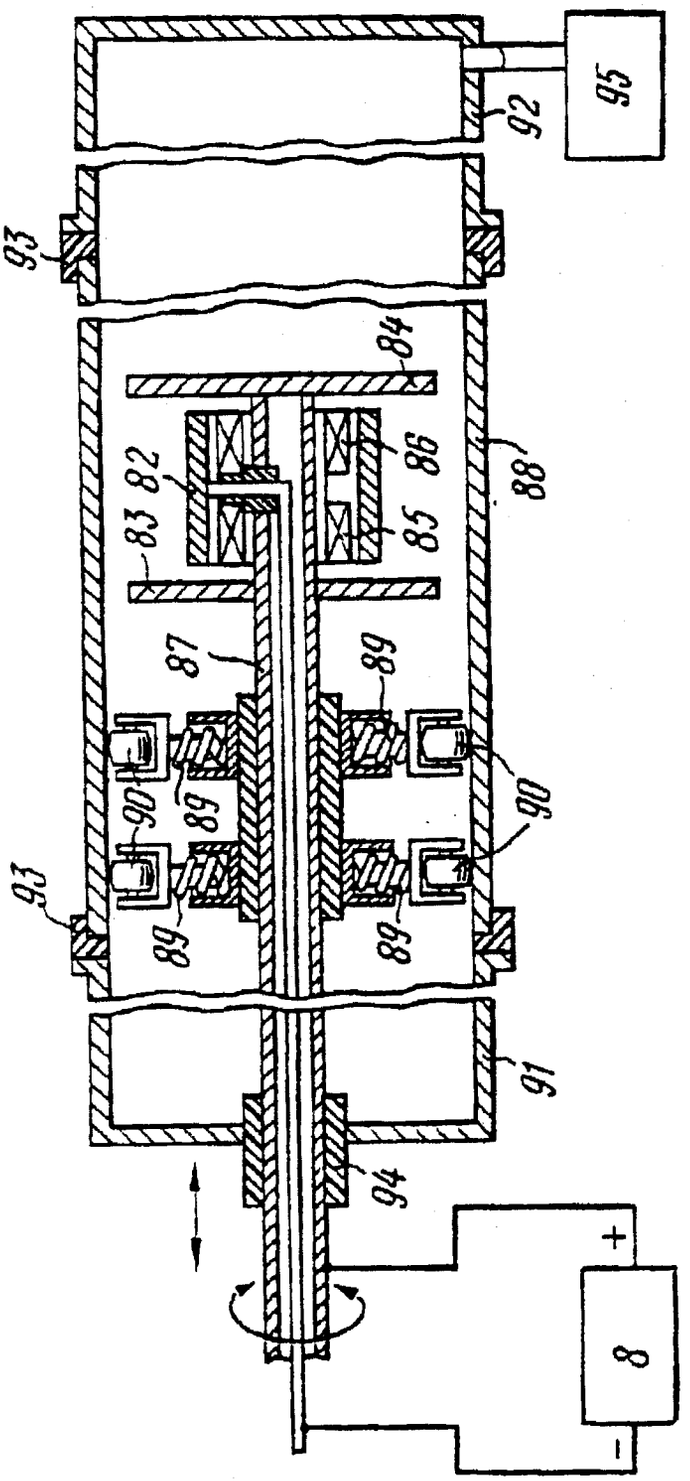

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 92/00141

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl.5 B21B 9/00, 45/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl.5 B05D 3/00, B21B 9/00-45/08, C21D 1/82

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SU, A, 322420 (INSTITUT KILERNETIKI AN UKRAINSKOI SSR), 9 February 1972 (09.02.72), the claims	1-9
A	SU, A, 313872 (LEVIN G.I. ET AL.), 10 November 1971 (10.11.71)	1-9
A	US, A, 4099399 (SOUTHWIRE COMPANY), 11 July 1978 (11.07.78), the claims	10-26
A	US, A, 4233830 (SECIM) 18 November 1980 (18.11.80)	10-26

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 September 1992 (29.09.92)	21 October 1992 (21.10.92)
Name and mailing address of the ISA/ RU/ISA	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)