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METHOD FOR THE MULTIPLE USE OF A COPPER WIRE USED AS
ELECTRODE WIRE FOR ELECTRICAL RESISTANCE LONGITUDINAL
SEAM WELDING

5 The invention relates to a method for the reuse of
a copper wire which is used in a first practical
application as an electrode wire for electrical
resistance longitudinal seam welding, particularly of
tinned sheet metal. For this purpose the wire is formed,
10 before this first application, into a wire with a cross-
sectional shape differing from the circular shape,
particularly into a flat wire, and is hardened in that
form. The wire is contaminated, during this first
application, in its regions coming into contact with the
15 weld, by material originating from the work being welded
and transferred to it during the welding.

Already during the first known attempts at
electrical resistance longitudinal seam welding of tinned
metal sheets using copper wire as electrode wire, the
20 reuse of the copper wire used as an electrode has been
considered.

For example, in the first unsuccessful attempt
described in US Patent 2838651 for electrical resistance
longitudinal seam welding of tinned metal sheets using an
25 electrode wire which establishes the contact between an

electrode roller and work being welded and so prevents contamination of the electrode roller by tin passing over from the weld, it was thought the electrode wire which had come into contact with the weld and so been
5 contaminated by tin transferred to it from the weld could be freed from these impurities and used again as an electrode wire in the same welding machine (US-PS 2838651, column 4, lines 39-54). In this case, consideration was given to removing the contamination
10 from the electrode wire by guiding the electrode wire through a sizing die having a slightly smaller diameter than the original diameter of the wire "so that a thin outer coating of the wire is removed by the process and thereby the removal of any type of foreign material from
15 the wire is guaranteed". (US-PS 2838651, column 4, lines 43-46).

In fact, however, the method described in the US-PS 2838651 could not be brought into practice for a whole number of reasons. The main reason for this was that the
20 electrode wire was rolled down under the pressure of the electrode roller while passing through the welding position and was flattened in the course of this (the effect of the rolling down of the electrode wire and of the resulting wire extension is known, for example, from
25 the CH-PS 436513 and could only be overcome more than 10

years after the publication of the US-PS 2838651 by the measures described, for example, in the CH-PS 536163), because the extension of the wire as a result of the rolling down under the first of the two electrode rollers which the electrode wire has to pass in the method according to the US-PS 2838651, in conjunction with the condition that the electrode wire must have the same speed when passing both electrode rollers (US-PS 2838651, column 4, lines 9-13), leads to the fact that a loop forms in the wire run between the first and second electrode rollers and in practice leads to the method according to the US-PS 2838651 being inoperable (as already mentioned, the effect of the rolling down and of the resulting loop formation could only be overcome much later by the measures of the CH-PS 536163). Apart from the generally inoperable nature of the method described in the US-PS 2838651 as a result of said rolling down of the electrode wire, the intended guiding of the electrode wire through the sizing die did not lead to the desired result either. For the rolling down of the electrode wire under the pressure of the electrode rollers leads to the fact that those regions of the electrode wire which come into contact with the weld and are therefore contaminated with tin, are also the regions which are rolled down and so flattened at the same time. If a thin

surface layer of the wire is passing through the die as stated above, then the peripheral regions of the wire, which have been rolled down and so flattened, are not included in this removal because their distance from the axis or centre of the wire is less than the spacing of the other peripheral regions of the wire after removal of the thin surface layer so that, during the guiding of the electrode wire through the sizing die, the impurities are not removed precisely in those peripheral regions of the wire which are contaminated with tin.

In addition, the general idea of making an electrode wire, used in a welding machine for resistance longitudinal seam welding, reusable in the same welding machine by reducing its diameter after use is naturally not realizable in practice because the electrode wire must bear against the electrode roller with a relative large surface in order that the contact resistance between electrode roller and electrode wire may be as low as possible in order to exclude welding of the electrode wire to the electrode roller, and such a relative large contact area between electrode wire and electrode roller can only be achieved if the electrode wire fits precisely into the groove provided for it in the electrode roller and therefore bears snugly against the groove walls with its peripheral regions situated inside the groove, that

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is to say if the radius of curvature of the groove walls is equal to the radius of the electrode wire and this condition is naturally no longer fulfilled with a reduced diameter of the electrode wire. That is to say the reduction in the diameter of the electrode wire caused by the sizing die leads to the fact that the wire no longer makes bearing contact over an area but only has a substantially linear bearing contact with the groove in the electrode roller, and therefore an excessive contact resistance results between roller and wire, with the risk of the wire being welded onto the roller. To this must be added the fact that, with a reduced diameter of the electrode wire, there is at the same time poorer guidance of the wire in the groove in the electrode roller, which can lead to the wire jumping from the roller during the welding operation.

For all these reasons, the idea of repeated use of the electrode wire in the same welding machine, expressed in the US-PS 2838651, could not be realized in practice and under expert testing was unable to give any encouragement for such repeated use.

The repeated use of electrode wires in a welding machine serving for the resistance longitudinal seam welding of tinned metal sheets as later considered in the CH-PS 370175 (page 2, lines 22-41) also proved impossible

to carry out in practice. It is true that there the diameter was not reduced, the electrode wire only being cleaned after each passage through, so that the problems mentioned above in connection with the method according to the US-PS 2838651 and arising with the reduction in diameter of the electrode wire, did not occur, but neither did this cleaning lead to the required result that such previously used, cleaned electrode wires would lead to even approximately equally satisfactory welding results as new wires. The reasons for this lay not only in the cleaning methods used but were also largely inherent in the system, that is to say they were of a fundamental nature. For cleaning, the method mainly considered of drawing the electrodes, after use, through a cleaning diaphragm whereby "the impurities adhering to the wires in the forms of elements of tin are stripped off" (CH-PS 370175, page 2, lines 27-30), was unsuitable if only because the adhering tin naturally cannot simply be stripped off in the cold state and therefore only a very incomplete removal of the tin from the wire surfaces was possible by means of these cleaning diaphragms, which could in no way impart to the wire a surface nature comparable with a new wire.

The chemical cleaning methods further considered of detaching the tin from the surface of the wire by

means of dilute hydrochloric acid or dilute caustic soda solution (CH-PS 370175, page 2, lines 35-38) were also practically impossible to carry out if only because such chemical detachment would have taken much too long and in addition the hydrochloric acid or caustic soda would have attacked the surface regions of the wire which were not covered with tin or only slightly covered with tin and so would have led to an unacceptable risk of breakage of the wire at positions which were severely attacked. On the other hand, the method also considered, of cleaning by melting the tin off the used electrode wire (CH-PS 370175, page 2, lines 38-41), for example by means of guiding the used electrode wire through a tin bath as well as a diaphragm disposed at the exit therefrom and serving to strip off the molten tin, at first appeared most promising because a surface finish of the used electrode wire at least similar in quality to that of a tinned new wire can be achieved thereby.

It was then found, however, that even this form of "cleaning" did not lead to a reusable electrode wire with which welding results similar in quality to those with an (untinned) new wire could be achieved. The reason for this lies in the fact that the tin transferred to the electrode wire during the welding not only adheres superficially to the copper wire but also penetrates into

the surface layers of copper, forming an alloy, and the resulting copper-tin alloy in the surface layers of the wire has a specific resistance which is a multiple of the specific resistance of copper and is even considerably
5 above the specific resistance of tin which itself amounts to about 6.5 times the specific resistance of copper. Because of the high specific resistance of the copper-tin alloy formed in the surface layers of the wire during welding, when the wire is reused an extremely severe
10 heating of these surface layers results when the welding current flows through them and may lead to the welding of the wire to the work being welded and in any case leads to a much poorer quality of weld than when a new wire is used. Later research then also showed that this is a
15 decisive reason standing in the way of reuse of the electrode wire not only in the case of cleaning by melting off the tin but also in the case of the other cleaning methods mentioned, that is to say that even with careful mechanical or chemical removal of the tin
20 adhering to the surface of a used electrode wire, no satisfactory welding results can be achieved on reusing the cleaned electrode wire because of the copper-tin alloy in the superficial layers and that accordingly the formation of the copper-tin alloy in the superficial
25 layers of an electrode wire during welding is a

fundamental hindrance to the reuse of electrode wire which has already been used. A further obstacle of a fundamental nature standing in the way of the reuse of cleaned electrode wires which have already been used, considered in the CH-PS 370175, is the rolling down of the wire under the pressure of the electrode rollers, which has already been mentioned, because that naturally leads to a fresh, altered cross-sectional shape of the electrode wire on each further use, and in order to achieve a constant welding quality, constant conditions and therefore also a constant cross-sectional shape of the used electrode are essential, quite apart from the fact that such changes in the cross-sectional shape would naturally also have required a change of the diaphragms used for the cleaning, after each passage through, for adaptation to the altered cross-sectional shape of the wire.

For the above-mentioned reasons, therefore, even the form of a repeated use of the electrode wire in the same welding machine considered in the CH-PS 370175 could not be realized in practice.

Thus, since it already became clear in the first years of the practical realization of welding machines for resistance longitudinal seam welding of tinned metal sheets with the aid of wire electrodes, that reuse of the

electrode wires was impossible mainly because of the formation of tin-copper alloys in the surface layers of the electrode wires during the welding and the rolling down of the electrode wires under the pressure of the electrode rollers, in order to avoid a loss of the relatively expensive copper used for the electrode wires no other alternative remained but to melt down the contaminated wires in accordance with the recommendation already given in the CH-PS 370175 (page 2, lines 20-21), after they had been used once and, with a refining process, to free the molten copper from the tin which had been introduced as a result of the process to contaminate the wires, partly in the form of a copper-tin alloy and partly in the form of tin adhering to the wires.

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In the first years of the use of welding machines for resistance longitudinal seam welding of tinned metal sheets with the aid of wire electrodes, the collection of the contaminated electrode wires after they had been used once was effected by winding the used wires on a spool as can be seen, for example, from the CH-PS 436513 (Figure, part 44). This method of collecting the used electrode wires intended for recovery of the copper is disadvantageous however, insofar as the removal of the wire from the spool requires further expenditure in every case, namely either a time-consuming unwinding of the wire from the spool or the use of special spools which could be dismantled and which permitted a removal of the whole package of wire from the spool. After a certain time, therefore, there was a changeover to stacking the used wire in so-called container-type coil winders such as are known, for example, from the CH-PS 552436 (column 1, lines 65-69 and Figure 1, part 37), as can be seen, for example from the CH-PS 519961 (column 2, line 14 and Figure 1), instead of winding the wire on a spool. Since, in the meantime, with the further development of the wire welding technique (and in particular with the overcoming of the loop formation already mentioned above during resistance longitudinal seam welding with only one electrode wire running over both electrode rollers, by

using a hard wire hardened by rolling out before entry into the first electrode roller as described in the CH-PS 536163), the effective welding speeds had also greatly increased in comparison with those which were previously achieved in the method described in the CH-PS 436513 for resistance longitudinal seam welding with only one electrode wire running over both electrode rollers, wherein the used wire was wound on a spool, and with this rise in the effective welding speeds, the accumulation of used wire per unit of time had naturally also increased considerably, correspondingly large container-type coil winders were also used which could substantially receive the amount of used wire produced daily, and here the problem then arose, in connection with the above-mentioned melting down and refining, that the volume occupied by the irregularly stacked wire in the container-type coil winder was considerably greater than the actual copper volume of this wire and so a correspondingly incomplete utilization of the volume of the copper converter used for the refining resulted.

In order to avoid this inadequate utilization of the copper converter and to make better use of it by achieving as high a ratio as possible of the actual copper volume to the volume occupied by the used wire, there was therefore a changeover - as can be seen, for

example from the Soudronic brochure "VSA 50 E" (second page, right-hand column, second paragraph) and from the Schuler brochure "LCS Body-Welder" (page 7, Figure wire guiding and right-hand column, lines 1-4) - to chopping
5 the used wire into short pieces of wire about 20 to 40mm long by means of a so-called wire chopper, already at the welding machine and then conveying this "wire chaff", which was subsequently collected in a container and which naturally occupied a considerably smaller volume than a
10 corresponding amount of wire irregularly stacked in the container-type coil winder, to the processing in a copper converter in order to recover the copper.

A further development of this technique of chopping the electrode wire into short pieces of wire
15 after it has been used once, and then recovering the copper from these by melting down and refining, which technique has been used almost exclusively in the last decade, is represented by the proposal recently made and not previously published that the wire should be chopped
20 considerably finer into pieces of wire only 1 to 3mm long and this "granulated wire" should be subjected, by means of a screw press, to such a high pressure that the copper - possibly with additional heating - changes over into a state in which it can flow and can then be extruded, in
25 the manner of the known extrusion process, through a die

into a copper strand with a diameter of 2 to 5mm which can then be drawn, in a wire drawing device, into a wire with a suitable diameter which can be used again as electrode wire. In the attempts at industrial realization of this proposal, however, a number of unforeseen problems arose, particularly in the conversion of the granulated material into a compact material capable of flow and having no air occlusions, which problems caused considerable difficulties and so far have only been able to be overcome in an experimental model. In any case, up to now it has only been possible in the experimental stage to produce wires by this method which could be used again as electrode wires in welding machines and quite apart from this, it has also been found that the technical expenditure for this method of processing is considerably higher, because of the problems which have arisen and the resulting high investment costs for an installation corresponding to the proposal, than if the said wire chaff were to be melted down in conventional manner, refined, cast into strands and then new wires were drawn from the cast strands.

Summing up, it may be said that it is common to all the known and proposed forms of reusing electrode wires that have been used in resistance longitudinal seam welding, that, in practice hitherto, the copper wires

forming such electrodes have only been used once and then only the copper has been recovered from the electrode wires used once and all attempts at and proposals for repeated use of these copper wires have hitherto failed in practice.

It is therefore the object of the invention to provide a method whereby, after its first application as an electrode wire for resistance longitudinal seam welding, a copper wire can in fact be supplied in practice to a further useful application and no longer is there no alternative but to supply it, as used wire, to waste utilization for the recovery of the copper.

According to the invention, this is achieved processing the deformed and contaminated copper wire through a wire drawing device comprising a plurality of drawing stages, in which it is drawn in such a manner that the distances from the centre of the wire of the peripheral regions of the wire furthest away from the centre are reduced in all drawing stages and the distances from the centre of the wire of the peripheral regions nearest to the centre are reduced in at least some of the drawing stages and that furthermore the distances from the centre of the wire of the peripheral regions of the wire furthest away from the centre are reduced successively in the drawing stages at least to

such an extent that they become shorter than the distances from the wire centre of the peripheral regions situated closest to the centre before drawing, and that the distances from the centre of the wire of the peripheral regions of the wire nearest to the centre are reduced in said some of the drawing stages to such an extent that, after passing through the last drawing stage, they are as great as the distances from the centre of the wire of the peripheral regions previously furthest away from the centre, so that a new round copper wire with a circular cross-section and a smaller diameter than the smallest external dimension of the deformed and contaminated copper wire is produced in the wire drawing device, and that this new round copper wire is supplied for a further application.

The main advantage of the present method is that with it, the resistance longitudinal seam welding of tinned sheet metal by means of wire electrodes can be rendered possible for the first time, and the wire electrodes no longer cause continuous operating costs but on the contrary can even contribute to a reduction in the other operating costs because the new round copper wire produced by the present method has a smaller diameter than the copper wire used as electrode wire at the beginning and for this reason, the value of the new round

wire produced by the present method is greater, per unit of weight, than the value of the wire used the electrode wire at the beginning. Surprisingly, it has actually been found that the properties of the new round copper wire originating from the present method do not differ from the properties of a corresponding wire drawn to the same diameter directly in a wire drawing mill or only differ to a negligible extent far below the standard tolerances, that therefore, contrary to all expectation, the tin entrained by the electrode wire after its use for the resistance straight seam welding of tinned metal sheets, partly adhering to its surface and partly contained in the copper-tin alloy in its surface layers, is practically without influence on the properties of the round wire drawn from the electrode wire in any way. This applies to the electrical properties, for example the specific resistance, as well as to the mechanical properties, for example the strength, and also to the appearance of the new drawn round copper wire, that is to say the faultless smooth surface thereof.

Thorough research into this surprising result leads to the assumption that the tin entrained by the electrode wire is obviously displaced in the regions of the so-called slip planes during the drawing of the wire, in which planes various zones of the copper crystals

essentially forming the wire are displaced in relation to one another during the drawing of the wire and that this is the reason why the electrical conductivity of the wire, for example, is hardly influenced in the longitudinal direction and also its tensile strength in the longitudinal direction is hardly influenced by the incorporated tin. The tin originally adhering to the electrode wire obviously accumulates on the surface of the wire in the form of atomic layers, insofar as it does not enter the interior of the wire as a result of the drawing operation, and accordingly can likewise not influence the electrical and mechanical properties of the wire in its longitudinal direction. In this connection, it should be noted that during resistance longitudinal seam welding by means of wire electrodes, the welding current does not flow in the longitudinal direction of the wire but through the wire in its transverse direction, and that therefore it is easy to explain why electrode wires which have already been used produce considerably poorer welding results on reuse because there the welding current actually has to flow through the superficial copper-tin alloys and the tin adhering to the surface of the wire, while a current flowing in the longitudinal direction of the wire can flow past such surface layers.

In any case, the result is achieved by the present method, for the first time since the original provision of welding machines for resistance longitudinal seam welding, that the electrodes used for the welding may not be a constant operating cost but may instead contribute to the reduction of the other operating costs, because earlier, when welding was still effected directly with electrode rollers (and the welding of tinned metal sheets, which only became possible through the use of wire electrodes, was still not possible), their rolling surfaces came into contact with the work to be welded (generally bare steel sheets), became worn, and led to a decline in the welding quality after a certain running period so that the electrode rollers had to be replaced each time after a certain running period which naturally added to the operating costs.

With the absence of the additional costs for the electrodes, the present method therefore leads to considerable technical progress in resistance longitudinal seam welding in general because with it, it is now possible to changeover to welding by means of wire electrodes even for the resistance longitudinal seam welding of bare steel sheets with which welding has hitherto still been predominantly effected directly with electrode rollers for reasons of cost, in which case

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savings are also achieved in addition to improvement in the welding quality.

Further advantages can be achieved with the present method even within the art of resistance longitudinal seam welding by means of wire electrodes. Thus, when using the present method, it is easily possible, as a result of the absence of the constant operating costs for the electrodes which can be achieved thereby, to change over from the method of welding with only one wire electrode guided over both electrode rollers, which has been used almost exclusively in the art of resistance longitudinal seam welding with wire electrodes in the last two decades, to the original method again, known for example from the CH-PS 370175 (Figure 1), of welding with a separate wire electrode for each of the two electrode rollers and so to simplify the whole method of resistance longitudinal seam welding with wire electrodes again without accepting higher operating costs into the bargain, because the changeover from welding with a separate wire electrode for each of the two electrode rollers to welding with only one wire electrode guided over both electrode rollers was made at the time exclusively to reduce the consumption of wire and the associated operating costs and led to some difficult technical problems, overcoming which was only

possible with increased expenditure on apparatus for the corresponding welding machines, and with the use of the present method and a simultaneous changeover to welding with a separate wire electrode for each of the two electrode rollers, this increased expenditure on apparatus can be reduced again while, at the same time, the operating costs are eliminated which were hitherto necessary for the wire electrode guided over both electrode rollers.

10 Additional advantages can be achieved by further preferred developments of the invention.



As a rule, with the method according to the invention, the new copper wire drawn in the wire drawing device will be supplied for a further useful application different from the said first application. It is true
5 that a further application resembling the first application is not excluded in general but it will scarcely be considered in practice if only because the diameter of the new drawn copper wires is generally below the usual diameter range of electrode wires used for
10 resistance longitudinal seam welding. The further application different from the said first application may advantageously be one in which the new round copper wire is used for conducting current in the longitudinal direction of the wire and may appropriately be a
15 permanent application, preferably as a signal conductor or a winding wire. The advantage of a further application different from the said first application is that in this case, as already mentioned above, influencing of the properties of the new drawn round
20 copper wire by the first application is excluded.

In the method of the present invention, the new wire drawn in the wire drawing device may advantageously be provided with an insulating sheath, preferably with a coat of lacquer or varnish, before being supplied to the
25 said further application. This applies in particular to

the said applications as signal conductor or winding wire. It may likewise be an advantage for these and other applications, to anneal the new wire after drawing by heating to a temperature corresponding at least to its recrystallisation temperature and preferably above that, after leaving the last drawing stage.

If, with the present method, the copper wire was hardened, before the first application, to such an extent that its ultimate (fracture) elongation is still below 10% after the first application, the deformed and contaminated copper wire should preferably be annealed by heating to a temperature corresponding at least to its recrystallisation temperature and preferably above that, after the first application and before it is supplied to the first drawing stage of the wire drawing device. This has the advantage that wire breakages during travel through the device as a result of excessive embrittlement of the wire are substantially excluded.

If a wire drawing device is used for the method of the present invention, the processing capacity of which per unit of time is a multiple of the consumption of electrode wire per unit of time of the welding machine used for the longitudinal seam welding, then it may be a considerable advantage for the better utilization of the processing capacity of the drawing device to collect the

electrode wires from a plurality of welding machines after they have been used there and to convey the collected deformed and contaminated wires in succession to the drawing device. In order to collect a wire after it has been used in a welding machine, a driven spool, preferably a flanged spool may appropriately be used, to which the wire is applied in layers and the drive of which is controlled by the welding machine and which is preferably mounted on the machine. The use of a common wire drawing device for a plurality of welding machines or the used wire accumulating from these is particularly advantageous for large production plants with a plurality of welding machines, because a separate wire drawing machine is then worthwhile and such machines constructed specially for wire drawing can process considerably larger amounts or weights of wire than the used wire produced at one welding machine. Such a separate wire drawing machine may, however, naturally advantageously also process the used wire collected from a plurality of smaller production plants each with only one or two welding machines.

In a preferred form of execution of the method of the present invention, the copper wire is deformed, in the first application, into a wire with a cross-sectional shape wherein the distances from the centre of the wire

of the peripheral regions of the wire situated closest to the centre are less than 0.7 times the distances from the centre of the peripheral regions furthest away from the centre of the wire and after the first application, the deformed and contaminated copper wire is drawn in the wire drawing device in such a manner that the distances from the centre of the wire of the peripheral regions of the wire situated closest to the centre before the drawing are only reduced in the last drawing stage or the last few drawing stages and accordingly, in the first drawing stage or the first few drawing stages, only the distances from the centre of the wire of the peripheral regions furthest away from the wire centre are reduced, dies with axially symmetrical drawing holes being used at least in the said last drawing stage or last few drawing stages, but preferably in all the drawing stages. The use of dies with axially symmetrical drawing holes naturally has the advantage over the use of dies with drawing holes adapted to the cross-sectional shape of the wire, of considerably less technical expense, because the production of dies with non axially symmetrical drawing holes is extremely complicated and correspondingly expensive and after all the dies become worn in operation and therefore have to be replaced periodically, but on the other hand, when drawing a wire with a cross-

sectional shape deviating from the circular shape using a die with an axially symmetrical drawing hole, there is naturally the danger of the wire bending in the direction of one of its peripheral regions situated closest to the centre of the wire during the drawing operation and this danger is naturally the greater the smaller the ratio of the distances from the centre of the wire of the peripheral regions of the wire situated closest to the centre to the distances from the centre of the peripheral regions of the wire furthest away from the centre. If this ratio is greater than 0.7, then this danger is slight and even if the ratio is between 0.5 and 0.7 this danger can be kept low by a relatively small reduction in cross-section of the wire in comparison with the usual reductions in cross-section, in the die in question, but if this ratio is less than 0.5 and particularly less than 0.4, then adapting a relatively small reduction in cross section in the die in question is frequently no longer sufficient to keep the danger of such bending during drawing sufficiently low, and in this case, the use of guide means preventing such bending is recommended.

Accordingly, an appropriate further development of the said preferred form of execution of the method according to the present invention is characterised in that the copper wire is deformed, in the first

application, into a wire with a cross-sectional shape wherein the distances from the centre of the wire of the peripheral regions of the wire situated closest to the centre are preferably less than 0.5 times the distances from the wire centre of the peripheral regions furthest away from the centre of the wire, and that the copper wire, deformed and contaminated after the first application, is drawn, in the wire drawing device, in at least some of those drawing stages in which only the distances from the centre of the wire of the peripheral regions of the wire furthest away from the centre are reduced, through axially symmetrical drawing holes provided in the drawing stages in question and is guided in the drawing holes, in at least some of these drawing stages, which are provided with axially symmetrical drawing holes and in which only the distances from the centre of the wire of the peripheral regions furthest away from the centre are reduced, by guide means projecting into the drawing holes from the entrance thereto in such a manner that bending of the wire in the direction of one of its peripheral regions situated closest to the centre is avoided during the drawing operation. The essential advantage of such guide means is that if they are used, the adoption of a relatively small reduction in cross-section of the wire in the die

in question can be avoided without the danger of the wire bending during the drawing operation resulting and so, if such guide means are used, the number of drawing stages in the wire drawing device can naturally be reduced
5 considerably whereby the use of such guide means may also be a considerable advantage even when the ratio of the distances from the centre of the wire of the peripheral regions situated closest to the centre to the distances from the centre of the wire of the peripheral regions
10 furthest away from the centre is equal to or greater than 0.5 and in particular is between 0.5 and 0.7.

A plate disposed at the inlet side of the drawing die may be used to particular advantage as a guide means for guiding the wire in the drawing hole, which plate is
15 provided with a slot and with two nose-like projections which are disposed at the side of the plate adjacent to the die and project into the drawing hole and which are situated opposite one another with the backs of their noses remote from one another and bearing against the
20 wall of the axially symmetrical drawing hole and the adjacent wall faces of which noses follow, preferably without breaks, on the two opposed wall portions bounding the slot and have, at least in the region or regions of the drawing hole in which the hole cross-section of the
25 drawing hole decreases from the inlet side to the outlet

side of the drawing die, a spacing from one another corresponding at least substantially to the spacing apart of the peripheral regions of the wire situated closest to the centre of the wire, so that the slot, together with the adjacent wall faces of the nose-like projections and the wall faces of the drawing hole which are not covered by these projections, forms a drawing channel in which, as the wire is drawn through, only the distances from the centre of the wire of the peripheral regions furthest away from the centre and coming into contact with the wall faces of the drawing hole not covered by the projections are reduced and in which bending of the wire in the direction of one of the peripheral regions situated closest to the centre is prevented by the adjacent wall faces of the nose-like projections.

The advantage of using such a plate, provided with a slot and nose-like projections and disposed at the inlet side of the drawing die as a guide means for guiding the wire in the drawing hole, is that the combination of the plate with the associated axially symmetrical drawing die forms a channel which is adapted to the cross-sectional shape of the wire to be drawn through the die, but that the replacement necessary periodically as a result of wear only affects the die because the nose-like projections of the guiding plate

only serve to guide the wire but not to reduce its cross-section and therefore practically do not become worn so that the plate does not also need to be exchanged on replacement of the die.

5 In order to secure the drawing die and guiding plate, securing means may advantageously be used whereby they are rotatable in relation to one another and can be located in various angular positions so that the die can be reset n times by locating them relatively to one
10 another in n different angular positions each offset by $180^\circ/n$, n being a whole number which is greater than 1 and smaller than or at most equal to $90^\circ/\arcsin \frac{a}{d}$, and a being equal to the spacing apart of the peripheral regions of the wire situated closest to the centre of the
15 wire and d being equal to the diameter of the drawing hole at the position of its smallest hole cross-section. The advantage of using such securing means and the utilization of the die n times which is thus rendered possible is an n times operating life of the die and in
20 conjunction with the general advantage already mentioned above of guide means for guiding the wire in the drawing hole, that adoption of relative small reductions in cross-section in drawing can be dispensed with and accordingly the number of drawing stages can be kept
25 relatively small, a wire drawing device can thus be

provided wherein not only the expenditure on apparatus but also its operating costs can be kept very low and which is therefore particularly suitable for direct installation in a welding machine.

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Particularly in the case of relatively large reductions in cross-section of the wire per drawing stage, however, it is advisable to use, as a plate provided with slot and nose-like projections, a plate wherein at least its wall portions coming into contact with the wire travelling through, preferably at least the nose-like projections and the adjacent wall portions of the walls bounding the slot, consist of hard metal. This has the advantage that even with a considerable reduction in the wire cross-section and resulting attempts by the wire to bend as well as correspondingly greater friction thereof on the nose-like projections, practically no wear of the adjacent wall faces results.

The invention further relates to a device for carrying out the method according to the invention which is characterised by a welding machine for electrical resistance longitudinal seam welding by means of wire electrodes and a wire drawing device integrated in the welding machine for drawing the used electrode wire accumulating in the form of deformed and contaminated copper wire during welding into new round wire with a circular cross-section and a smaller diameter than the smallest external dimensions of the deformed and contaminated wire.

The advantage of integration of the wire drawing

device in the welding machine is primarily that, apart from its main product, that is to say the welded metal sheets, the welding machine also delivers a finished by-product and not merely an intermediate product which
5 still has to be further processed in a separate wire drawing device. A further advantage is the adaptability of the integrated wire drawing device to the operating conditions preset by the welding machine such as the possibility resulting with the relatively low speed of
10 emergence of the used wire from the welding station in comparison with the usual drawing speeds, for example, of drawing the wire almost dry in the integrated drawing device.

The invention further relates to an installation
15 for carrying out the method of the present invention which is characterised by a plurality of welding machines for electrical resistance longitudinal seam welding by means of wire electrodes as well as means for collecting the used electrode wire accumulating in the form of
20 deformed and contaminated copper wire at each of the welding machines and a separate wire drawing machine having a processing capacity per unit of time corresponding at least to the total electrode wire consumption of all these welding machines per unit of
25 time, for drawing the collected used wire from all these

welding machines into new copper wire with a circular cross-section and a smaller diameter than the smallest external dimension of the deformed contaminated copper wire.

5 The advantage of such an installation lies in the processing of the used electrode wire from all the welding machines of the installation in said separate wire drawing machine and the resulting absence of individual drawing devices at each individual machine as
10 well as the resulting lower technical expenditure for the whole installation. Such an installation design has the further advantage that it can be used at existing production plants or existing welding machines in that these machines are simply each provided with an
15 additional unit for collecting the used wire.

 In this installation, the means for collecting the used electrode wire may advantageously comprise a driven spool, preferably a flanged spool, at each of the welding machines, for winding the used wire, means for driving
20 the spool and control means for the driving means as well as preferably means for applying the used wire to the spool in layers. In this case, it is an advantage if the spools of all the welding machines of the installation are standardized in such a manner that each of these
25 spools can be inserted directly in the withdrawal device

of the separate drawing machine.

The invention is explained in more detail below by way of example by reference to two embodiments.

In the first embodiment, a semi-soft bare copper
5 wire having a diameter of 1.38mm and a wire cross-section
of 1.496mm², a tensile strength $\sigma_{0.2}$ at the 0.2% creep
limit of 19.5 kg/mm² and a specific resistance at 20°C of
0.01747 Ohm.mm²/m is supplied for a first useful
application at a speed of 0.78m/sec to a fully automatic
10 welding machine for the electrical resistance
longitudinal seam welding of can bodies of tinned steel
sheet 0.18mm thick by means of only one electrode wire
guided over both electrode rollers and in order to prevent
loop formation in the wire between the two rollers is
15 there first rolled down, in accordance with the CH-PS
37C175, in a compression unit with two driven rolls, into
a hard wire in the form of a flat wire 0.73mm high with a
maximum width of 1.82mm and two substantially plane
electrode surfaces 1.67mm wide at its top and bottom and
20 having a wire cross-section of 1.292mm², and in the
course of this, it is elongated by about 15.8% and
strengthened to a tensile strength $\sigma_{0.2}$ at the 0.2% creep
limit of 29.2kg/mm². The rolled down and strengthened
wire leaves the compression unit at a speed of about
25 0.90m/sec as a result of its elongation by the rolling

down and is then guided, at this speed, over the first of the two electrode rollers in such a manner that its top is adjacent to the work and its bottom is adjacent to the roller. Tin is transferred to this top of the electrode wire adjacent to the work from the lower one of the two edges of tinned steel sheet being welded, with which the top of the wire guided over the first roller comes into contact while passing through the welding position, which tin partially penetrates into the surface at the top of the wire and forms a copper-tin alloy in the surface layers in question and partially covers the top of the wire with a thin layer of tin, as a result of the welding current flowing through and heating of the wire.

The wire then runs to the second of the two rollers and is guided over this in such a manner that its bottom, which is still not contaminated with tin, is adjacent to the work to be welded and its top to the roller. Tin is therefore transferred to this bottom of the wire adjacent to the work from the upper one of the two edges of tinned steel plate being welded, with which the bottom of the wire guided over the second roller comes into contact on passing the welding position, which tin partially penetrates into the surface at the bottom of the wire and forms a copper-tin alloy in the surface layers in question and partially covers the bottom of the

43

wire with a thin layer of tin likewise. While passing the second electrode roller, a slight elongation of the wire also results as well as a corresponding reduction in cross-section, which is attributable to the combined

5 action of the heating of the wire at the welding position by the current flowing through and the resulting loss of hardness of the wire and to a relatively great tensile stress exerted on the wire by a conveyor member through which the wire travels after leaving the second roller.

10 The flat wire leaving the second electrode roller therefore only has a wire cross-section of 1.23mm^2 , a height of 0.71mm , a total width of 1.78mm , a width of its two flat sides of 1.63mm and a tensile strength $\sigma_{0.2}$ at the 0.2% creep limit of 20.4kg/mm^2 and has been

15 lengthened by a further 5.1% so that it passes through the aforesaid conveyor member at a speed of 0.95m/sec . After leaving the conveyor member, this flat wire contaminated with tin on its two flat sides is then wound, by means of a winding device mounted on the

20 welding machine, on a flanged spool in layers, the spool being driven by a drive motor, the speed of which is regulated by means of a measuring member detecting the wire tension between conveyor member and spool, in such a manner that the tension between conveyor member and spool

25 remains substantially constant at about 5kg/mm^2 . The

winding device is provided with two spools on which the wire is wound alternately, and at the moment when one spool is fully wound, the wire is automatically cut off each time, the end of the wound wire is fixed on the full spool, the new beginning of the wire is fixed to the other empty spool and then the wire is wound on this other spool. While the other spool is being wound, the full spool is removed and replaced by an empty spool on which the wire is then wound after the next change. In this manner, the change of spools at the winding device can be effected without interrupting the welding operation. Corresponding winding devices which also comprise the drive motor the motor speed regulating device, the device to measure the wire tension and a wire guiding device for winding on in layers, are known both from the art of wire production and from the art of textile thread production and therefore do not need to be described in more detail here.

The full spools from the welding machine and a relatively large number of other similar welding machines are then supplied to a wire drawing machine where the flat wire is withdrawn from the spools inserted in succession, at a speed of about 9.2m/sec and is drawn, in the drawing device thereof, into a new round copper wire with a diameter of 0.6mm. As a result of the feed speed

of about 9.2m/sec of the wire withdrawn from the spools and the speed of the flat wire of 0.95m/sec at the output side of the said conveyor member of the welding machine, the wire drawing machine, with a daily operating time substantially equal to that of the welding machines, has a processing capacity which is sufficient to process the spools wound with wire from 9 or 10 welding machines. In the drawing device of the wire drawing machine, the flat wire supplied is drawn, in 10 drawing stages, into the new round copper wire with a diameter of 0.6mm. In all 10 drawing stages, drawing dies with axially symmetrical drawing holes are used, the diameters of which, at the narrowest point in each case, amount, in sequence, to 1.69mm, 1.58mm, 1.455mm, 1.32mm, 1.18mm, 1.04mm, 0.905mm, 0.782mm, 0.684mm and 0.6mm. As already mentioned above, the speed of the wire when it is supplied to the drawing device is 9.2m/sec and after the individual drawing stages it is, in sequence, about 9.72m/sec, 10.45m/sec, 11.42m/sec, 12.71m/sec, 14.43m/sec, 16.73m/sec, 19.89m/sec, 24.36m/sec, 30.78m/sec, and 40m/sec. Accordingly, wire elongations of about 5.66%, 7.46%, 9.33%, 11.3%, 13.49%, 15.96%, 18.92%, 22.43%, 26.39% and 29.96% result in sequence in the individual drawing stages and the wire cross-section, which is about 1.23mm² on introduction into the first drawing stage, decreases

in sequence in the individual drawing stages to about
1.10mm², 1.08mm², 0.99mm², 0.89mm², 0.78mm², 0.66mm²,
0.57mm², 0.46mm², 0.37mm², and 0.28mm².

After leaving the last drawing stage, the round
5 copper wire is annealed by a continuous process still in
the wire drawing machine and for this purpose is first
preheated to about 80°C to 110°C by means of a current
conducted through the wire over a pre-annealing section
about 2m long and is then heated to 220°C to 250°C,
10 likewise by means of an electric current conducted
through the wire in a passage about 2m long forming the
so-called main annealing section, in a water-vapour
protective-gas atmosphere serving to prevent oxidation of
the wire and then, after leaving this passage, is wound
15 on spools by means of a winding device with a basic
construction like that of the winding device already
described above and afterwards conveyed to a lacquering
installation for the insulation, after leaving which, the
new insulated round copper wire is then supplied to the
20 further application, for example as a signal conductor in
telephone cables or as winding wire for electric motors.
The new wire has a conductor cross-section of 0.283mm², a
tensile strength $\sigma_{0.2}$ at the 0.2% creep limit of
11.3kg/mm² and a specific resistance at 20°C of 0.01734
25 Ohm.mm²/m and cannot be distinguished, in its electrical

and mechanical properties, from a corresponding wire drawn directly on a wire drawing machine.

In the second embodiment, a semi-soft bare copper wire with a diameter of 1.36mm and a wire cross-section of 1.453mm², a tensile strength $\sigma_{0.2}$ at the 0.2% creep limit of 19.7kg/mm² and a specific resistance at 20°C of 0.01749 Ohm.mm²/m is supplied for a first application, at a speed of 0.66m/sec, to a fully automatic welding machine for the electrical resistance longitudinal welding of can bodies of tinned steel sheet 0.19mm thick by means of only one electrode wire guided over both electrode rollers and is there first deformed and strengthened to form a hard wire in accordance with the CH-PS 370175 in conjunction with the CH Application 5117/83-6 in order to prevent loop formation in the wire run between the two electrode rollers, but in this example the wire is first drawn, in a first deforming stage, by means of a die, from its diameter of 1.36mm to a diameter of 1.2mm and a wire cross-section of 1.131mm² in the course of which it is elongated by about 28.4% and brought to a wire speed of about 0.85m/sec and at the same time strengthened to a tensile strength $\sigma_{0.2}$ at the 0.2% creep limit of 3.6kg/mm² and only this 1.2mm wire is then rolled down, in a second deformation stage, in a compression unit with two driven rolls, into a flat wire

with a height of 0.585mm and a maximum width of 1.84mm with two substantially plane electrode surfaces 1.74mm wide at its top and bottom and with a wire cross-section of 1.058mm^2 , in the course of which it is again elongated by about 6.9% and so brought to a wire speed of about 0.91m/sec and at the same time further strengthened to a tensile strength $\sigma_{0.2}$ at the 0.2% creep limit of 36.3kg/mm^2 .

The flat wire is then guided over the two electrode rollers in the same manner as in the first example and likewise leaves the second roller with a copper-tin alloy in the surface layer of its two flat sides and a thin layer of tin thereon, and furthermore with a reduced hardness and a slight elongation as well as a corresponding reduction in cross-section and therefore, after leaving the second roller, only has a cross-section of 1.009mm^2 , a height of 0.57mm, a total width of 1.80mm, a width of its two flat sides of 1.71mm and a tensile strength $\sigma_{0.2}$ at the 0.2% creep limit of 23.8kg/mm^2 and, in addition, has lengthened by a further 4.9% so that it passes through the conveyor member disposed after the second roller at a speed of 0.95m/sec.

After leaving the conveyor member, the wire contaminated with tin on its two flat sides is then supplied to a drawing device with a series of drawing stages which is mounted directly on the welding machine and driven in synchronism with the conveyor member, and is drawn by this, in 6 drawing stages, into a new round copper wire with a diameter of 0.5mm. In all 6 drawing stages, diamond drawing dies with axially symmetrical drawing holes are used, the diameters of the holes at the narrowest point in each case being, in sequence, 1.43mm, 1.14mm, 0.844mm, 0.701mm, 0.578mm and 0.5mm. As stated above already, the speed of the wire, on being supplied to the drawing device, is about 0.95m/sec and after the individual drawing stages, it is, in sequence, about 1.21m/sec, 1.54m/sec, 2.06m/sec, 2.74m/sec, 3.66m/sec and 4.88m/sec. Accordingly, wire elongations of about 27.19%, 27.57%, 33.28%, 33.41%, 33.49% and 33.37% result in sequence in the individual drawing stages and the wire cross-section, which is about 1.01mm^2 on introduction into the first drawing stage, decreases, in sequence, in the individual drawing stages, to about 0.793mm^2 , 0.622mm^2 , 0.466mm^2 , 0.35mm^2 , 0.262mm^2 and 0.196mm^2 .

Since the technical expense for a wire drawing device mounted on the welding machine naturally has to be kept as low as possible and accordingly the number of

drawing stages in such a wire drawing device should be as small as possible, considerably greater reductions in the wire cross-section result in the present example, as can be seen, particularly in the first drawing stages, than in the wire drawing machine in the above first example, and with these reductions in wire cross-section of 27 to 33.5%, during the drawing of flat wires using dies with axially symmetrical drawing holes - as distinct from with the small reductions in wire cross-section of only 5 to 10% in the first three drawing stages of the wire drawing machine in the first example - there is the danger of bending of the flat wire, during the drawing operation, in the direction of one of its peripheral regions situated closest to the centre of the wire, and this danger is naturally the greater, the flatter the wire is or the smaller the ratio of wire height to width is.

Since this ratio in the present example for the first three drawing stages, with values of $0.57:1.80 = 0.317$, $0.57:1.43 = 0.399$ and $0.57:1.14 = 0.5$ is in the range between 0.3 and 0.5, and so is relatively small and at the same time relatively large reductions in wire cross-section of 27.19%, 27.57% and 33.28% are provided in the first three drawing stages, in the present example to prevent bending of the flat wire and to guide the wire in the first three dies, guide means are provided in each

of the first three stages in the form of a plate which is disposed at the inlet side of the die and which is provided with a slot and with two nose-like projections which are disposed at the side of the guiding plate adjacent to the die and project into the drawing hole and which are situated opposite one another with the backs of their noses remote from one another and bearing against the wall of the axially symmetrical drawing hole and the adjacent wall faces of which noses follow, without a break, on the two wall faces of the drawing hole bounding the slot. The slot, together with the adjacent wall faces of the nose-like projections and the wall faces of the drawing hole which are not covered by these projections, forms a passage having a cross-section adapted to the cross-section of the wire to be drawn through, the passage walls having a spacing of about 0.1mm from the peripheral faces of the wire at the entrance, practically no spacing in the narrowing region of the drawing hole, and a spacing of about 0.025mm at the exit. The adjacent wall faces of the projections lie in parallel planes in the narrowing region of the drawing hole and have a spacing of 0.6mm.

The guiding plates are rotatably secured to the holding means of the associated dies and can be located in certain angular positions, namely the plates provided

in the first and second drawing stages each in 3 angular positions each offset by 60° in relation to one another and the plate provided in the third drawing stage in two angular positions offset by 90° in relation to one another. As a result, the dies in the first and second stages can each be used three times over and the die in the third stage can be used twice over. With this multiple use of the dies in the first three stages and the use of diamond drawing dies and with the relatively low drawing speed determined by the welding machine and the correspondingly slow passage of wire through the drawing device, the dies can have an operating life of several decades so that they practically never have to be exchanged.

15 In order to avoid wear of the guide surfaces provided, that is to say the wall portions of the guiding plates which come into contact with the wire travelling through, the projections and the adjacent wall portions of the walls bounding the slot consist of hard metal.

20 Thus the plates also reach an operating life as long as that of the dies because, after all, these guide surfaces only serve for guiding and in contrast to the dies do not have any action on the wire which reduces the cross-section and accordingly are subjected to practically no

25 wear - at least if they consist of hard metal. In order

to keep the friction low inside the dies as well, drawing oil is supplied to the passages in the first three stages, via the plates, in such small amounts that the oil remains adhering to the wire in the form of an oil film and very little is stripped off by the dies. The oil adhering to the wire is also sufficient for the lubrication in the last three drawing stages so that no oil needs to be supplied in these stages, and even after leaving the last stage, the drawn wire still has a thin film of oil on it acting as a protective layer against corrosion. The dies of all drawing stages are surrounded by cooling jackets in the usual manner, which are connected to the water cooling system of the welding machine. It should be noted in this connection, however, that water cooling of the drawing plate is not absolutely essential because the frictional heat developed is relatively little because of the relatively low drawing speed preset by the welding machine and therefore even convection cooling by a surrounding atmospheric flow would be sufficient.

After leaving the last drawing stage, the round copper wire is then annealed in a continuous process and for this purpose is first preheated to about 80°C to 110°C by means of a current conducted through the wire over a pre-annealing section about 30cm long and is then

heated to 220°C to 250°C likewise by means of a current conducted through the wire over a main annealing section about 30cm long and is then conveyed through a cooling section about 30cm long. The pre-annealing and main-annealing sections and also the cooling section can be kept so short because of the relatively low wire speed of only 4.88m/sec. In order to avoid oxidation the pre-annealing, main-annealing and cooling sections lie in a passage which is S-shaped in the present case and through which nitrogen is conveyed from the outlet of the cooling section and is subsequently used as protective gas for the welding. The passage may further extend over the whole drawing device, which may be considered, in particular, if water cooling of the drawing dies is dispensed with and the nitrogen flow is used for convection cooling instead and also prevents oxidation of the wire during drawing in the event of relatively great heating in the dies. In this last case, the pre-annealing stage may also be dispensed with. At the outlet from the cooling section, the stream of nitrogen enters the said passage and then flows, counter to the direction of movement of the wire, through the portions of the passage surrounding the cooling section, the main annealing section and the pre-annealing section, and then possibly also through a portion of passage surrounding

the drawing device and is then conveyed to the welding station as protective gas. After leaving the cooling section, the annealed wire lubricated with a film of oil is then wound on spools by means of a winding device with
5 a basic construction like the winding device already described above in connection with the first example to be supplied, with these spools, for further application.

Finally, in order to define the terms used, it is pointed out that the line on which, if the wire were
10 divided into thin discs transversely to the longitudinal direction of the wire, the centres of gravity of the individual discs would lie is termed the "centre of the wire" and the shortest distance between two points on the surface of the wire, the rectilinear connection of which
15 extends through the centre of the wire is termed the "smallest external dimension of the deformed and contaminated copper wire".

CLAIMS

1. A method of permitting reuse of a copper wire which is employed in a first application as a wire electrode for electrical resistance longitudinal seam welding, e.g. for tinned sheet, and for this purpose is formed into a wire with a cross-section different from a circular form, e.g. into a flat wire, before this first application and hardened in this form and which is contaminated during this first application in the region coming into contact with the weld by material originating from the weld and passing over to the wire during welding, after said application as an electrode the wire being drawn in a multiplicity of drawing stages in a wire-drawing device in such a manner that the distances from the centre of the wire of the peripheral regions of the wire most distant from the centre are reduced in all drawing stages and the distances from the centre of the wire of the peripheral regions nearest to the centre are reduced in one or more of the drawing stages, and further that the distances of the peripheral regions most distant from the centre are reduced successively in the drawing stages, at least to such an extent that they become smaller than the distances from the centre of the wire of the peripheral regions nearest to the centre before drawing, and that the distances from the centre of the



5 wire of the peripheral regions nearest to the centre are reduced in the said part of the drawing stages to such an extent that after passing through the last drawing stage they are as large as the distances from the centre of the wire of the peripheral regions having previously been most distant from the centre, so that a round copper wire with circular cross-section and a smaller diameter than the smallest outer dimension of said contaminated wire is drawn from said contaminated wire in the wire-drawing device, and that this new round copper wire is supplied for a further application.

2. A method according to claim 1 wherein the new wire drawn in the drawing device is supplied for a further application different from said welding electrode application.

3. A method according to claim 2 wherein said further application for which the new wire is supplied is a permanent application, e.g. as a signal conductor or winding wire.

20 4. A method according to any one of claims 1-3 wherein the new wire drawn in the drawing device before being passed to said further application is provided with an insulating sheath, e.g. a coating of lacquer or varnish.

25 5. A method according to any one of claims 1-4



wherein the new wire drawn in the drawing device is annealed after leaving the last drawing stage by heating the wire at least to a temperature corresponding to its recrystallization temperature and preferably to a temperature exceeding the recrystallization temperature.

6. A method according to any one of claims 1-5 wherein before the first application, the wire is hardened such that after the first application its fracture elongation is less than ten percent, and the contaminated wire is annealed before passing through the first stage of the drawing device by heating to a temperature corresponding at least to its recrystallization temperature and preferably to a temperature above the recrystallization temperature.

7. A method according to any one of claims 1-6 wherein a drawing device is employed which has an operating capacity per unit of time amounting to a multiple of the wire electrode consumption rate per unit of time of the welding machine employed for said seam welding, and for improved utilization of the operating capacity of the wire drawing machine the wire electrodes from several welding machines employed for said seam welding are collected after their use as electrodes and these collected, contaminated wires are then passed one after another through the wire drawing device.



6. A method according to claim 7 wherein for collecting a wire electrode after its use in a welding machine, a driven spool, preferably a flanged spool, is employed, and the wire electrodes are wound onto this
5 spool in layers the drive for the spool being controlled by the welding machine and is preferably located at the welding machine.

9. A method according to any one of claims 1-8 wherein the copper wire is deformed in the first
10 application to a cross-sectional shape in which the distances from the centre of the wire of the peripheral regions lying closest to the centre are less than 0.7 times the distances of the peripheral regions most distant from the centre, the deformed and contaminated
15 wire being drawn in the drawing machine such that the distances from the centre of the wire of the peripheral regions lying closest to the centre before the drawing are only reduced in the last stage or the last few stages and accordingly in the last or the last few drawing
20 stages, only the distances from the centre of the wire of the peripheral regions most distant from the centre are reduced, while at least in the last or the last few drawing stages, and preferably however in all drawing stages, drawing plates or dies being employed with
25 rotationally symmetric drawing holes.



10. A method according to claim 9 wherein the wire is deformed in the first application to a cross-section in which the distances from the centre of the wire of the peripheral regions lying closest to the centre are preferably less than 0.5 times the distances of the peripheral regions most distant from the centre, and in at least some of the drawing stages for the contaminated wire only the distances from the centre of the wire of the peripheral regions most distant are reduced through the rotationally symmetric drawing holes provided in said drawing stages, the wire being guided in the drawing holes for said stages by guiding means projecting into the holes such that bending of the wire in the direction of one of its peripheral regions lying closest to the centre is avoided.

11. A method according to claim 10 wherein at the or each stage in which said wire guidance is employed there is a plate positioned at the inlet side of the drawing die, the plate being provided with a slit as well as with two nose-like projections positioned on the side of the plate facing the drawing die and projecting into the drawing hole, which projections stand opposite one another with backs of the projections remote from one another and lying against the wall of the rotationally symmetric drawing hole and the projections having



adjacent wall surfaces defining the slit connecting preferably break-free with the wall surfaces of the drawing hole between them to define the slit and having at least in the region or regions of the drawing hole, in which the cross section of the hole is reduced from the inlet side toward the outlet side of the dies, a distance from one another corresponding at least approximately to the distance of the peripheral regions of the wire lying closest to the wire centre, so that the slit together with the adjacent wall surfaces of the projections and the wall surfaces of the drawing holes not obstructed by the projections form a drawing channel in which only the peripheral regions of the wire most distant from the centre of the wire coming into contact with the wall surfaces of the drawing hole not covered by the projections are reduced and bending of the wire in the direction of one of its peripheral regions lying closest to the wire centre is prevented by the wall surfaces of the projections adjacent to one another.

12. A method according to claim 11 wherein for securing the drawing die and plate securing means are employed with which the drawing die and the plate are rotatable relative to one another and are settable in various angular positions so that the drawing die is fully usable n times by setting of the drawing die and



plate relative to one another in n different angular positions displaced from one another at each $180^\circ/n$ whereby n is a whole number which is larger than 1 and smaller or at the most equal to 90° divided by $\arcsin a/d$, a being equal to the distance between the peripheral regions of the wire lying closest to the wire centre and d being equal to the diameter of the drawing hole at the position of its minimum hole cross section.

13. A method according to claim 11 or claim 12 wherein the plate provided with the slit and the nose-like projections has at least its wall portions coming in contact with the wire passing therethrough, and preferably at least the nose-like projections and the associated wall parts of the walls bounding the slit, formed of a hard metal.

14. A device for performing the method according to any one of claims 1-13 comprising a welding machine for electrical resistance longitudinal seam welding with the use of a wire electrode, and a wire drawing device integrated into the welding machine for drawing the resulting used wire electrode in the form of a deformed and contaminated copper wire into a new round copper wire with a circular cross section and a smaller diameter than the minimum outside measurement of the deformed and contaminated copper wire.



15. An installation for performing the method according to any one of claims 1-13 comprising a plurality of welding machines for electrical resistance seam welding with the use of wire electrodes, and means for collecting the resulting used electrodes in the form of deformed and contaminated copper wires at each of the welding machines and an individual wire drawing machine with an operational capacity per unit of time corresponding at least to the total wire electrode consumption of all the welding machines per unit of time for drawing the collected used wire electrodes from all of the machines into new wire electrodes with circular cross sections and a diameter smaller than the smallest outside measurement of the deformed and contaminated copper wires.

16. An installation according to claim 15 wherein the means for collecting the used wire electrodes comprising at least one driven spool, preferably a flanged spool, at each of the welding machines for winding the used wire electrodes onto the spool, means for driving the spool, and control means for control of the driving means and preferably as well means for guiding the used wire electrodes onto the spool in layers.

17. A method of permitting reuse of a copper wire which is employed in a first application as a wire



* C L N S *

electrode for electrical resistance longitudinal seam welding, substantially as described herein with reference to the two exemplary embodiments.

16. Apparatus for performing a method of permitting
5 reuse of a copper wire which is employed in a first application as a wire electrode for electrical resistance longitudinal seam welding, substantially as described herein with reference to the two exemplary embodiments.

19. A reused copper wire produced from a deformed and
10 contaminated electrode wire by the method of any one of claims 1-13 and 17.

