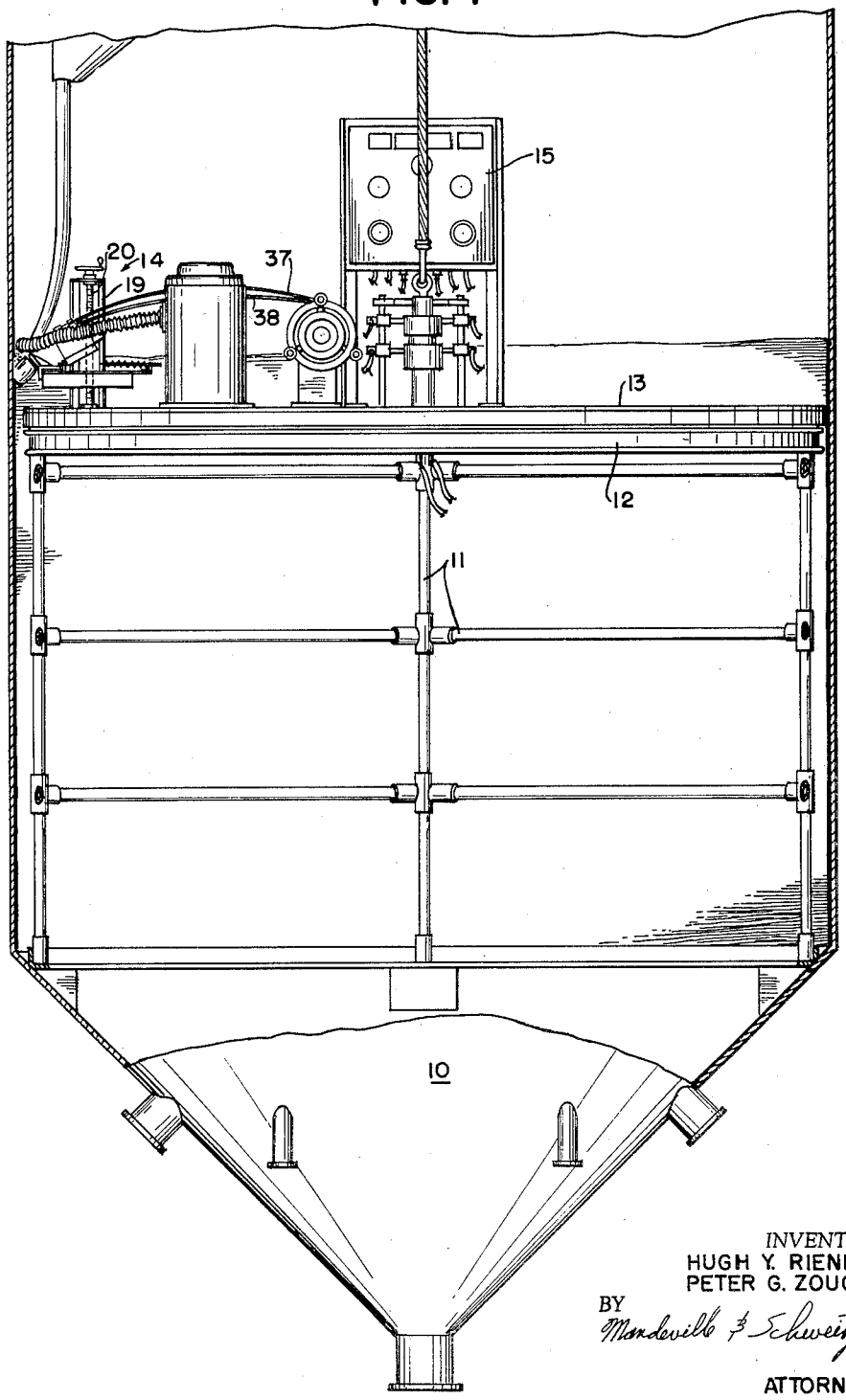
May 12, 1964 H. Y. RIENHOFF ETAL 3,133,184

METHOD AND APPARATUS FOR MULTIPLE OVERLAY ALLOY CLADDING OF BASE METALS

Filed Oct. 19, 1961 4 Sheets-Sheet 1

FIG. 1



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METHOD AND APPARATUS FOR MULTIPLE OVERLAY ALLOY CLADDING OF BASE METALS

Filed Oct. 19, 1961

4 Sheets-Sheet 2

FIG. 3

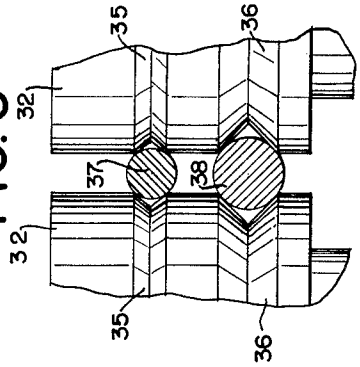


FIG. 2

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METHOD AND APPARATUS FOR MULTIPLE OVERLAY ALLOY CLADDING OF BASE METALS

Filed Oct. 19, 1961 4 Sheets-Sheet 3

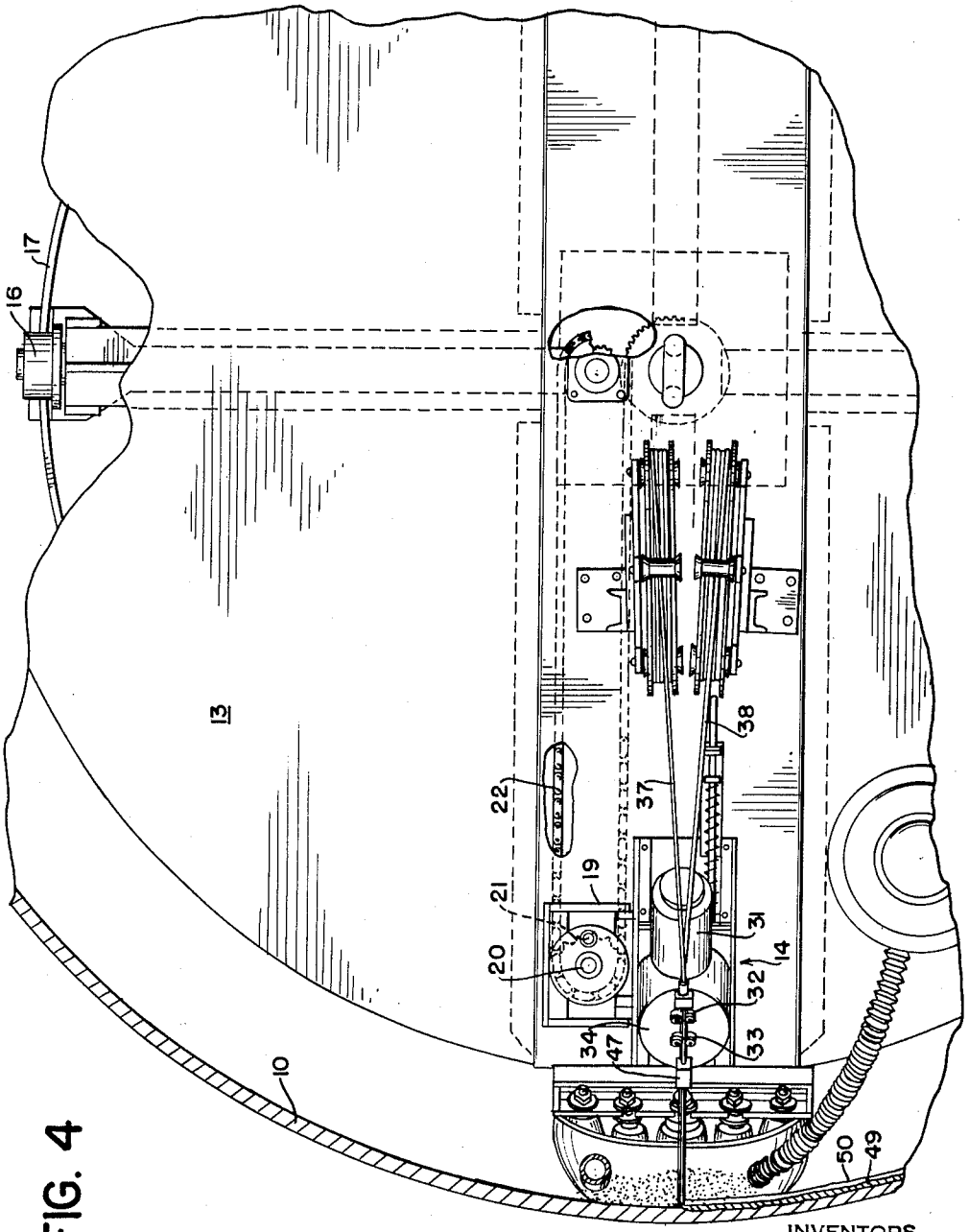


FIG. 4

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ALLOY CLADDING OF BASE METALS
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FIG. 5

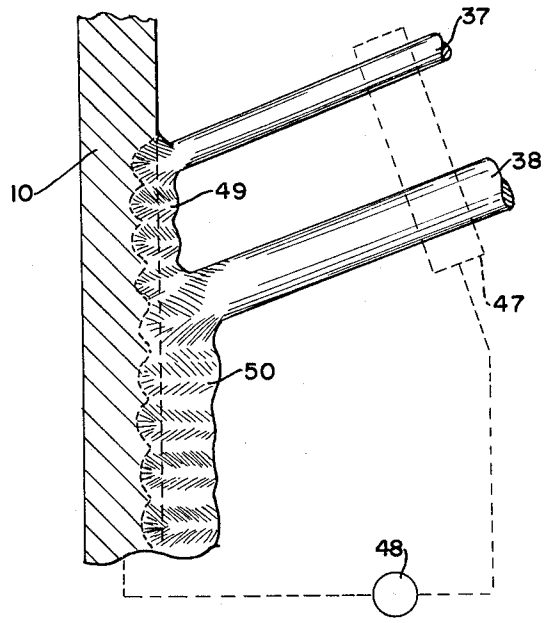
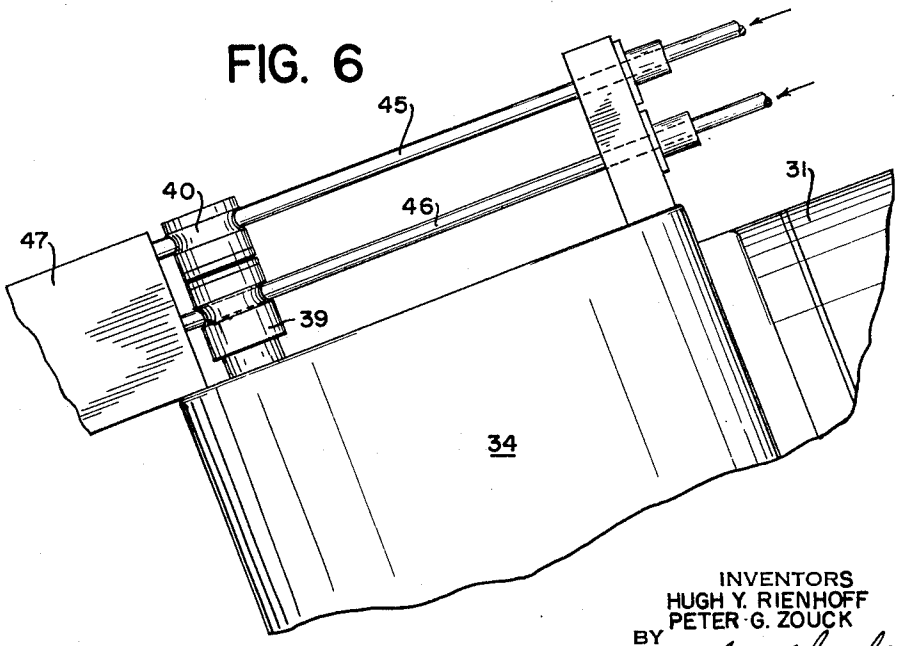


FIG. 6



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United States Patent Office 3,133,184 Patented May 12, 1964

3,133,184

METHOD AND APPARATUS FOR MULTIPLE OVERLAY ALLOY CLADDING OF BASE METALS

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Filed Oct. 19, 1961, Ser. No. 146,254
24 Claims. (Cl. 219—76)

The present invention relates to the alloy-cladding or lining of base metal surfaces, and particularly the inner walls of vessels or containers, for example, for improvement of corrosion resistance or the like. In specific respects, the invention represents an improvement over the method and apparatus of our prior United States Patent 2,902,588, owned by the assignee of this invention. However, the subject of the present invention has wider application, as will be indicated herein.

As mentioned in our prior Patent No. 2,902,588, it is often necessary or desirable to line the interior wall of a vessel with an alloy material to improve corrosion resistance. By way of example, in certain paper-making processes, it is conventional to cook pulp in a large vessel, known as a digester. The cooking process takes place in a liquor which is highly corrosive in nature and tends to corrode the inner walls of the digester. As set forth in our before mentioned prior patent, it has been found that the corrosion resistance of digesters and other vessels can be significantly increased by lining the interior walls with a material such as stainless steel alloy, and our prior patent is directed to a novel and improved procedure for economically and substantially continuously applying the alloy by arc weld cladding techniques.

One of the inherent difficulties encountered in connection with the stainless steel alloy cladding of an ordinary steel vessel resides in the fact that substantial dilution of the welding alloy with the base metal material occurs during the weld cladding process. Thus, in a typical weld cladding operation, the stainless steel weld alloy material may be diluted by approximately an equal amount of the base metal material, by reason of the mixing which occurs in the molten pool of metal produced by the welding arc. The final weld bead, in such cases, is a 50–50 mixture of the base metal and the welding alloy. Further, although it is possible in special cases to limit the dilution of the weld bead to a lesser amount the techniques required to achieve lower dilution cause conditions of instability with respect to the welding process, such that uniform cladding is extremely difficult. Accordingly, where the cladding is carried out by automatic, self-propelling welding apparatus, it is impractical to seek to reduce the base metal dilution significantly below the 50% level.

A typical stainless steel welding alloy type 310 stainless steel, includes as significant alloy constituents approximately 27% chrome and 21% nickel. When applying such an alloy in a typical cladding operation, wherein a 50% dilution by base metal is experienced, the resulting weld bead which forms the cladding layer comprises about 13.5% chrome and about 10.5% nickel. Such an alloy is not, however, high enough in alloy content for most applications and it is subject to gradual corrosion under contemplated operating conditions.

Theoretically, it would be possible to achieve a desired, true stainless steel alloy cladding layer by increasing the percentages of chrome and nickel in the stainless steel welding rod material. However, as a practical matter, such richer alloys are incapable of being rolled or drawn into usable wire form on an economical basis.

In accordance with one of the significant aspects of the present invention, an effective stainless steel alloy cladding layer is provided by applying to the base metal

surface a stainless steel alloy weld material to form a first weld bead in which the alloy material is substantially (e.g., 50%) diluted by the base metal material. The first weld bead is allowed to solidify, and thereafter a second stainless steel alloy weld material is overlaid. The rate of application of the second weld material is calculated to be such as to cause the second applied weld material to dissolve the first weld bead substantially entirely, without dissolving any significant further amounts of the base metal material. The resulting final weld bead has significantly increased percentages of the important alloy constituents, such that a high alloy stainless steel surface cladding is afforded.

Another significant aspect of the invention resides in the provision of a novel apparatus and procedure for simultaneously and with a single apparatus applying two or more beads of weld metal in succession and according to the principles outlined in the preceding paragraph, in such manner as to reliably achieve, in an automatic process, a uniform surface cladding of the desired alloy composition. To this end, in a practical embodiment of the invention means are provided for simultaneously feeding a pair of weld rods by an automatically progressing welding head, such that first and second weld beads are laid down in a predetermined sequence and in predetermined, accurately controlled proportions, whereby proper dissolution of the first weld bead by the second is achieved.

For a better understanding of the invention, reference should be made to the following detailed description and to the accompanying drawing, in which:

FIG. 1 is a fragmentary cross-sectional view of a typical digester or other vessel having positioned therein an apparatus according to the invention for applying a high alloy stainless steel surface cladding;

FIG. 2 is an enlarged, fragmentary, cross-sectional view of the apparatus of FIG. 1, showing particularly the manner in which successive weld beads are laid down in predetermined, desired relationship;

FIG. 3 is an enlarged, fragmentary view, partly in section, of a novel form of weld rod feeding head for achieving proportioned application of weld rod material according to the invention;

FIG. 4 is a fragmentary top plan view of the vessel and apparatus of FIG. 1;

FIG. 5 is an enlarged, fragmentary, cross sectional view illustrating the manner in which successive alloy weld beads are applied in accordance with the invention; and

FIG. 6 is an enlarged, fragmentary view, with parts broken away, of a modified form of welding head for feeding a pair of weld rods to apply successive weld beads in predetermined proportion.

Referring now to the drawing and initially in FIGS. 1–4, the reference numeral **10** designates generally a steel vessel, which typically may be a digester vessel used in paper making processes, for example. As set forth in more detail in our prior United States Patent No. 2,902,588, the cylindrical interior wall of the vessel **10** can be clad in an advantageous and economical manner using an apparatus comprising a support structure **11**, consisting of a plurality of structural modules and supporting a track structure **12**. A platform **13** is mounted for rotation on the track structure **12** and carries an automatic welding apparatus, generally designated by the numeral **14**, and a suitable control panel **15** for the welding apparatus.

For specific details of the construction and general operation of the automatic weld cladding installation, reference may be made to our prior patent, the disclosure of which may be considered to be incorporated herein by reference. For the purpose of this description, it is

sufficient to note that the platform 13 is provided with a plurality of flanged wheel 16 (FIG. 2) supported by a circular track 17. At least one of the wheels is driven by a motor 18, which may be controlled to rotate the platform at a desired speed. The welding head 14 is mounted on a vertical guide assembly 19 and positioned thereon by a threaded shaft 20. The shaft 20 has a sprocket 21 at its lower end and is driven by a chain 22 in accordance with the rotation of the platform 13. The arrangement is such that, as the platform rotates, the welding head 14 is gradually raised so that a spiral weld bead is laid down. The pitch of the spiral advantageously may be somewhat less than the width of the weld bead, in a single head apparatus, whereby successive revolutions of the platform 13 will cause overlapping weld beads to be laid on the vessel wall to form a continuous surface cladding.

In accordance with one of the significant aspects of the invention, the method and apparatus of the improved system provides for the laying of two successive beads of alloy welding material in predetermined relation, such that the completed layer of cladding material is substantially homogeneous and has predetermined minimum proportions of desired alloy constituents. To this end, the first-laid weld bead advantageously is made by a type 446 stainless steel welding rod, the primary alloy constituent of which is chromium. The second-laid weld bead advantageously is made by a type 310 stainless steel welding rod, containing a substantial percentage of nickel, as well as chromium. It will be understood, however, that other alloying materials may be employed within the purview of the invention.

In laying a first weld bead with type 446 stainless steel weld rods, using automatic welding techniques substantially as set forth in our prior Patent No. 2,902,588, there normally will be approximately 50% dilution of the welding alloy. Thus, with type 446 stainless steel welding rod, incorporating approximately 27% chromium, there will be a resulting weld bead in the form of a substantially homogeneous 50–50 mixture of the welding alloy and the base metal. And, assuming the base metal to be ordinary steel, the resulting alloy weld bead will have as a principal alloy constituent approximately 13.5% chromium.

The cladding alloy provided by the first-laid weld bead, having as its major constituent only about 13.5% chromium, while representing a significant improvement over the base metal material in respect of corrosion resistance, is still undesirably susceptible to corrosive attack. Accordingly, the invention involves the overlaying of the first bead by a second bead, which dissolves the first bead and forms an intermediate alloy material having desirable percentages of the major alloy constituents. Thus, using a type 310 stainless steel alloy welding rod to make the second-laid weld bead and laying the bead in such manner as to substantially dissolve the first bead without dissolving significant amounts of the base metal, the alloy material of the second weld material is diluted only by the alloy material of the first weld bead. With type 310 stainless steel welding rod, including as its major alloy constituents about 27% chromium and about 21% nickel, and assuming a 50% dilution of the second-laid bead by the first-laid bead, the resulting bead is a substantially homogeneous alloy mixture comprising about 20% chromium and about 10.5% nickel. The thus resulting alloy has a high alloy content and is highly resistant to the corrosive attack experienced in a digester, for example.

In one advantageous cladding procedure according to the invention, the first-laid weld bead may be made with a 0.110 inch diameter type 446 stainless steel electrode, which is deposited at a rate of 2.5 pounds of electrode material per square foot of surface. The resulting alloy bead, assuming a 50% dilution by the base metal, will have an effective weight of 5 pounds per square foot of surface. The second-laid bead is made with a 0.156 inch diameter electrode of type 310 stainless steel, which is

applied at the rate of 5 pounds per square foot of surface. Again assuming a 50% dilution, the 5 pounds per square foot of the second electrode material is diluted by the 5 pounds per square foot of the diluted first weld bead, such that the resulting cladding material has an effective weight of 10 pounds per square foot of surface, of which 7.5 pounds are represented by the electrode materials, while 2.5 pounds consist of the base metal. The effective dilution of the cladding material thus is about 25%, and the resulting intermediate alloy has adequately high percentages of the significant alloy constituents.

In accordance with one aspect of the invention, the novel cladding procedure, as described above, may be carried out by a single welding head arranged to feed simultaneously and at the same rate a pair of spaced electrode wires, whose respective diameters are such as to provide the desired proporations of weld rod deposition. By way of example, in carrying out the method of the invention using first and second electrodes of 0.110 inch and 0.156 inch diameter respectively as described above, means are provided for feeding the electrode rods at an equal rate, to result in the deposition of approximately twice as much of the second electrode material as of the first electrode material.

Referring specifically to FIGS. 2 and 3, the welding head 14 comprises an electrically actuated and automatically controlled electric motor 31, which actuates feed rollers 32, 33 through an appropriate gear box 34. As shown in detail in FIG. 3, the feed rollers 32, 33 are arranged in pairs, and each roller of a pair is provided with spaced grooves 35, 36 of an appropriate size and shape to receive respective electrode rods 37, 38.

In the illustrated form of the invention, the progression of weld rod deposition is spirally upward and, accordingly, the dispositoin of the pairs of feed rollers 32, 33 is such as to support the "first" welding electrode generally above the "second" electrode, by a predetermined spacing. Other configurations are, of course, possible, a primary requirement being that the "first" weld bead is laid down sufficiently in advance of the "second" weld bead, in the direction of progression of the cladding operation, that the first weld bead has had an opportunity to solidify before the second bead is applied thereover.

Where, as in the example above specified, the second electrode rod has an area equal to twice that of the first electrode rod, and advancement or feeding of the respective rods is to occur at the same rate of speed, the respective grooves 35, 36 in the feed rollers 32, 33 must be contoured to engage the rods at points equidistant from the roller axes. In the arrangement specifically illustrated in FIG. 3, this is accomplished by contouring the grooves to engage the respective weld rods near the periphery of the feed rollers. The arrangement is such that the annular areas of the feed rollers which have driving contact with the respective weld rods have equal effective diameters. Conveniently, this is accomplished by using V-shaped grooves, the size and included angle of which is such as to bring the walls of the grooves into tangent relation with the weld rods immediately adjacent the cylindrical peripheral surface of the feed rollers.

A modified arrangement for feeding the respective first and second welding rods is illustrated in FIG. 6, wherein the motor 31 and gear box 34 drive pairs of feed rollers generally designated by the numerals 39, 40. The pairs of rollers in the illustrated arrangement are rotatable at different speeds with respect to each other. Further modification, such as feeding the separate rods with pairs of rollers of different diameter, readily suggest themselves to persons skilled in the art.

In the mechanism of FIG. 6, the pairs of feed rollers 39, 40 guide and feed first and second welding rods 45, 46 whose relative sizes need not correspond to the relative rates of desired weld rod deposition. Thus, although it is desired to effect deposition of the material of the weld rod 46 at a rate twice as great as that of the weld rod 45,

for example, the respective weld rods actually may be of equal size, with provision being made to drive the inner pair of feeding rollers **39** at double the effective speed of the outer pair of rollers **40**. Further, by relating the operating speeds of the inner and outer pairs of rollers through suitable variable transmission means (not shown) a variety of control effects may be achieved.

In accordance with a significant aspect of the invention, both of the weld rods are supplied with arcing current from the same terminal source, such that the voltage supplied to one electrode is substantially identical to that supplied to the other. Thus, a single brush contact member **47** (FIGS. 2 and 5) engages and makes electrical contact with outer portions of the electrodes and is connected to one terminal of a source **48**. The other terminal of the source is connected directly to the base metal to be weld cladded. Welding current is divided between the respective electrodes largely in accordance with the condition of the respective arcs in a manner which provides substantial mutual compensation for any tendency of one electrode to burn off at a faster rate than the other. For example, in the illustration of FIG. 5, any tendency of the electrode **37** to draw excessive current and burn off at a faster than desired rate will immediately effect a lengthening of the arc and cause a diversion of a greater proportion of the current to the electrode **38**. A similar effect is achieved in the modified arrangement of FIG. 6.

In practice, it has been found that the use of a single supply source for the first and second electrodes, by contacting both electrodes with a single brush element **47**, provides an extremely stable welding condition, which reliably assures the proper proportional deposition of the respective weld material.

In the operation of the device of the invention, arcs are struck between the first and second welding electrode materials and the platform **13** is driven in a rotary manner and at a predetermined speed to effect the simultaneous deposition of a pair of spaced weld beads. In conjunction with the rotary motion of the platform, the platform is progressively raised, so that the spaced beads actually are laid in spiral fashion, with the lead of the spiral being slightly less than the width of the narrowest weld bead to assure complete cladding of the surface of the vessel as the platform goes through successive revolutions.

The first and second welding rod are spaced apart a distance sufficient to prevent merging of the molten pools formed by the respective arcs and also sufficiently far apart in terms of time to permit solidification of the first weld bead prior to the application thereover of the second weld bead as the deposition progresses in a spiral manner. In the illustrated apparatus, in which the respective welding rods are spaced apart in the direction of axial progression of the platform, a three-eighths inch spacing has been found to be particularly satisfactory. Further, when employing the new procedure in conjunction with an automatic apparatus, such as described and claimed in our Patent No. 2,902,588, it is especially advantageous to space the respective weld rods a distance equal to a multiple of the lead of the weld bead advancing mechanism, so that the second weld bead is laid directly over the first. Thus, where the weld beads are laid in a spiral manner, with a lead of three-sixteenths inch, for example, a weld rod spacing of three-eighths inch is appropriate.

As shown in FIG. 5, successive cycles of operation causes overlapping beads to be applied by the first weld rod **37** to form a continuous surface layer **49** comprising the weld rod alloy material about 50% diluted by the base metal material. After an axial progression of the equipment a distance equal to the spacing between the respective welding electrodes, the surface **49** is overlaid by the second weld bead, which forms a continuous surface **50**, consisting of the second electrode material diluted about 50% by the material of the first surface **49**.

In the formation of the final surface **50**, the alloy material of the second welding electrode **38** completely dissolves the material of the first surface **49**, so that the final surface **50** is a substantially homogeneous mixture consisting of about 50% material of the second electrode, about 25% material of the first electrode and about 25% base metal material. Thus, where the electrodes are conventional stainless steel alloy materials, the final clad surface **50** will contain sufficient percentages of the significant alloy constituents to have desired characteristics for corrosion resistance, while the material of the first applied surface **49**, being excessively diluted by the base metal material, will not have these characteristics.

In actual practice, small percentages of the base metal may be dissolved during the laying of the second weld bead, because of practical operating tolerances of the control system or because, in a particular instance, the dissolution of minor additional amounts of base metal does not render the cladding alloy unsuitable for a particular use. It is intended that such minor departures from the theoretical ideal be included within the definition of the process as including a second welding overlay accomplished without dissolving significant amounts of base material.

The method and apparatus of the invention represent a significant advance in the art of protectively cladding base metal materials, particularly where high alloy content is desired in the clad surface. Further, the invention is fully compatible with the advantageous method and apparatus of our prior United States Patent No. 2,902,588, in that it advantageously may be carried out in a semi-continuous manner as described and claimed in the patent, with low cost modification of the prior equipment.

It should be understood, however, that the method and apparatus of the above invention have wide application and are not necessarily limited to uses contemplated by our prior patent. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

We claim:

1. The method of applying an anti-corrosion weld overlay to a steel vessel wall which comprises applying to said wall a first layer of weld overlay material in a manner providing a first weld bead alloy material consisting of a substantial percentage of the base metal of the wall, causing said first layer to solidify, and thereafter applying to the overlaid wall a second layer of weld overlay material in a manner to dissolve substantially completely the first weld bead alloy and to form a second weld bead alloy material of predetermined characteristics.

2. The method of claim 1, in which said weld overlay materials comprise stainless steel alloys including in excess of 20% chrome.

3. The method of claim 2, in which the first weld overlay material is an alloy substantially corresponding to type 446 stainless steel, and said second overlay material is an alloy substantially corresponding to type 310 stainless steel.

4. The method of claim 3, in which said first weld bead alloy material comprises on the order of 50% base metal of the vessel wall and said second weld bead alloy material comprises on the order of 50% first weld bead alloy material.

5. The method of claim 1, in which said second weld bead alloy material comprises on the order of 20% chrome.

6. The method of claim 1, in which said first weld bead alloy material comprises more than one-third but less than two-thirds base metal of the vessel wall, and said second weld bead alloy material includes substantially all of said first weld bead alloy material and comprises more than one-third but less than two-thirds first weld bead alloy material.

7. The method of claim 6, in which said first weld bead

alloy material comprises on the order of 13% to 14% chrome and said second weld bead alloy material comprises on the order of 20% chrome.

8. The method of claim 7, in which said second weld bead alloy material comprises on the order of 10% to 11% nickel.

9. The method of applying a weld overlay of predetermined composition to a base metal which comprises applying to said base metal a first layer of weld overlay material in a manner providing a first weld bead alloy material comprising more than one-third but less than two-thirds base metal, causing said first weld bead alloy material to solidify, and thereafter applying to the overlaid base metal a second layer of weld overlay material in a manner providing a second weld bead alloy material comprising more than one-third but less than two-thirds first weld bead alloy material.

10. The method of claim 9, in which said second weld bead alloy material includes substantially all of said first weld bead alloy material.

11. The method of alloy cladding a base metal surface which comprises advancing over the surface in successive rows a pair of widely spaced welding rods, establishing an arc welding relationship between the surface and each of the rods to simultaneously apply separate, spaced weld beads of alloy cladding material, the rate of application of successive rows being such, in relation to the separation of said spaced weld beads, as to cause the leading bead in the direction of progression of the rows to become solid before the leading bead is overlaid with the following bead, said leading and following beads being so related that substantial amounts of the leading bead are dissolved in the following bead to form a predetermined cladding alloy.

12. The method of claim 11, in which said rods are spaced apart a distance sufficient to prevent merging of the pools of molten metal formed by the respective arcs.

13. The method of claim 11, in which the rate of application of weld rod metal from the following rod, in relation to the rate of application of weld rod metal from the leading rod, is inversely proportional to the proportion of base metal dissolved in the leading bead and the proportion of leading bead dissolved in the following bead.

14. The method of claim 13, in which said weld rods are fed at different rates of speed.

15. The method of cladding a base metal to provide an alloy surface having a predetermined constituent in a significantly greater proportion than originally present in the base metal, which comprises applying a first weld material to the base metal to form a weld bead between one-third and two-thirds of which consists of said first weld material, said first weld material comprising a predetermined proportion of said predetermined constituent, causing said weld bead to solidify, and applying a second weld material over said weld bead in a manner to substantially entirely dissolve the first weld bead without dissolving substantial additional amounts of base metal, said second weld material comprising a predetermined proportion of said predetermined constituent.

16. Apparatus for alloy cladding of a base metal surface, comprising means for supporting and feeding a pair of welding rods, said supporting and feeding means mounting said rods in sufficiently spaced relation to enable the simultaneous deposition of separate weld beads, means to advance the welding rods across the base metal surface for the deposition of spaced weld beads in side-by-side relation, and means to progress the welding rods in a direction generally transverse to the weld beads, the magnitude of progression being a multiple of the spacing of the weld beads, whereby, in a continuing sequence of directly overlaid by the second weld bead.

17. The apparatus of claim 16, which includes means for applying substantially equal arc welding voltage between said base metal surface and said welding rods.

18. The apparatus of claim 16, in which said welding rods are of different sizes, such that the weld metal deposition in applying the second weld bead is greater to a predetermined extent than the weld metal deposition in applying the first bead.

19. The apparatus of claim 16, in which said supporting and feeding means comprises means for feeding one of said rods at a predetermined greater speed than the other rod, such that the weld metal deposition in applying the second weld bead is greater to a predetermined extent than the weld metal deposition in applying the first bead.

20. The method of alloy cladding a base metal surface, which comprises applying to said base metal a first layer of weld overlay material in a manner providing a first weld bead alloy material, causing said first weld bead alloy material to solidify and thereafter applying to the overlaid base metal a subsequent weld overlay material in a manner substantially completely to dissolve the first weld bead alloy material without dissolving significant additional amounts of the base metal material.

21. The method of alloy cladding a base metal surface which comprises advancing over the surface in successive rows a pair of widely spaced welding rods, establishing an arc welding relationship between the surface and each of the rods to simulanteously apply separate, spaced weld beads of alloy cladding material, the rate of application of successive rows being such, in relation to the separation of said spaced weld beads, as to cause the leading bead in the direction of progression of the rows to become solid before the leading bead is overlaid with the following bead, and the rate of application of the weld rod metal from the following rod, in relation to the rate of application of the weld rod metal from the leading rod, being inversely proportional to the proportion of base metal dissolved in the leading bead and the proportion of leading bead dissolved in the following bead, and metal from the following rod being applied on the order of two times the rate of application of metal from the leading rod.

22. The method of alloy cladding a base metal surface which comprises advancing over the surface in successive rows a pair of widely spaced welding rods, establishing an arc welding relationship between the surface and each of the rods to simultaneously apply separate, spaced weld beads of alloy cladding material, the rate of application of successive rows being such, in relation to the separation of said spaced weld beads, as to cause the leading bead in the direction of progression of the rows to become solid before the leading bead is overlaid with the following bead, and the rate of application of the weld rod metal from the following rod, in relation to the rate of application of the weld rod metal from the leading rod, being inversely proportional to the proportion of base metal dissolved in the leading bead and the proportion of leading bead dissolved in the following bead, said weld rods being of different sizes and being fed at the same rate of speed.

23. The method of alloy cladding a base metal surface which comprises advancing over the surface in successive rows a pair of widely spaced welding rods, establishing an arc welding relationship between the surface and each of the rods to simultaneously apply separate, spaced weld beads of alloy cladding material, the rate of application of successive rows being such, in relation to the separation of said spaced weld beads, as to cause the leading bead in the direction of progression of the rows to become solid before the leading bead is overlaid with the following bead, and the rate of application of the weld rod metal from the following rod, in relation to the rate of application of the weld rod metal from the leading rod, being inversely proportional to the proportion of base metal dissolved in the leading bead and the proportion of

leading bead dissolved in the following bead, said weld rods being of different sizes and being fed at different rates of speed.

24. The method of alloy cladding a base metal surface which comprises advancing over the surface in successive rows a pair of widely spaced welding rods, establishing an arc welding relationship between the surface and each of the rods to simultaneously apply separate, spaced weld beads of alloy cladding material, the rate of application of successive rows being such, in relation to the separation of said spaced weld beads, as to cause the leading bead in the direction of progression of the rows to become solid before the leading bead is overlaid with the following bead, and the rate of application of the weld rod metal from the following rod, in relation to the rate of application of the weld rod metal from the

leading rod, being inversely proportional to the proportion of base metal dissolved in the leading bead and the proportion of leading bead dissolved in the following bead, about one half of the leading weld bead consisting of base metal and about one half of the following weld bead consisting of the leading weld bead.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,133,184 May 12, 1964

Hugh Y. Rienhoff et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 2, for "wheel" read -- wheels --; column 4, line 17, for "proporations" read -- proportions --; line 35, for "dispositoin" read -- disposition --; column 7, line 73, after "of" insert -- operations, the first-laid weld bead is progressively and --; column 8, line 28, for "simulanteously" read -- simultaneously --; column 10, line 13, under "References Cited" for "Zouch" read -- Zouck et al. --.

Signed and sealed this 15th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

UNITED STATES PATENT OFFICE

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Signed and sealed this 15th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents