Aug. 2, 1966 R. F. ARNOLDY 3,264,445

WELD OVERLAY

Filed Sept. 23, 1963 4 Sheets-Sheet 1

Fig. 1

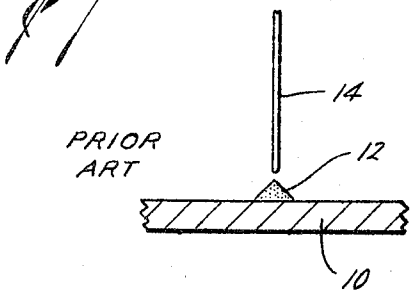
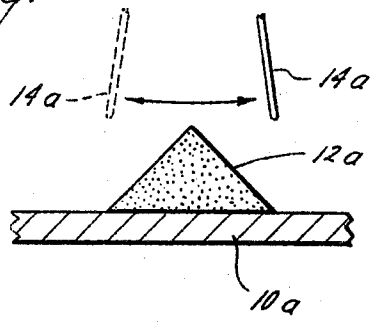


Fig. 2



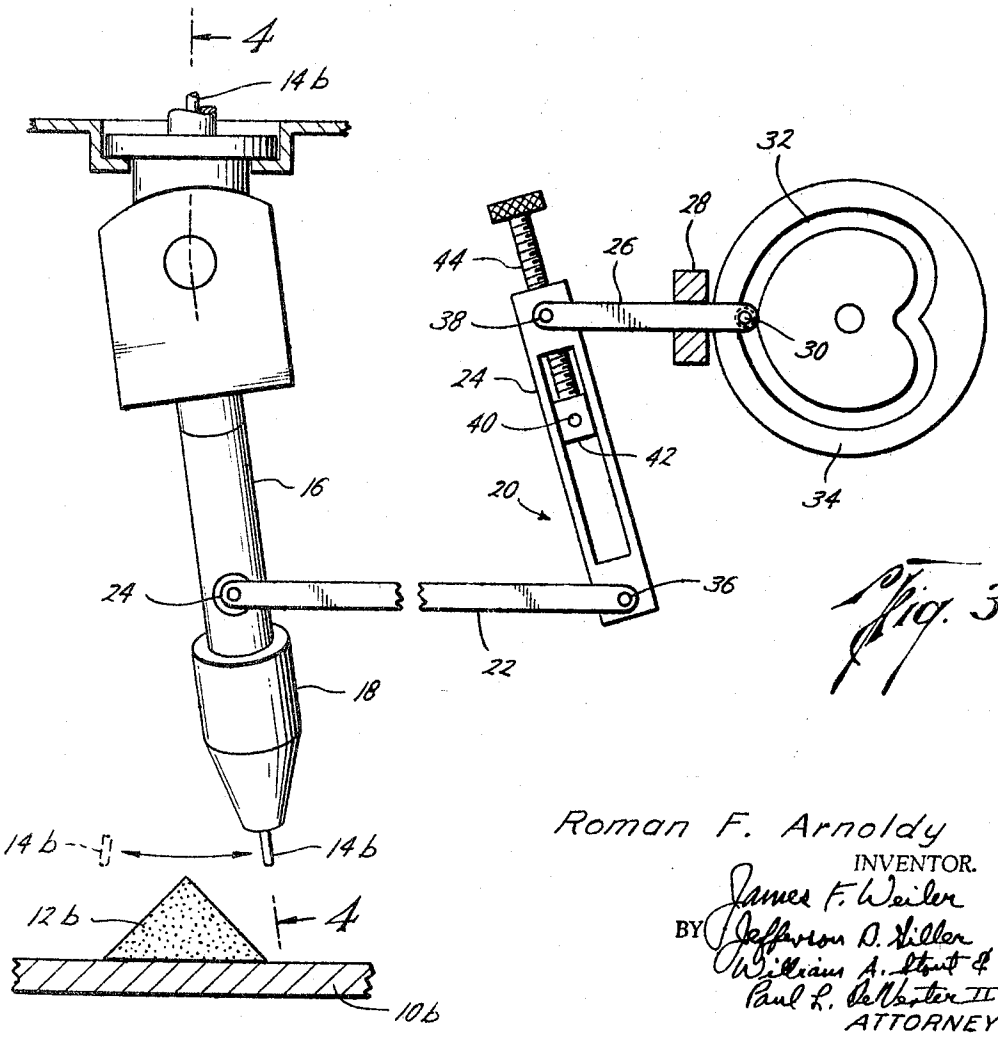


Fig. 3

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Aug. 2, 1966 R. F. ARNOLDY 3,264,445

WELD OVERLAY

Filed Sept. 23, 1963 4 Sheets-Sheet 2

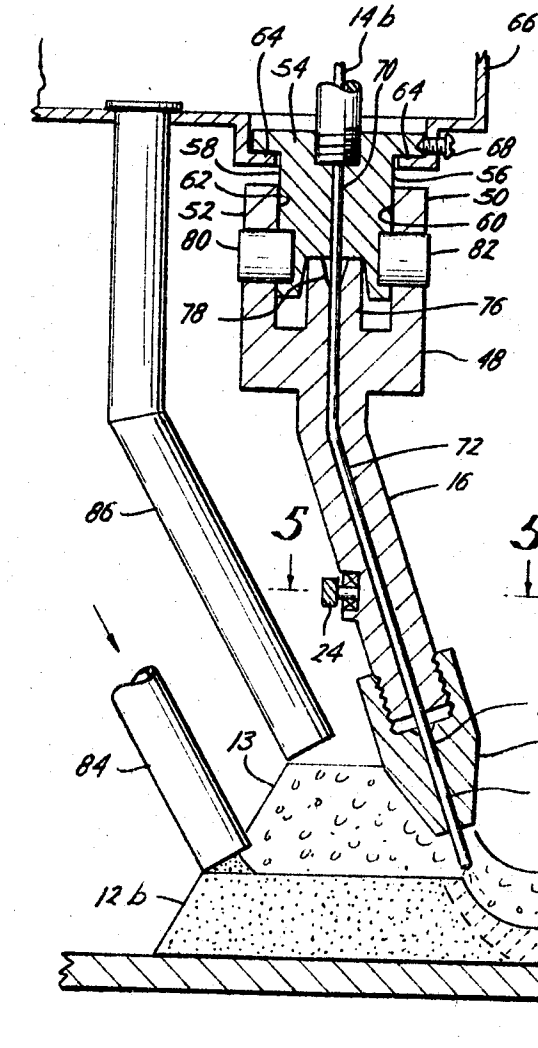


Fig. 4

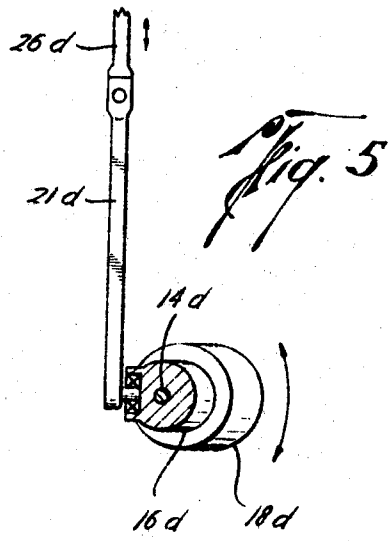


Fig. 5

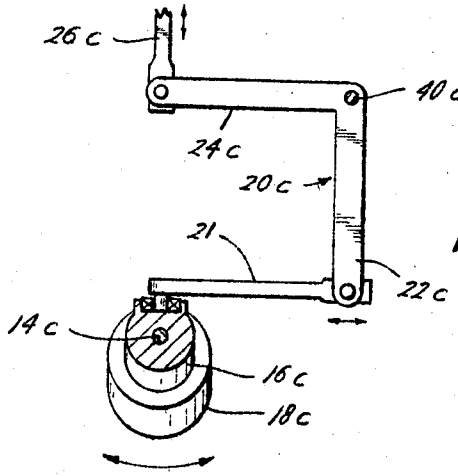


Fig. 6

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WELD OVERLAY

Filed Sept. 23, 1963 4 Sheets-Sheet 3

Fig. 7

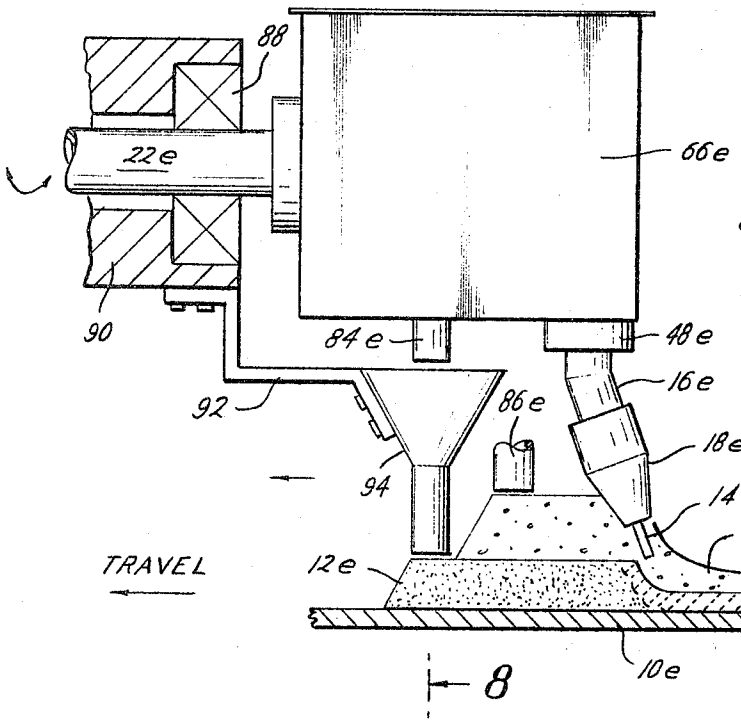


Fig. 8

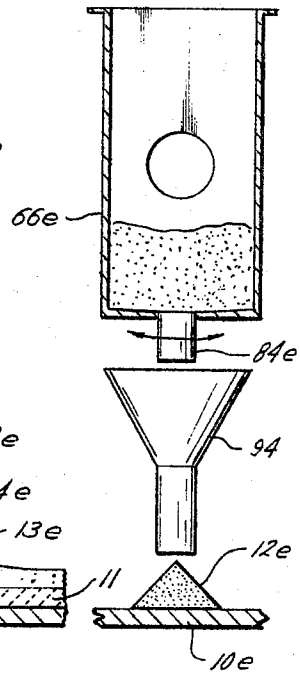


Fig. 9

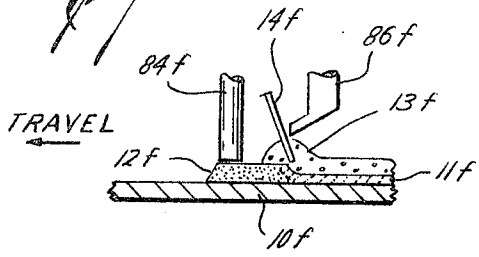


Fig. 10

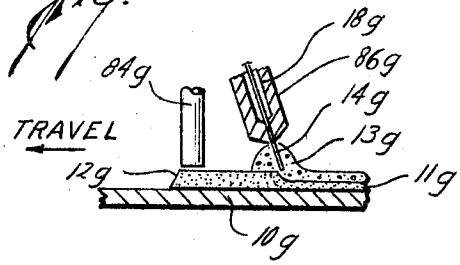
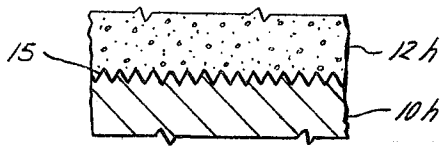


Fig. 11



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WELD OVERLAY

Filed Sept. 23, 1963 4 Sheets-Sheet 4

Fig. 12

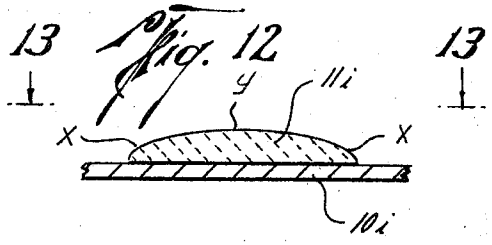


Fig. 13

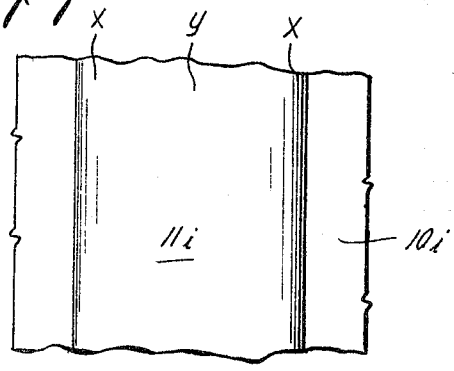


Fig. 14

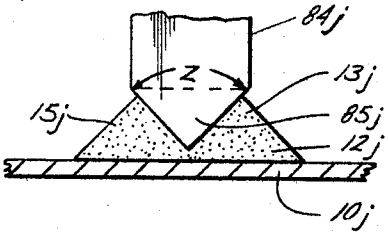


Fig. 15

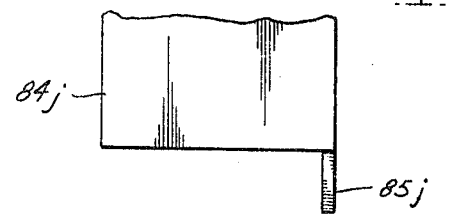


Fig. 16

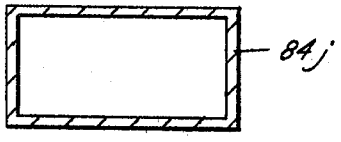
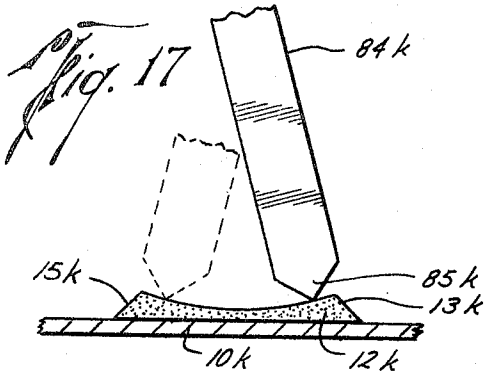


Fig. 17



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United States Patent Office 3,264,445 Patented August 2, 1966

3,264,445

WELD OVERLAY

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Filed Sept. 23, 1963, Ser. No. 311,290
15 Claims. (Cl. 219—76)

The present invention relates to improvements in weld overlaying and more particularly relates to methods of and means for weld overlaying by which improved and advantageous results are obtained.

In my United States Patent No. 3,076,888 there is disclosed and claimed methods of producing weld coatings or fusion welds and in my United States Patent No. 3,060,307 there is disclosed and claimed a suitable apparatus for depositing predetermined measured amounts of electrodes and metal particles by which predetermined compositions of alloy weld overlays are obtained with very little penetration of the base metal, and hence, a minimum of dilution of the alloy overlay by the base metal. It would be highly advantageous, however, to provide a method of and apparatus for weld overlaying in which the weldable amount of the pile is considerably increased, one which permits the use of moderate forward travel speeds while obtaining greater increased deposition rates and allowing thorough melting and mixing of the granular materials and electrodes to produce a uniform alloy analysis, one in which a mixing action is provided which more thoroughly melts and mixes the ingredients and in which the bead edges are smooth and straight and trapping of flux or oxides is avoided between the beads when overlapping.

It would be further highly advantageous to provide such a method of and means for providing weld overlays on a base metal in which a complete bond with a very small, easily controlled and fully predictable penetration is obtained thereby readily providing commercial overlaps of high analysis and accuracy.

The present invention is directed to such a method and means.

It is therefore an object of the present invention to provide a method of and means for producing weld overlays in which the amount of deposition of metal particles is materially increased and which allows a much higher deposition rate without impracticable and unworkable high travel speeds.

Yet a further object of the present invention is the provision of a method of and means for producing weld overlays in which weldable amounts of the weldable particles are very greatly increased, yet a relatively low forward travel speed is permitted to insure thorough melting and mixing of the granular materials and electrodes thereby producing a uniform alloy analysis.

Still a further object of the present invention is the provision of such a method and means which produces a stirring action to the puddle which results in a thorough melting and mixing of the ingredients of the puddle.

Yet a further object of the present invention is the provision of such a method and means by which smooth and straight bead edges are provided and in which flux or oxides are not trapped between the beads when overlapping.

Still a further object of the present invention is the provision of a method of producing weld overlays in which there is substantially no penetration of the base plate or metal by the overlay material, yet there is complete bonding between the overlay and the base metal.

Yet a further object of the present invention is the provision of such a method of weld overlaying in which there is substantially no penetration of the base metal yet complete bonding of the overlay with the base metal in

an easily controlled and fully predictable manner so as to readily provide overlays of high analysis and accuracy by commercial operations.

It has been determined that the composition or analysis of beads welded sometimes has composition or structure variations, or both between the sides of the bead and its center. For example, examination of a bead of 18–8 stainless steel shows up to twice as much ferrite (free iron) in the austenitic mixture may be present at the edges as in the center of the bead. A free swinging magnet passed close to the surface readily identifies these areas by swinging to the bead edges. It would be highly advantageous to provide a method of and means for welding a bead in which the composition and structure of the bead is uniform. One aspect of the present invention is directed to such a method and means.

Accordingly, it is yet a further object of the present invention to provide a method and means by which a bead or overlay is welded to a surface in which the composition and structure of the bead is uniform and of a predetermined closely controlled composition or analysis.

Other and further objects, features and advantages of the present invention will be apparent from the following description of presently-preferred embodiments thereof, taken in conjunction with the accompanying drawings, in which like reference numerals designate like parts throughout the several views, and where,

FIGURE 1 is a diagrammatic view illustrating a method of weld overlaying of the prior art,

FIGURE 2 is a schematic view, similar to FIGURE 1, illustrating a method of weld overlaying according to the present invention and illustrating the increase in weldable particles when overlaid to the base in a single pass over those of FIGURE 1,

FIGURE 3 is a fragmentary, side elevational view, illustrating suitable apparatus for oscillating the electrode illustrated in FIGURE 2,

FIGURE 4 is a sectional view taken along the line **4—4** of FIGURE 3,

FIGURE 5 is a sectional view taken along the line **5—5** of FIGURE 4,

FIGURE 6 is a view similar to FIGURE 5 illustrating a modification,

FIGURE 7 is a view similar to FIGURE 3 illustrating a modification,

FIGURE 8 is a view taken along the line **8—8** of FIGURE 7,

FIGURE 9 is a fragmentary view, similar to FIGURE 7 illustrating a still further modification,

FIGURE 10 is a view similar to FIGURE 9 illustrating yet a further modification,

FIGURE 11 is a diagrammatic view illustrating the method of obtaining substantially no penetration of the base metal yet at the same time obtaining substantially complete bonding of the weld overlay,

FIGURE 12 is a side sectional view illustrating a bead or overlay welded to a surface,

FIGURE 13 is a view taken along the line **13—13** of FIGURE 12,

FIGURE 14 is a view illustrating means for depositing weld particles resulting in uniform composition and structural beads or overlays,

FIGURE 15 is a side view of the funnel illustrated in FIGURE 14,

FIGURE 16 is a view taken along the line **16—16** of FIGURE 15, and

FIGURE 17 illustrates the funnel of FIGURE 14 being oscillated transversely of its travel path.

Referring first to FIGURE 1, a metal base member or plate **10** is illustrated upon which is placed particles of alloy material **12** and an arc is struck between the electrode **14** and the pile of weldable particles **12** to melt the

pile while feeding the electrode **14** at a predetermined rate thereby providing a weld overlay on the base metal **10** of a predetermined composition with a minimum amount of penetration of the base metal **10** and hence a minimum amount of dilution of the resulting weld overlay by the metal of the base **10**. This is generally described and claimed in my United States Patent No. 3,076,888 to which reference has previously been made.

In FIGURE 1 there is no oscillation or movement in a lateral direction of the wire electrode **14**. When weld overlaying without oscillation of the electrode **14** the maximum width of the bead is approximately ⅝ inch since this is about as far as the arc will reach on either side of a non-oscillated electrode. Hence, the pile of weldable particles can have a maximum width of about ⅝ inch in order to be completely melted by the arc. The pile height then will be about 5/16 inch since the angle of repose of the granular or particular weldable material in the pile **12** is about 45°. This results in a volume of granular composition per lineal inch of

$$5/16 \times 5/8 \times 1/2 \times 1 = .098$$

cubic inch. At a composition bulk density of .12 pound per cubic inch, the weight would be .0117 pound. In order to weld at a 3 to 1 ratio the wire **14** used in one inch would be .0039 pound per inch.

As travel speeds of the wire electrode **14** increase above 15 inches per minute, mixing can become less complete, the surface becomes rougher and the bead edges become irregular. Thus, using 15 inches per minute travel speed of the wire electrode **14** to obtain a quality deposit, the rate becomes .058 pound of wire per minute. This would require the use of a 1/16 inch wire electrode and would result in a deposition rate of only .234 pound per minute or 14 pounds per hour at a practical travel speed.

From the foregoing, it is readily apparent that the volume and weight of the deposited pile **12** is generally proportional to the square of the height or width of the pile, and that the use of a wider pile permits higher powder to wire ratios and high deposition rates without requiring impractical and unworkable high travel speeds of the wire electrode **14**. This is accomplished by oscillating the wire electrode **14** as hereinafter set forth.

Referring now to FIGURE 2, where the reference letter *a* has been added to the numerals designating corresponding parts in FIGURE 1 for convenience of reference, the width of the pile **12***a* has been increased to as much as several inches. Since the pile weight is proportional to the square of the width of the pile **12***a*, the weldable amount is very greatly increased. For example, using a pile width of 1¼ inch would require about one inch oscillation of the wire **14***a* to provide a satisfactory weld overlay on the base **10***a*. The powder weight per inch of length now becomes $1\frac{1}{4} \times \frac{5}{8} \times \frac{1}{2} \times 1 = .39$ cubic inch × .12 pound per cubic inch = .0468 pound per inch. Wire deposition at a 3 to 1 ratio becomes .0156 pound per inch at 15 inch per minute travel speed of the wire electrode **14***a* or a deposition of 4 times as much material by making the pile width twice as much as that of the pile **12** in FIGURE 1 and thus allows use of a 3/32 inch wire. Further, the use of still larger piles will allow use of electrode wires of very large sizes with deposition rates proportionately higher, as for example a ¼ inch wire allows a deposition rate of 3.75 pounds per minute or 225 pounds per hour with 2.5 inches wide oscillation.

Advantageously, the oscillation of the wire electrode **14***a*, when combined with arcing to the top of the pile **12***a*, permits the use of relatively low forward travel speeds of the electrode **14***a* which results in more thorough melting and mixing of the granular alloy materials of the pile **12***a* and electrode wire **14***a* producing a uniform alloy analyses, since the weld puddle is fluid for a considerably longer period of time than in the method exemplified by FIGURE 1, without any substantial contamination by the base metal.

In addition, the travel of the electrode **14***a* over the puddle formed by the electrode **14***a* and the pile **12***a* of granular alloy materials produces a stirring action which more thoroughly melts and mixes the components. Since a low forward speed of the electrode **14***a* is utilized, the bead edges become smooth and straight and prevent trapping of fluid or oxides between beads when overlapping.

Preferably, the wire electrode **14***a* should be oscillated in pendulum fashion, so that the end of the electrode **14***a* rises at each end of its travel at the sides of the pile **12***a* which prevents short circuiting against a previous bead welded to the base on one side and on the free side gives a momentary high voltage which smooths out the edge or bead at that side.

Referring now to FIGURE 3, an apparatus according to the invention is illustrated for obtaining the pendulum like oscillation of the electrode, to which the reference letter *b* has been added to parts corresponding to those of FIGURE 2. In this embodiment a generally tubular body **16** is provided to which is threadedly or otherwise secured the nozzle **18** through which the wire electrode **14***b* extends. In this embodiment variable linear oscillation of the wire electrode **14***b* is obtained by utilizing the crank **20** consisting of the crank arm **22** pivotably secured by the pivot **24** to the body **16** and the crank arm **24** is secured to the rod **26** which extends through the guide **28** and is connected to the follower **30** which slides in the milled heart-shaped slot **32** of the constant displacement cam **34**. Thus, rotation of the cam **34**, by any suitable means not shown, causes reciprocation of the rod **26** which, through the crank **20**, causes a pendulum-like oscillation of the body **16** and hence, the wire electrode **14***b*.

In the arrangement illustrated in FIGURE 3 there is provided means for varying the linear oscillation of the electrode **14***b*. This is accomplished by having the arm **22** and the rod **26** pivotally connected by means of the pivots **36** and **38**, respectively, to the arm **24** and, provided within the hollow arm **24** is a pivot **40**, which is fixed by means not shown, secured to the movable member **42**, the position of which is adjusted by the adjusting screw **44**. Thus, adjustment of the adjusting screw **44** causes a movement of the arm **24** which, in turn, varies the width of the oscillation of the electrode **14***b*.

If desired, of course, the linear oscillation of the wire electrode **14***b* may be varied by any suitable means. For example, with reference to FIGURE 6, the reference letter *c* has been added to parts corresponding to those of FIGURE 3, a fixed crank **20***c* is provided and an additional arm **21** is connected to the body **16***c* rather than the crank arm **22** as illustrated in FIGURE 3. If it is desired to change the width of the oscillation of the wire electrodes **14***c* in this embodiment, different size cams, such as illustrated in FIGURE 3, are utilized.

In some instances it may be desirable to change the direction of oscillation of the wire electrode **14***b*. Such an arrangement is illustrated in FIGURE 5 to which reference is now made and in which the reference letter *d* has been added to parts corresponding to those of FIGURES 3 and 6. In this embodiment, the arm **21***d* is directly connected to the cam arm **26***d* without any crank arrangement so that oscillation of the body **16***d* and hence the wire electrode **14***d* is in the direction illustrated which is generally at right angles to the direction of oscillation of the wire electrode **14***c* in FIGURE 6 and **14***b* in FIGURE 3.

No further description is given of the means for oscillating the body, and hence the wire electrode, in these views as a wide variety of arrangements may be utilized as desired and to accommodate the conditions of use.

Referring now to the details of construction of the apparatus of FIGURES 3 and 4, and with particular reference to FIGURE 4, the upper end of the body **16** is enlarged, as at **48**, and is provided with the front and

back pivot members **50** and **52**. A fixed body member **54**, provided with the flat slide surfaces **56** and **58**, which engage the inner flat slide surfaces **60** and **62**, respectively, of the pivot members **50** and **52**, is secured by means of the shoulders **64** to the body **66** and by the set screw **68**.

Disposed in the fixed member **54** is the passage **70** which communicates with the passage **72** in the body **16** and in the enlarged body portion **48** and with the passage **74** in the nozzle **18** through which the wire electrode **14***b* slidably extends. The inwardly projecting portion **76** in the inner portion of the enlarged portion **48** of the body **16** terminates at the axis of the pivot so that there is essentially no motion at the point the wire enters the passage **76** and has a generally tapered opening **78** so that as the enlarged body portion **48** and the body **16** are oscillated the wire electrode **14***b* can be threaded into the passage **76**.

There are provided a pair of pivot pins **80** and **82** which pivotally secure the large body portion **48** to the stationary body member **54** so that only the large body portion **48**, the body **16** and the nozzle **18** are oscillated and the remainder of the body parts remain fixed with the body **66** of the feeder.

As illustrated, a tube **84** is provided through which the granular alloy weld materials making up the pile **12***b* are deposited in advance of the travel of the nozzle **18** and, for submerged welding, a tube **86** is provided to deposit flux **13** on top of the pile **12***b* of particulate weld material. If desired, and as illustrated, the tubes **84** and **86** may be secured to the body **66** and remain stationary, the openings in these tubes being sufficiently large to provide the desired width of pile **12***b* and flux **13** for the oscillation of the wire electrode **14***b* so that only the electrode **14***b* oscillates. The remainder of the welding assembly may be the same as illustrated in my U.S. Patent No. 3,060,307 so that measured amounts of wire electrode **14***b* and amounts of granular material making up the pile **12***b* and flux **13** are deposited on the work or base metal **10***b* which is to be provided with an overlay bonded to its surface. Accordingly, no further details of the feeder arrangement is given or deemed necessary.

Preferably, the electrode **14***b*, and hence the body **16** and the nozzle **18** should be directed at about a 20° angle in a trailing direction to the surface of the work **14***b*.

If desired, either or both the tubes for the metal pile and flux may be fixed and the entire body of the metering or feeder head for the wire electrode, granular metal pile and flux oscillated. Such an embodiment is illustrated in FIGURES 7 and 8, to which reference is now made, and to which the reference letter *e* has been added to numerals designating parts corresponding to those of FIGURES 3 and 4. In this embodiment the body **66***e* is secured to a pivot shaft **22***e* which is oscillated by a means of a constant displacement cam, not shown, such as illustrated in FIGURE 3. The pivot shaft **22***e* is journalled by means of the anti-friction assembly **88** within the boom **90** by which the travel of the metering head is accomplished and which supports the various parts in relation to the work **10***e*.

Connected to the boom **90** by means of the bracket **92** is the funnel **94** which is maintained in a stationary position and which receives from the tube **84***e* the particulate metal alloying materials for deposit on the work **10***e* as the pile **12***e*. The funnel **94** is of sufficient size to receive the alloying particles from the body **66***e* through the tube **84***e* during its oscillation as best illustrated in FIGURE 8.

A similar arrangement is provided for the flux tube **86***e*, but because of space limitations, only the funnel **86***e* is illustrated.

The arrangement of the electrode and tubes for providing particulate or granular weldable material may be varied considerably as desired and to accommodate conditions encountered in use. Such modified arrangements are illustrated in FIGURES 9 and 10, to which the reference letters *f* and *g*, respectively, have been added to numerals designating corresponding parts in the preceding figures.

Referring first to FIGURE 9, an arrangement is illustrated in that the flux tube **86***f* is disposed behind the electrode **14***f* but the flux tube **86***f* is arranged so that the flux flows across the wire electrode **18***f* as it is oscillated transversely of the direction of travel.

In FIGURE 10, the flux tube **86***g* is arranged concentric with and about the nozzle **18***g* so that the flux **13***g* flows onto the pile **12***g* of particles of weldable material and is oscillated with the wire electrode **14***g*.

No further parts are illustrated in FIGURES 9 and 10 as the remaining parts are the same and operate in the same manner as in preceding views and no further description is deemed necessary or given.

As previously mentioned, in producing weld overlays on steel or other metal plates, there has been some difficulty in controlling the amount of penetration and it has been difficult to obtain the values desired, that is, provide complete bonding with minimum penetration. As an example of one set of welding conditions, utilizing the process set forth in my United States Patent No. 3,076,888, no penetration of the base plate is obtained, however, close control of current, base preheat, travel speed and other factors are necessary to insure complete bonding without penetration as an incremental increase in current causes penetration to occur, and the range of current setting between 1/64 inch penetration and 1/16 inch penetration is small. It would be highly desirable to produce a 100% bond with a very small and easily controlled and fully predictable penetration. In this embodiment of the invention the surface of the work or metal base is prepared by suitable means so as to have an exposed surface area of 1½ to 4 times the normal flat or projected area of the surface. By a normal flat surface is meant one that has a surface of 125 R.M.S. or less, average.

Referring now to FIGURE 11, in which the reference letter *h* has been added to reference numerals designating corresponding parts throughout the preceding views, a series of thread like serrations are provided, such as by machining, in the plate or work piece **10***h*. These may be rolled, the surface may be blasted with rough material, such as flint and the like so that the exposed surface is 1½ to 4 times more than that of a generally flat surface. In the serrations **15** illustrated in FIGURE 11, a distance of between 1/64 to 3/32 of an inch between crests of the thread, and a distance of from 1/64 inch to 1/16 inch between the crest and the root are satisfactory to provide an exposed surface area of 1½ to 4 times the normal flat or projected area.

When utilizing the increased exposed surface area within the range set forth, the temperature of the weld overlay is sufficient to melt the narrow projections of the surface and cause bonding thereof to the work in a uniform manner whereas the same temperature of the molten overlay material would not be sufficiently high to produce penetration and uniform bonding of the plate if the surface were not so prepared.

The preparation of the exposed surface of the base or work is particularly advantageous when combined with oscillating the electrode and forming an arc between the electrode and the top of the pile, all as previously described.

This is particularly advantageous in producing overlays of high analysis accuracy, for example an overlay of AISI type 304L stainless steel. This material has a carbon content of .04 maximum for an overlay. The usual base metal will have .25 to .40% carbon.

	Percent
Carbon from overlay	⅔ × .02 = .0133
Carbon from base metal	⅓ × .36 = .12
Total	.1333

This amount is over three times that allowed to make 304L stainless steel.

Similarly, the dilution effect will cause the amounts of other elements to fall out of the allowable range. Thus, by controlling the penetration which is readily and easily accomplished, overlays of high analysis accuracy within allowable amounts are readily obtained.

As previously mentioned, the composition or structure or both of the bead or overlay varies between its center and edges. Referring now to FIGURES 12 and 13, in which the reference letter *i* has been added to reference numerals designating parts corresponding to those of the preceding views, the overlay or bead **11***i* of 18–8 stainless steel is shown welded to the work or base **10***i*. The sides *x* of the overlay or bead **11***i* have about twice as much ferrite (free iron) as the center *y* as determined by the test previously mentioned.

To overcome this disadvantage and to prevent this condition from happening, and with reference to FIGURES 14, 15 and 16, in which the reference letter *j* is added to reference numerals designating corresponding parts of the previous figures, there is provided a funnel **84***j* which deposits weld particles **12***j* on the work or base **10***j* in such a manner so that there are more weld or alloy particles at the edges than in the center thus requiring less flow of weld or alloy material to the edges from the center to complete the mixture. To this end, a plow-shaped or generally triangularly-shaped member **85***j* is provided at the trailing end of the funnel **84***j* which extends transversely of the path of movement of the funnel **84***j*. As best seen in FIGURE 14, this causes the metal pile **12***j* to be deposited on the work **10***j* in the form of two triangular metal piles **13***j* and **15***j* which intersect one another. Preferably, the angle *z* of the sides of the projection or plow **85***j*, is about twice the angle of repose of the granular metal pile or weld particles **12***j*. In most cases, this is about 45°. Any desired shaped member, however, may be used which deposits enough metal on the sides to avoid nonuniform composition or structure of the bead or overlay.

In order to allow for the spreading action of the projection or plow **85***j*, the funnel or tube **84***j* may be elongated to have a length greater than its width, for example, a length twice its width, as best seen in FIGURES 15 and 16.

In some cases it may be desirable to oscillate the funnel or tube. Such an arrangement is illustrated in FIGURE 17, to which reference is now made and in which the reference letter *k* has been added to reference numerals designating parts corresponding to those of the preceding figures. It is noted that the sides **13***k* and **15***k* of the pile **12***k* have more weld particles than its center portion. In this embodiment, the funnel or tube **85***k* is connected to the portion of the assembly which oscillates, such as the body member **66**. The opening in the funnel or tube **84***k* should be sufficiently elongated or narrowed in its direction of travel to prevent throwing weld particles out of the effective oscillatory path of the electrode.

Similarly, in oscillating the tube or funnel for depositing weld particles or flux in the embodiments illustrated by the preceding figures, the opening is elongated and narrowed in the direction of travel. For example, in FIGURES 7 and 8, the bracket **92** and funnel **94** would be eliminated and the tube **84***e* extend to the pile **12***e*, as in FIGURE 4, and the opening of the tube **84***e* elongated and narrowed, as previously described.

It is desirable in these various embodiments of the invention to bring the weld particles into the weld zone at a point which is of less distance from the arc than the length of the molten puddle and one aspect of the invention is directed thereto. This is particularly advantageous where there are changes or fluctuations in travel speed or rate of wire feed while the electrode is traveling from one point over the distance to the point of introduction of the pile of weldable overlay particles on the work or base will vary within the distance between

the electrode and the point of weldable particle deposition. If this distance is greater than the molten puddle length, the analysis can vary outside the specified range. If this distance is shorter than the puddle length, the smaller and greater amounts of weldable overlay particles are integrated into the same puddle and cancel out the variation.

Combining this aspect of the invention with the other aspects thereof insures uniform composition of predetermined analysis and structure of the overlay with relatively fast rates of deposition and greater thickness of the overlay and a minimum of dilution of the overlay with the base metal, but with good bonding.

The present invention, therefore, is well suited and adapted to attain the objects and ends and has the advantages and features mentioned as well as others inherent therein.

Numerous changes may be made in the details, arrangement of parts, and steps of the invention which is to be limited only by the spirit thereof as defined by the scope of the appended claims.

What is claimed is:

1. A method of producing a weld overlay on the surface of a base comprising,

placing on the surface of the base a pile of electrically conductive, weldable overlay particles in a predetermined amount,

the width of the pile being in excess of that which can be completely melted by a linearly moving electrode without substantial penetration of the base,

creating an arc from an electrode to the upper portion of the pile, and

oscillating the electrode transversely of the pile while melting and moving the electrode along the length of the pile at a speed corresponding to the linearly moving electrode thereby melting the pile and a thin skin of the base and bonding the overlay of predetermined composition to the base without substantial dilution of the overlay by the material of the base.

2. The method of claim **1** where,

the surface has an exposed area of about 1½ to about 4 times that of a substantially flat surface.

3. A method of producing a weld overlay on the surface of a base comprising,

placing on the surface of the base a pile of electrically conductive, weldable overlay particles in a predetermined amount,

the width of the pile being in excess of that which can be completely melted by a linearly moving electrode without substantial penetration of the base,

the height of the pile being substantially the height of the material as determined by the angle of repose of the particles,

creating an arc from an electrode to the upper portion of the pile, and

oscillating the electrode transversely of the pile while melting and moving the electrode along the length of the pile at a speed corresponding to the linearly moving electrode thereby melting the pile and a thin skin of the base and bonding the overlay of predetermined composition to the base without substantial dilution of the overlay by the material of the base.

4. The method of claim **3** where,

the surface has an exposed area of about 1½ to about 4 times that of a substantially flat surface.

5. A method of producing a weld overlay on the surface of a base comprising,

depositing on the surface of the base a pile of electrically conductive, weldable overlay particles in a predetermined amount,

the width of the pile being in excess of that which can be completely melted by a linearly moving elec-

trode without substantial penetration of the base,
depositing flux over the pile,
creating an arc from an electrode to the upper portion of the pile, and
oscillating the electrode transversely of the pile while melting and moving the electrode along the length of the pile at a speed corresponding to the linearly moving electrode thereby melting the pile and a thin skin of the base and thereby bonding the overlay of predetermined composition to the base without substantial dilution of the overlay by the material of the base.

6. The method of claim **5** where
the surface has an exposed area from about 1½ to about 4 times that of a substantially flat surface.

7. A method of producing a weld overlay on the surface of a base comprising,
depositing on the surface of the base a pile of electrically conductive, weldable overlay particles in a predetermined amount,
the width of the pile being in excess of that which can be completely melted by a linearly moving electrode without substantial penetration of the base,
the height of the pile being determined by the angle of repose of the weldable overlay particles,
depositing a flux over the pile,
creating an arc from an electrode to the upper portion of the pile, and
oscillating the electrode transversely of the pile and while melting and moving the electrode along the length of the pile at a speed corresponding to the linearly moving electrode thereby melting the pile and a thin skin of the base and thereby bonding the overlay of predetermined composition to the base without substantial dilution of the overlay by the material of the base.

8. The method of claim **7** where
the surface has an exposed area from about 1½ to about 4 times that of a substantially flat surface.

9. A method of producing a weld overlay on the surface of a base comprising,
depositing on the surface of the base a pile of electrically conductive, weldable overlay particles in a predetermined amount, the sides of the pile containing more of said particles than the center,
the width of the pile being in excess of that which can be completely melted by a linearly moving electrode without substantial penetration of the base,
creating an arc from an electrode to the upper portion of the pile, and
oscillating the electrode transversely of the pile at a speed corresponding to the linearly moving electrode while melting and moving the electrode along the length of the pile thereby melting the center and side of the pile and a thin skin of the base and bonding

the overlay of predetermined substantially uniform composition and structure without substantial dilution of the overlay with the material of the base.

10. The method of claim **9** in which the sides of the pile, when viewed transversely, are generally in the form of triangles and the center of the pile is formed by the intersection of the inner sides of the triangles.

11. The method of claim **10** where the sides of the triangles are generally at the angle of repose of the overlay particles.

12. A method of producing a weld overlay on the surface of a base comprising,
depositing on the surface of the base a pile of electrically-conductive, weldable overlay particles, and
creating an arc from an electrode to the upper portion of the pile thereby providing a molten puddle, the point of depositing the weldable overlay particles being less distance from the arc than the length of the molten puddle.

13. A method of producing a weld overlay on the surface of a base comprising,
depositing on the surface of the base a pile of electrically-conductive, weldable overlay particles,
creating an arc from an electrode to the upper portion of the pile thereby providing a molten puddle,
the point of depositing the weldable overlay particles being less distance from the arc than the length of the molten puddle,
the width of the pile being in excess of that which can be completely melted by a linearly moving electrode without substantial penetration of the base, and
oscillating the electrode transversely of the pile while melting and moving the electrode along the length of the pile at a speed corresponding to the linearly moving electrode.

14. The method of claim **13** where
the sides of the pile contain more weldable overlay particles than the center thereof.

15. The method of claim **14** where
the surface has an exposed area from about 1½ to about 4 times that of a substantially flat surface.

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