Dec. 2, 1969 S. BRIGGS III Re. 26,726

LONGITUDINAL STRIP EDGE BUTT WELDING

Original Filed Nov. 27, 1963 2 Sheets-Sheet 1

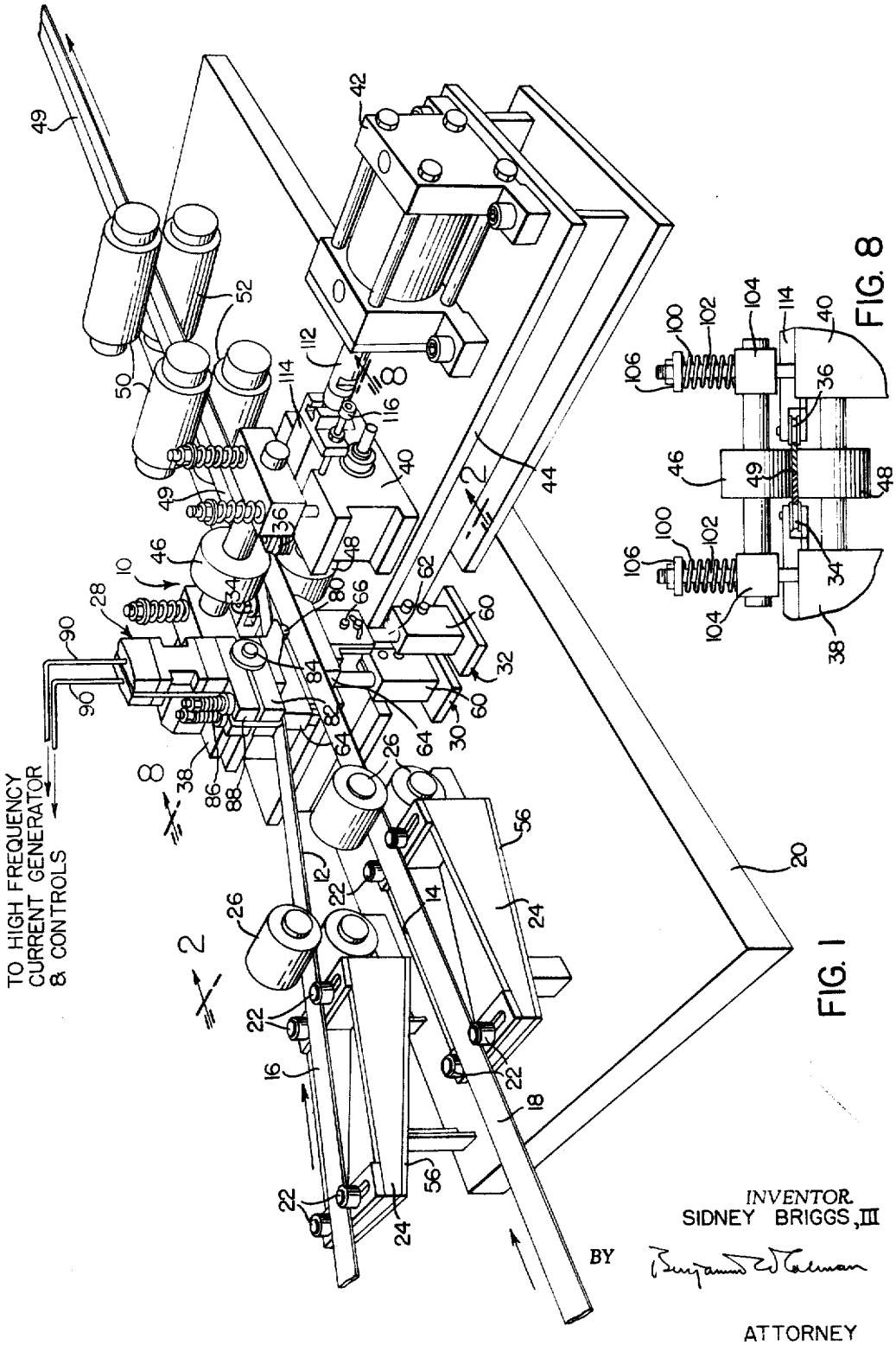


FIG. 1

FIG. 8

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LONGITUDINAL STRIP EDGE BUTT WELDING

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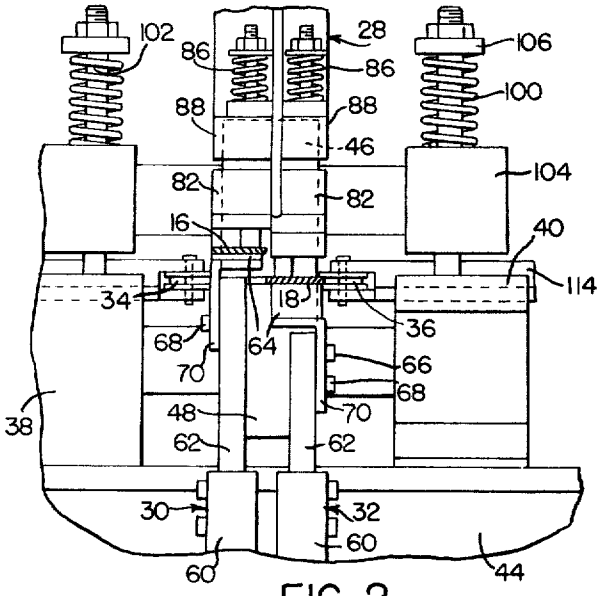


FIG. 2

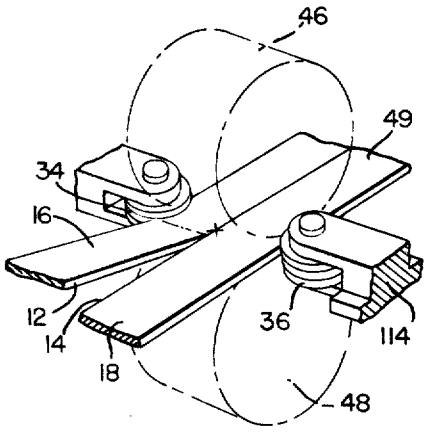


FIG. 3

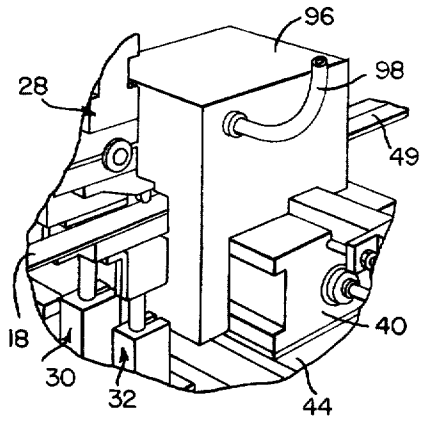


FIG. 4

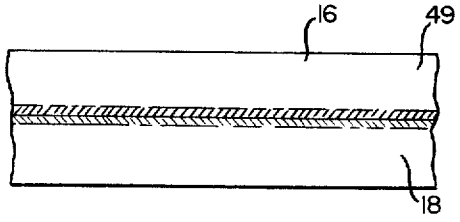


FIG. 7

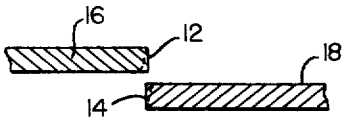


FIG. 5A

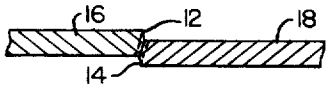


FIG. 5B

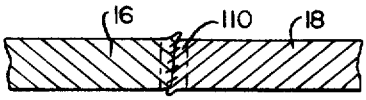


FIG. 6

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LONGITUDINAL STRIP EDGE BUTT WELDING

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Original No. 3,325,623, dated June 13, 1967, Ser. No. 326,545, Nov. 27, 1963. Application for reissue Feb. 19, 1968, Ser. No. 728,096

Int. Cl. B23k *9/02, 11/02, 11/04*

U.S. Cl. 219—102 21 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates to longitudinal metal strip edge butt welding and more particularly to apparatus for and a successful method of continuous welding coil strip metals at adjacent longitudinal edges by high frequency electrical currents.

The invention involves bringing metal strips into edgewise contact under pressure after heating such edges to plastic forging temperature by the application of edge heating high frequency currents. The edges to be welded are substantially disposed in a common vertical plane but separated from each other from a point at which welding of the strips occurs. In one embodiment of the invention, the adjacent longitudinal strip edges are disposed at a vertical angle to each other but lie in a plane such that as the two strips are welded and drawn away from their weld point no distortion of either of the strips is generated through the mechanical efforts applied by the apparatus.

In effecting a continuous running weld of the strips (taken from coils) at their adjacent edges, one of the strips enters the welding area of the apparatus at a substantially horizontal plane and leaves the area butt welded to its complementary strip in substantially the same plane. The second strip enters the welding area from an elevated position and at an acute angle to the first strip, the planes of the two strips intersecting in a line substantially at or closely adjacent the welding point of the strips. Inasmuch as the two strip planes are intersected by a transverse plane containing the longitudinal edges to be welded, the more nearly the transverse plane is normal to the strip planes the more effective and efficient will be the welding of the two strips.

A theoretically perfect vertical alignment of the edges would not, however, provide a successful weld. If the adjacent strip edges would just pass each other or would just brush against each other as they come into planar alignment, it would be necessary to compress the strips in their welding plane to a degree or magnitude such that planar distortion forward of the weld or forging point would naturally result. In such event, the meeting edges would be put into tension and the remote edges into compression, the planar distortion interfering with a successful continuous production weld.

A practical successful solution to the strip butt edge welding problem has been found in the discovery that by a very slight overhang of the higher strip with respect to the inner edge of the lower strip, an overhang measured in a few thousandths of an inch, the two strips can be butt welded together by lateral forging rolls and vertical compression rolls on a continuous production basis by the apparatus and the method described below. It has further been found that by disposing the forging plane (i.e. a vertical plane passed through the vertical axes of the forging rolls) just slightly forward of the vertical compression plane (i.e. the plane through the horizontal axes of the compression rolls) more accurate and positive control over the weld point is achieved.

This control over the weld point is significant and important. High frequency electric currents, generated by a radio frequency generator capable of an output of 60 or more kilowatts of current at from 100 to 450 kilocycles, are utilized to heat the edge surface of each of the metal strips that will be compressed together by the forging rolls. In order to heat these edges by high frequency current, a generator of suitable capacity and frequency together with controls is installed adjacent the strip welding apparatus, and current conductors are extended from the generator and auxiliary equipment, if any, to electrodes making contact with the strips to be welded. The electrodes, one on each strip, are disposed at a short distance from the plane of the forging rolls passing transversely through the strips adjacent the weld point. The currents produced by the generator at high frequency travel substantially on the surface of the strips from and between the contact points of the electrodes to the weld point. As the conducting metal surfaces heat up under the excitation of the alternating current flow, the edge surfaces appear to become heated to plastic temperature in the range for cold rolled and stainless steels of from approximately 2000° F. to approximately 2400° F.

The temperatures reached by the edge surfaces are dependent in a measure upon the distances of the electrodes to the weld point. If the weld point varies or flunctuates, the temperature at the edge surfaces rises and falls in direct proportion, i.e. if the weld point distance from the electrode contact increases, the temperature increases, and if the weld point distance decreases, the temperature drops. Under these conditions, control of the weld point becomes a most desirable if not a necessary and essential factor in the process. It has been found that by disposing the plane through the strip forging rolls just slightly ahead of the plane through the horizontal pinch rolls the weld point shift is more closely confined and limited than when the two planes coincide. Thus, a significant variable has been reduced to a closely controlled factor whereby edge temperatures are relatively stable and controllable.

Heat depth penetration in the metal strip edges is another factor to be considered in the continuous butt welding process and is provided for in the apparatus of this invention. The heat depth penetration increases as the temperature of the edge increases. Only slight heat penetration is desirable inasmuch as the forging pressures applied are substantial, and excessive forging at the butt-weld edges will result in substantial and undesirable upset of the weld metal. Therefore, the flow rate of metal, the power and frequency of current applied at the electrodes, the distances of the electrodes to the weld point, the relatively constant position of the weld point, and the slight overhang relationship of the strip edges being heated to plasticity are all factors that require cooperation and coordination to produce a successful method and apparatus for butt welding the longitudinal adjacent edges of metal strip in a continuous production manner. These factors have been stabilized and controlled in the apparatus and by the method of this invention.

It is an object of the invention to provide apparatus and process for butt welding the surfaces of adjacent longitudinal edges of metal strip by means of high frequency electric currents applied to and heating such edge surfaces. Another object is to provide means for closely controlling the weld point in the path of such electric currents by means of forging and compression roll location and orientation. A further object is to provide apparatus for moving the metal strips into the welding area in such a manner that when the edges to be welded are brought into butt welding relationship there is a slight overhang of the edge portions heated to plasticity so that these portions engage and wipe across each other as they pass through the weld zone and are forged together by laterally applied forging rolls at or adjacent the weld point, rather than being substantially lapped horizontally and com-

pressed vertically, as in the forming of a lap seam or joint. Another object is to provide horizontal pinch rolls upon the composite welded metal strip at a point or line just a little beyond the line of application of the forging pressure. A further object is to coordinate the temperature of the electrically heated zones at the edges to be butt welded with the flow rate of the metal strips for controlling the location of the weld point within relatively close limits. A principal object is to provide apparatus and process for successfully butt welding longitudinal adjacent edges of metal strip in a continuous production manner by the application of high frequency electric current to such edges.

These and additional objects of the invention and features of construction and processing will become more clearly apparent from the description given below in which the terms employed are used for purposes of description and not of limitation.

Reference is here made to the drawings annexed hereto and forming an integral part of this specification, and in which

FIGURE 1 is a perspective view of one embodiment of apparatus for practicing the invention in connection with the butt welding of metal strips.

FIGURE 2 is a vertical elevational view partially in *section* [sectional] taken substantially on the line **2—2** of FIGURE 1.

FIGURE 3 is a slightly enlarged fragmentary perspective view taken from a point just forward of the weld point and the forging rolls.

FIGURE 4 is a fragmentary perspective view showing a gas hood over the welding zone, the forging rolls and the horizontal compression rolls.

FIGURE 5A is a vertical sectional view taken transversely of the two metal strips as they approach the weld point beyond the electrodes.

FIGURE 5B is a vertical sectional view, similar to that in FIGURE 5A, showing what is believed to occur as the two adjacent strip edges, heated to plasticity, slip and wipe across each other.

FIGURE 6 is an enlarged fragmentary transverse vertical sectional view taken at the welded zone of the composite strip.

FIGURE 7 is a fragmentary top plan view of the composite strip.

FIGURE 8 is a vertical view, substantially in elevation taken substantially on the line **8—8** of FIGURE 1.

As shown in the several views of the drawings, the apparatus **10** for butt welding adjacent longitudinal edges **12** and **14** of metal strips **16** and **18**, respectively, comprises a fixture base **20**, strip guide rolls **22** on stands **24**, strip tensioning rolls **26**, an electrode contact welding fixture **28**, strip supports **30**, **32** under the fixture, horizontally acting strip forging rolls **34**, **36** supported in fixtures **38**, **40** respectively and held in compression against the outer lateral edges of the two strips by a pneumatic air cylinder **42**, the fixtures **38**, **40** and the cylinder **42** being supported on an auxiliary base **44**, vertically acting compression rolls **46**, **48** operating on the welded composite strip to draw it toward a wind-up reel (not shown) from the compression rolls. The high frequency generator supplying the current and power for the welding operation is not shown, nor are several other units including a *current* transformer, and manually operable control devices, all well known by persons skilled in the art to which the invention pertains.

The metal strips **16** and **18** are electrically conductive in nature and more particularly, but not exclusively, are principally ferrous in composition. The strips may be relatively thin or thick in cross-section. Successful butt welding by the apparatus and method hereindisclosed has been practiced upon strips of from .018 to .028 inch inclusive, but strip thickness of greater or lesser magnitude can also be successively butt welded by the instant apparatus and method. Some of the strips that have been

butt welded together are electrogalvanized (zinc coated) cold rolled steel and stainless steel. Ordinary cold rolled steel and other steels have also been successfully butt welded together into *edge-fused strips.* [composite strips. The term "composite strip" includes welded identical strip materials as well as diverse strip materials.]

The two strips are taken from reel supported coils (not shown) mounted on stands insulated from each other and from the floor or base upon which the reels or mounts are supported. Electrical currents introduced by the generator and controls to the two strips by the contact fixture **28** will flow in the directions of least impedance and reactance and generally through a circuit toward each contact or to a ground. In order to limit current losses and undesired metal heating, the fixture elements making direct contact with the metal strips are preferably insulated from each other and from the base or mounts upon which they are supported. This requirement is particularly applicable to the stands **24**, tensioning rolls **26**, forging roll fixtures **38**, **40** and the compression rolls, **46**, **48**.

The fixture base **20** is preferably supported on a rigid base or stand so as to elevate the welding fixture **28** to a level about waist high, or slightly higher, for more effective observation of the strips passing through the fixture by an operator handling the power generator controls. Mounted on the base **20** are the strip guide roll stands **24** having at least four (4) guide rolls **22** adjustably secured to the stand so that strip **18** is positively guided into position laterally adjacent the complementary strip **16** at the weld zone, as in FIGURE 3. Alignment of the strips **16** and **18** starting from the coil and reel positions is critical and care must be exercised in respect to such alignment in order to produce a successful continuous production weld of the strips. The strip **16** is similarly guided by its stand **24** supported on base **20** but elevated by support **30** so that the strip **16** enters the weld zone at an acute angle to the plane of the strip **18**.

Under each of the guide roll stands **24** are insulating sheets or pads **56** required to electrically insulate the stands and their strips from each other. Guide rollers **22** are adjustable laterally of the stands **24** so that the strips **16** and **18** will line up in a very slightly overhanging relationship. This overhang disposition or attitude is maintained from the initial coil position, and is carried through guide roll stands **24** and the strip supports **30**, **32**. By so doing, the strips come into weld attitude in a true flat overhung disposition as shown in FIGURE 5A.

The overhang of strip **16** with respect to strip **18** is measured in a few thousandths of an inch. Coil strip stock is produced and sold in widths having variable tolerances. To hold the composite strip width within limits such that the upset at the weld line is relatively small and controllable, the width of the composite strip is established at from about .005 to about .010 inch less than the combined widths of the two strips being welded. The selection and determination of the width diminishing factor is based in part upon the compression force of the *compressive* [compression] rolls **46**, **48** operating against the upset bead and upon the variation in tolerances of the two strips. The nominal forging reduction of the rolls **34**, **36** for strips of approximately .020 inch thickness is about .008 inch, providing an upset bead at the weld line that is easily compressed by the compression rolls **46**, **48** to produce a [composite strip] *welded strip length* **49** of substantially uniform thickness throughout.

As the strips **16**, **18** leave their guide roll stands, a pair of pinch or drag rolls **26**, **26** apply a braking action upon the strips. These rolls are mounted in stands (not shown) in such a manner that the strips are subjected to considerable pressure by and between the rolls, which are made of a polyurethane plastic composition known by the trade name "Disogrin." However, other materials

similar in function can also be utilized. The pressure applied by the rolls **26, 26** is such that the strips are dragged and gripped by the rolls with great frictional engagement, thus effecting a braking or tensioning action upon them from the rolls **26, 26** through to the draw rolls **50, 52**. Holding the strips under firm tension in the weld zone eliminates buckling or flexing of the strips and consequently improves control of the overhanging relationship of the strip edges **12** and **14**, and of the weld point.

Upon leaving rolls **26, 26**, strip **18** moves to a slide position upon the support **32** which comprises a base **60**, a post **62**, and a strip rest **64** secured to the post which is adjustable vertically in base **60**. The rest **64** is rotatably adjustable in a vertical plane on a pin **66** mounted in the post, the adjusted position being secured by a screw **68** passed through a semi-circular slot in the rest plate **70**. The rest **64** of strip support **32** is disposed in a substantially horizontal plane for strip **18**. The strip support **30** is composed of the same elements as those described for support **32**, the rest **64** being disposed at an acute angle to the horizontal to accommodate the strip **16**. For the strips heretofore tested and welded, the rest **64** of strip support **30** is disposed at an acute angle to the horizontal plane ranging from 3° to 10°, as a preferred angular range. However, for other strip welding such angular relationship can be modified by increasing or decreasing the angle depending upon the criticality of the power input at the electrode contacts, the speed or flow rate of the two strips, the proximity of the current-carrying edge portions, the relative shift or non-shift of the weld point, and the presence of arcing across the strips in the area of the current-carrying edge portions. Since the electrical efficiency of the high frequency circuit between electrode contacts and through the weld point is increased as the angular relationship of the current paths approach zero, the optimum angular relationship of the two strips is reached when for a given power input at a particular frequency and at a given strip flow rate, the angle between the strips is just slightly greater than that angle at which arcing between the electrodes or the strips has or will occur.

Disposed above the strips **16** and **18** at the supports **30** and **32**, respectively, is the electrode mount **28**. This mount can be constructed in a number of ways, and such constructions form no direct part of the instant invention. A representative embodiment of a mount that can be utilized comprises an electrode contact **80** secured to an arm **82** pivotable about a pin **84**, the arm being held against a resilient spring **86** so that the contact **80** is freely slidable and in electrical and bearing contact with and upon the strip at all times, the upper end **88** of the mount being securely held in supports (not shown) cooperatively associated with the current generator equipment. Each side of the mount is insulated from the other side and is direct connected to the generator equipment by an individual liquid cooled current conductor **90**.

The electrode contacts **80** ride the strips **16, 18** adjacent the edges **12** and **14**, respectively, welding current flowing upon the surfaces of the strips adjacent these edges and heating them as the metal resists the high frequency flow and reverse flow of the current. Having in mind that the strips are moving at a very high speed past the electrode contacts **80**, where welding current is imparted to the strips, the time period of current acceptance is only a small fraction of a second. Yet within that period, the surfaces of the edges are heated to a temperature at which the metal is plastic and the edges weldable. As a representative example only, and without limitation against modification for other situations, electrogalvanized cold rolled steel strip has been butt welded to stainless steel strip in a continuous production manner at a speed or flow rate of 400 feet per minute or more, the electrode contacts **80** being disposed at a distance of approximately 3 inches from the weld point on the galvanized steel strip and at about 2 inches on the stainless steel strip, using a 60 kw. generator operating at a frequency of 450 kilocycles. Under these conditions the galvanized steel strip edge is being heated to welding temperature in about .0375 second and the stainless steel strip edge in about .025 second.

It has been found that in welding zinc coated galvanized steel strip to stainless steel strip, some of the zinc in the surface area heated by the electric currents becomes vaporized and oxidized and surrounds the weld zone in a cloud of zinc ions or zinc oxide particles that tend to short out the currents and reduce their welding effectiveness. To eliminate this defect where a zinc surface coating is present on the strip, a neutral or inert gas such as carbon dioxide has been introduced within a hood **96** by means of a conduit **98** leading from a source of supply of such gas (FIG. 4). Nitrogen or other inert gas may be applied within the hood or by jets to clear away the zinc. The hood is disposed over the area of the weld zone and is open wherever mechanical parts or other structural features are present. The gas is continuously fed or metered into the hood and escapes to the atmosphere from areas of machine components adjacent edges of the hood. The carbon dioxide gas reduces the oxidation of the zinc, thereby eliminating arcing or short circuiting of the currents during the heating and welding operation.

As seen in FIGS. 1, 3 and 8, the compression rolls **46, 48** are vertically arranged above the [composite strip] *welded strip* **49**, and are disposed slightly rearwardly of the forging rolls **34, 36**, i.e., a vertical plane passed through the horizontal axes of the compression rolls is just a bit rearwardly of a vertical plane passed through the axes of the horizontal forging rolls. It was found that setting the compression rolls in vertical alignment with the forging rolls interfered with effective butt welding of the strips. When the compression rolls were placed slightly behind the forging rolls, the latter were able to act more effectively upon the weld point and to weld the [composite strip] *welded strip*. By allowing only one set of rolls, the forging rolls, to operate upon the two strips at the weld zone, it was further found that the weld point was more successfully controlled and limited in its longitudinal shift, than if both sets of rolls were in operation simultaneously upon the strips.

The compression rolls **46, 48** are held in pressure bearing contact upon the *welded strip* [composite strip] **49** by the compression springs **100** operating on posts **102** against the shaft supports **104, 104** to compress the upset bead of the [welded composite] strip **49**. The pressure applied by the springs can be increased or decreased by adjusting the spring retaining caps **106** downwards or upwards. When both strips **16** and **18** are of equal thickness, the rolls **46, 48** are uniformly ground. Should a [composite strip] *product* be required or produced of two strips of unequal thickness, the rolls **46, 48** should be machined and ground to accommodate the configuration at the weld line, having in mind the compression of upset metal. This is the essential action of rolls **46, 48**, i.e., it is not an action of vertically compressing or mashing a lapped joint, as in known seam welders.

After passing through the compression rolls **46, 48**, the *welded strip* [composite strip] **49** is drawn by the rolls **50, 52**, which may be single stand or multiple stand as required, to the wind-up reel (not shown) that can be at a fair distance from the rolls **50, 52**. Time should be allowed for the welded metal to cool sufficiently for generation and stabilization of the desired metallurgical structure before subjecting the [composite strip] finished *strip* to mechanical working by bending about the wind-up reel.

The very slight overhang of the two strips **16, 18** as they approach the weld point (FIGURES 2 and 3) is so controlled that the heated edges **12** and **14**, as shown in FIGURES 5A, 5B and 6, tend to wipe across each other,

and become no longer overlapped. It is believed that, due to the heat generated in the edges and particularly to the concentration of heat in the surfaces of closely adjacent and approaching edge portions, the metal at one edge is wiped across the metal of the adjacent edge producing, under pressure of the forging rolls, a forged welded juncture **110** as shown in FIGURE 6 just prior to upset compression by the [compression] *compressive* rolls **46, 48**. Inasmuch as the speed of the welding operation is at the rate of 80 inches or more of strip per second, it is not as yet possible to fully and accurately determine exactly what takes place in the edge wiping area of the weld zone, but it is believed that the above constitutes a very possible and probable description of the operation.

Such a weld method is not a lap or mash weld of the two strips, but appears to be a true butt weld process in that the edges are in substantially planar contact when the forging rolls **34, 36** apply their horizontal pressure. Under such pressure, it would appear that the heat sink in each of the metal edges **12** and **14** is increased to a slightly greater depth so that a more uniform and more satisfactory weld structure is achieved than would occur with a lap or mash weld.

Forging pressure applied by the rolls **34, 36** is controlled by the pneumatic air cylinder **42** operating through the rod **112** and roll support **114**. The set screw **116** predetermines the width of the [composite strip] *finished strip* **49** and the allowable forward movement of the roll **36**.

The forging rolls **34, 36** are preferably made of bronze, brass or other nonmagnetic materials such as ceramics. It appears that, due to the close proximity of the rolls to the welding current paths, rolls of steel become inductively heated to temperatures at which they cannot operate with efficiency. Lubrication in the bearings of such steel rolls is liquified and runs out so that the rolls rotate on dry shafts and seize at their bearings. The forging rolls operate under an applied pressure from the air cyclinder **42**, further adding to the load on the bearings. To avoid such failure, the rolls **34, 36** and their bearings are therefore made of the aforementioned nonmagnetic materials which are not subject to induction heating.

Although actual testing resulting in the [composite strip] *welded strip* formed by the method and apparatus of this invention has been made with a high frequency generator operating at about 450,000 cycles per second, it is to be understood that high frequency equipment operating at frequencies of the order of from about 100,000 cycles per second up to and even beyond the range of 450,000 cycles per second can be utilized in the method and in connection with the apparatus of this invention. Where thin strip materials are being welded, the higher frequencies are preferred in order to obtain suitable surface welding temperatures with a minimum of heat depth penetration. For metal strips of relatively greater thickness the frequency range could be lower than 450,000 cycles per second in order to achieve a slightly greater heat depth penetration at the edges to be welded.

The overhanging and overhung relationship of the two strips **16** and **18** from positions adjacent their coils or from the positions of the drag rolls **26, 26** through to the draw rolls **50, 52** is of course somewhat critical. The wiping action of the heated edges desired in the processing of the *welded strip* [composite strip] will be effected if such overhang is less that which results in a lap at the welded edges. A lap weld requiring a mashing of the lap, does not come within the scope or concept of this invention which involves only a butt welding of the heated edges. Although some upset material is generated in the wiping action of the edges, no lap nor overlying weld of the two strips results from the overhanging relationship of one strip with respect to the other in the weld zone of this processing and apparatus. The forging rolls **34, 36** compress the strips **16** and **18** together into a butt weld, throwing up a slight upset from each strip, in the plane assumed by the strips just prior to their entry between the [compression] *compressive* rolls **46, 48**. See FIGS. 5A, 5B and 6.

For relatively light gauge strip stock, an overhanging-overhung magnitude of from just over the edge of one-strip to approximately one-half the thickness of the strip which is being overhung would appear to be satisfactory in the process of this invention for the production of an acceptable butt weld seam and [composite strip] *union*. Such gages would be in the thickness range of from .010" to .060" inclusive. For heavier strip stock, the overhanging-overhung magnitude could be up to as much as the full thickness of the strip which is being overhung.

The inventive method of high frequency electric current welding of *dual component* [composite strip] hereindisclosed comprises disposing two metal strips [in planes] at an acute angle to each other such that the adjacent interior edge of one strip just slightly overhangs the adjacent interior edge of the second strip as they are drawn toward a weld point, introducing and conducting such current to the strips at their adjacent edges, wiping the interior adjacent edges now heated to a welding state by such current across each other into butt relationship, and forging them together by laterally disposed rolls applied under pressure to the exterior edges of the strips just prior to the compression of the composite strip between rolls operating upon the now-welded strip. Neither the forging rolls nor the [compression] *compressive* rolls are draw rolls, these being applied beyond the site of the [compression] rolls and after welding of the strips into a [composite strip] *finished strip* has been completed.

In the process of the invention the two strips are aligned with respect to each other so that their interior edges are maintained in substantially the same parallel lines from the coil reels through the guide roll stands **24**, the drag rolls **26, 26**, and the strip supports **64** to the weld point, with a minimum of distortion and misalignment.

The apparatus described herein represents one embodiment of structures which can utilize the concept of invention hereindisclosed. Such apparatus provides guide roll stands that positively line up the interior strip edges **12** and **14** in a slightly overhanging relationship, supports that maintain the entry angle of the strips **16** and **18** of an order such that arcing is eliminated while maintaining current efficiencies at optimum or near-optimum values, and that provides laterally operating forging rolls to forge weld the strips together at a line ahead of [compression] *compressive* rolls which compress the weld upset bead and the [composite] *final* welded strip to a uniform thickness while maintaining the weld point substantially at a single position with respect to the fixed electrode contacts.

Having described the invention in its simplest terms, it is to be understood that the features of the process and apparatus hereindisclosed may be changed and somewhat varied in degree without departing from the essence of the invention.

I claim:

1. In the method for continuous production welding of a seam extending along adjacent edges of elongated metal strips, continuously advancing portions of said strips with their said adjacent edges toward and into the line of the desired seam and through and past a weld zone containing a weld point, introducing and conducting an electrical current from a source to said metal strips by two terminals in respective electrical contact with said strips so as to heat said edges by said current to a welding state, said terminals initiating said weld zone in said strips at positions where said strips are in a substantially spaced apart attitude and substantially in advance of said weld point, advancing one of said strips substantially

along a plane disposed at an acute angle to the plane along which the second strip is being advanced into said weld zone toward said weld point, and disposing and maintaining said adjacent edges at least in said weld zone in a slightly overhanging and overhung relationship, while restraining said adjacent edges from lateral separation parallel to said plane from said relationship by exerting restraining effort on the strips in said weld zone and in lateral directions toward said adjacent edges, so as to cause said heated edges to wipe across each other as they approach and pass into said weld point and become welded in a common plane.

2. The method of claim 1, in which said acute angle approximates 3° to 10°.

3. The method of claim 1, and further comprising placing said strips in tension between points substantially ahead of the strip contact positions of said terminals and a point beyond the position at which said strips are welded in a common plane.

4. In apparatus for welding a seam extending along adjacent edges of elongated metal strips, means for continuously drawing portions of said strips with their adjacent edges advancing toward and into the line of the desired seam, a source of electrical current, terminals connected to said source of current and disposed in electrical contact with each of said metal strips respectively to introduce said current to said metal strips adjacent said edges and form a weld zone from said terminals to a weld point, means for disposing one of said strips in a plane and another of said strips in a second plane at an acute angle to said first plane, and means to dispose and maintain said adjacent edges at least in said weld zone in a slightly overhanging-overhung relationship from said terminals to a position adjacent said weld point said last named means comprising means exerting restraining effort on the strips in said welded zone and in lateral directions toward said adjacent edges, so as to prevent lateral separation thereof and so as to bring said adjacent edges when heated to a welding state into edge wiping relationship in said weld zone as they approach and pass into said weld point and become welded in a common plane.

5. The apparatus of claim 4, in which the angle at which said first named disposing means positions said strips approximates 3° to 10°.

6. The apparatus of claim 4, and further comprising means to place said strips in tension between points substantially ahead of the strip contact positions of said terminals and a position beyond the point at which said strips are welded in a common plane.

7. The apparatus of claim 6, in which said strip tensioning means comprises a pair of rollers engaging each of said strips substantially ahead of the strip contact positions of said terminals and applying a braking action upon each strip.

8. The apparatus of claim 6, in which said strip tensioning means comprises a pair of rollers engaging each of said strips substantially ahead of the strip contact positions of said terminals and applying a braking action upon each strip, and means engaging opposite edges of each strip in advance of said strip contact positions to confine the same laterally in approaching said welded zone.

9. A method for continuous production welding of a seam extending along adjacent edges of elongated metal strips, comprising continuously advancing portions of said strips with their said adjacent edges toward and into the line of the desired seam and through and past a weld zone containing a weld point, intensely heating said edges to a welding state at positions where said strips are in a substantially spaced apart attitude and substantialy in advance of said weld point, advancing one of said strips substantially along a plane disposed at an acute angle to the plane along which said second strip is being advanced into said weld zone toward said weld point, and disposing and maintaining said adjacent edges at least in said weld zone in a slightly overhanging and overhung relationship, while restraining said adjacent edges from lateral separation parallel to said plane from said relationship by exerting restraining effort on the strips in said weld zone and in lateral directions toward said adjacent edges, so as to cause said heated edges to wipe across each other as they approach and pass into said weld point and become welded [as a composite strip] in a common plane.

10. The method of claim 9, in which said strips are of similarly relatively light gauge stock, the dimension of said overhanging and overhung relationship approximating one half the thickness of the stock.

11. The method of claim 9, in which the dimension of said overhanging and overhung relationship approximates the thickness of the stock of the strips.

12. The method of claim 9, and further comprising placing said strips in tension between points substantially ahead of said weld point and behind the point at which the strips are welded in a common plane, and laterally confining said strips against lateral separation in approaching said weld zone.

13. A method for the continuous production welding of a sedm extending along adjacent edges of elongated metal strips, comprising continuously advancing portions of said strips and their said adjacent edges toward, through and past a weld zone containing a weld point, intensely heating said edges to a welding state at positions where said strips are in a substantially spaced-apart attitude in advance of said weld point, advancing said strips convergently toward one another and substantially at an acute angle to a line along which said strips pass said weld point, and disposing and maintaining said adjacent edges at least in said weld zone in a slightly overhanging and overhung relationship, with said adjacent edges in a predetermined lateral relationship to said line, so as to cause said heated edges to wipe across each other as they approach said weld point and become welded in a common plane.

14. A method for the continuous production welding of a seam extending along adjacent edges of elongated metal strips, comprising continuously advancing portions of said strips and their said adjacent edges toward, through and past a weld zone containing a weld point, intensely heating said edges to a welding state at positions where said strips are in a substantially spaced-apart attitude in advance of said weld point, advancing said strips convergently toward one another and substantially at an acute angle to a line along which said strips pass said weld point, and disposing and maintaining said adjacent edges at least in said weld zone in a slightly overhanging and overhung relationship, with said adjacent edges in a predetermined lateral relationship to said line, by laterally guiding at least one of the strips forwardly of said weld point, so as to cause said heated edges to wipe across each other as they approach said weld point and become welded in a common plane.

15. The method of claim 13, in which said welded strips are of different metals.

16. The method of claim 14, in which said strips are of different metals and of similarly relatively light gauge stock.

17. The method of claim 13, is which said strips are of different metals and of similarly relatively light gauge stock, the dimension of said overhanging and overhung relationship approximating one-half the thickness of the stock.

18. The method of claim 13, in which said strips are of different metals and of similarly relatively light gauge stock, the dimension of said overhanging and overhung relationship approximating the thickness of the stock of the strips.

19. The method of claim 13, and further comprising placing said strips in tension substantially ahead of said weld point.

20. The method of claim 14, and further comprising

placing said strips in tension substantially ahead of said weld point.

21. A method for the welding of a butt seam between adjacent edges of metal strips, comprising relatively moving said strips toward one another in a weld zone, intensely heating said edges to a welding state when said strips are in a spaced-apart relation to one another in said weld zone, while maintaining said adjacent edges at least in said weld zone in a slightly overhanging and overhung lateral relationship and causing said heated edges to wipe across each other transversely of the strip surfaces to become welded in a common plane.

References Cited

The following references, cited by the Examiner, are of record in the patented file of this patent or the original patent.

UNITED STATES PATENTS

1,093,207	4/1914	Ryan	219—52 X
1,357,156	10/1920	Von Eckermann	219—105
2,647,981	8/1953	Wogerbauer	219—6
2,774,857	12/1956	Rudd et al.	219—67
2,821,619	1/1958	Rudd	219—107
2,857,503	10/1958	Rudd et al.	219—59
2,886,691	5/1959	Rudd	219—67
2,922,020	1/1960	Andrew	219—59 X
3,017,494	1/1962	Mackey	219—72 X
3,193,657	7/1965	Gebauer	219—72 X
1,092,207	4/1914	Ryan	219—52 X
1,357,156	10/1920	Von Eckmann	219—105
2,922,020	1/1960	Andrew	219—59
3,017,494	1/1962	Mackey	219—72 X
3,193,657	7/1965	Gebauer	219—72 X

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