

Oct. 10, 1939.

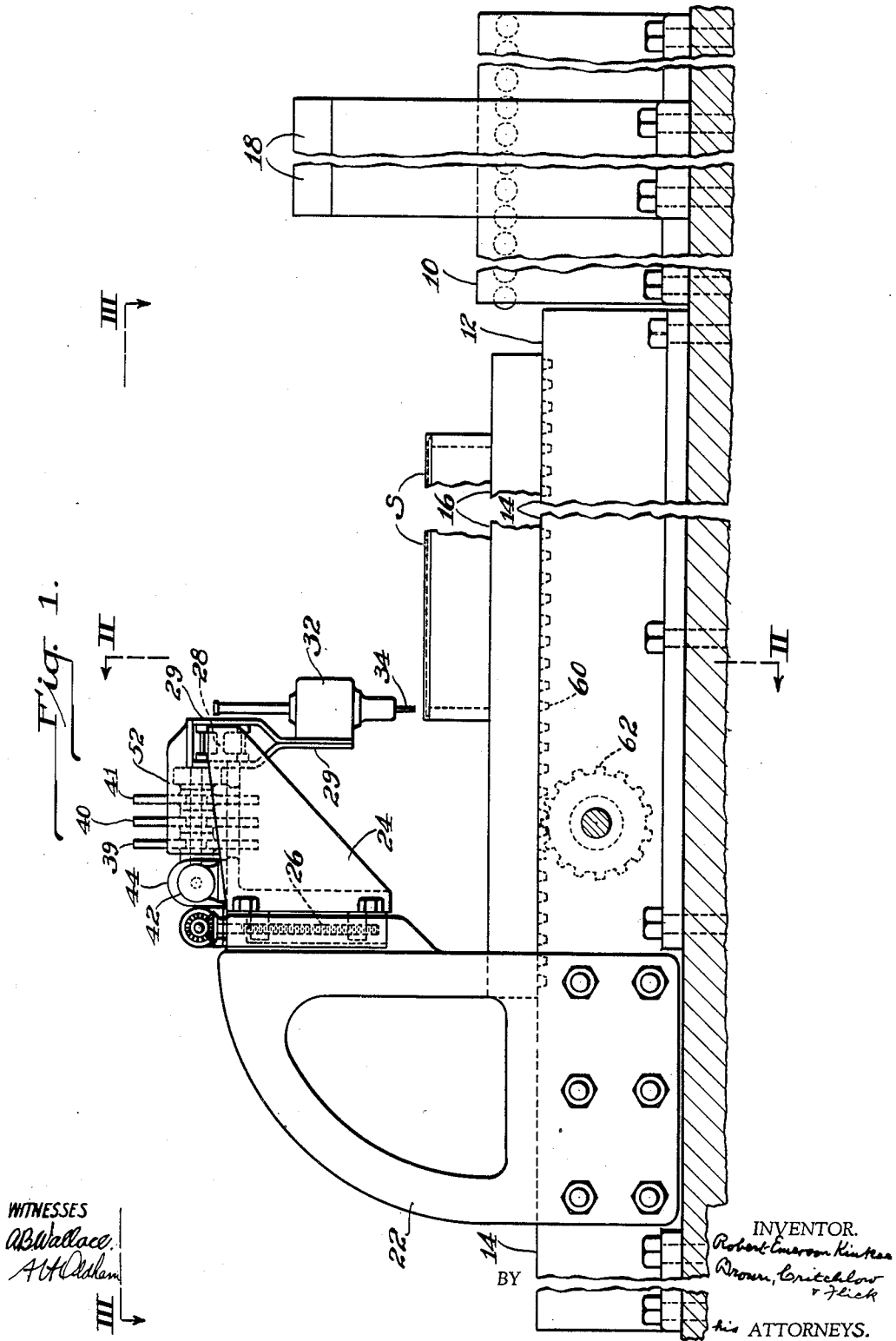
R. E. KINKEAD

2,175,606

METHOD AND APPARATUS FOR ALLOYING METAL

Filed Oct. 9, 1937

4 Sheets-Sheet 1



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METHOD AND APPARATUS FOR ALLOYING METAL

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4 Sheets-Sheet 2

Fig. 2.

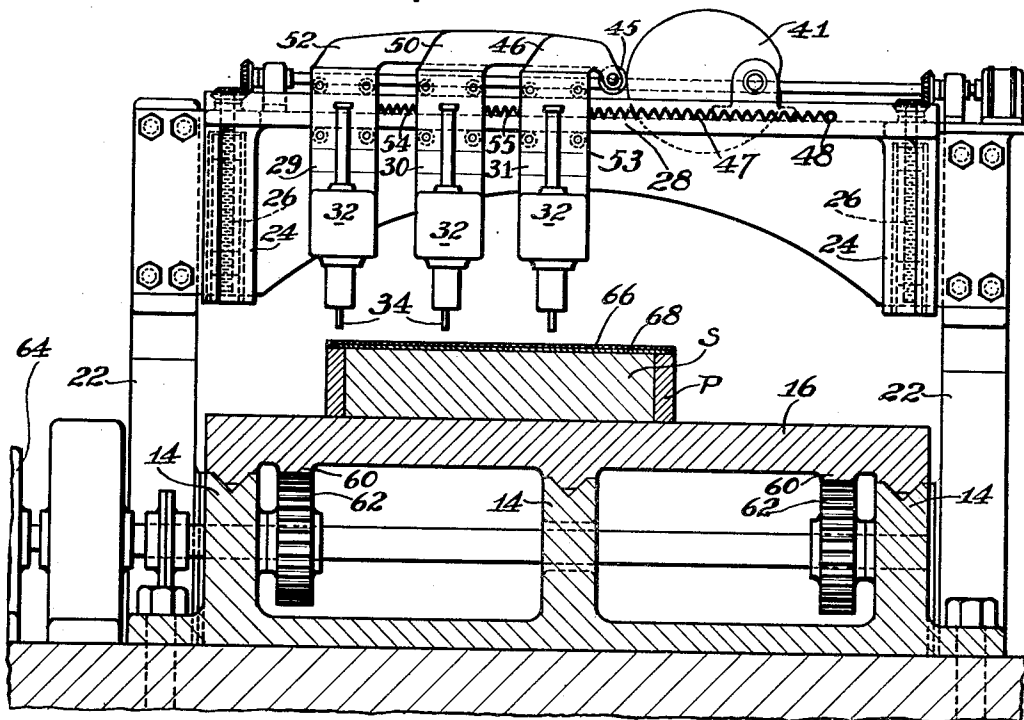
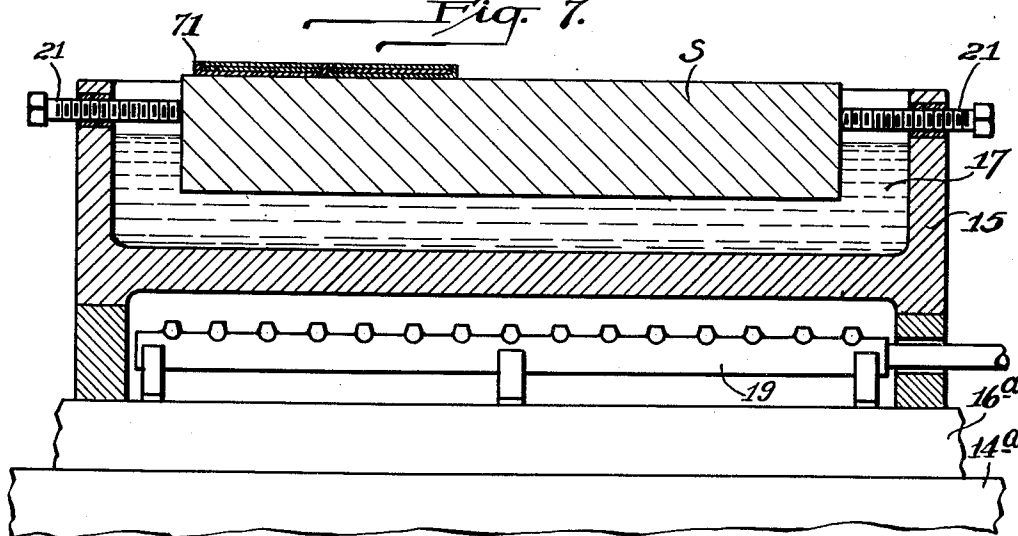


Fig. 7.



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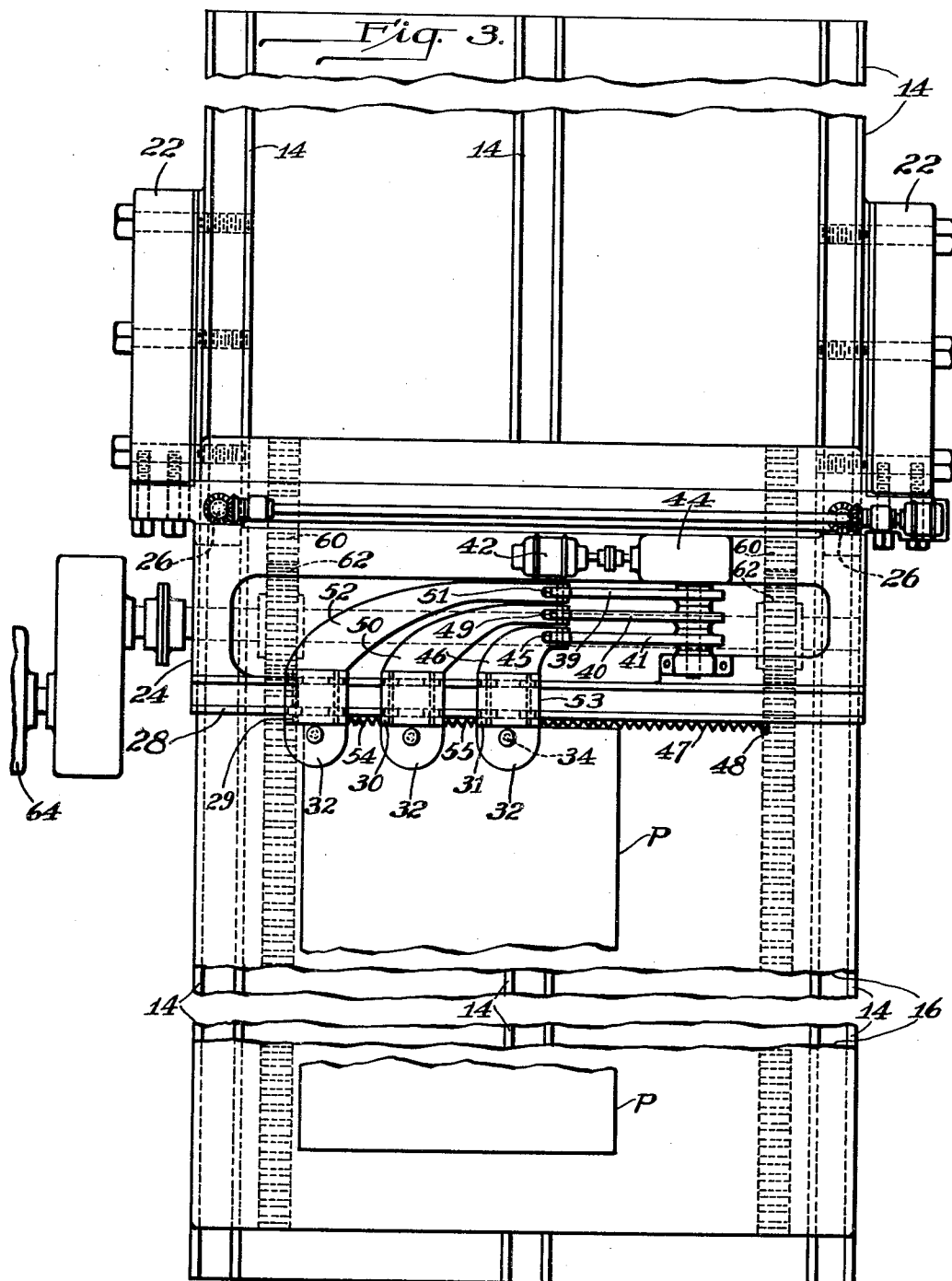
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METHOD AND APPARATUS FOR ALLOYING METAL

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4 Sheets-Sheet 3



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METHOD AND APPARATUS FOR ALLOYING METAL

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4 Sheets-Sheet 4

FIG. 4.

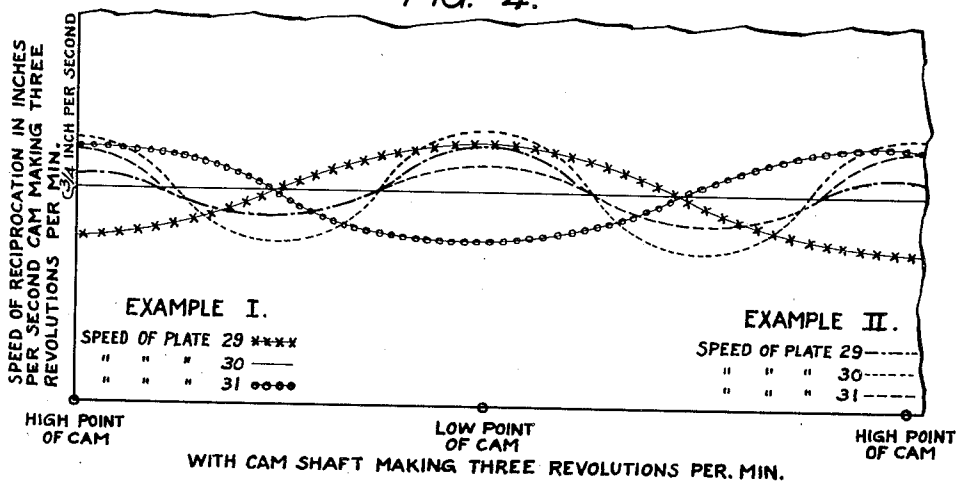


FIG. 5.

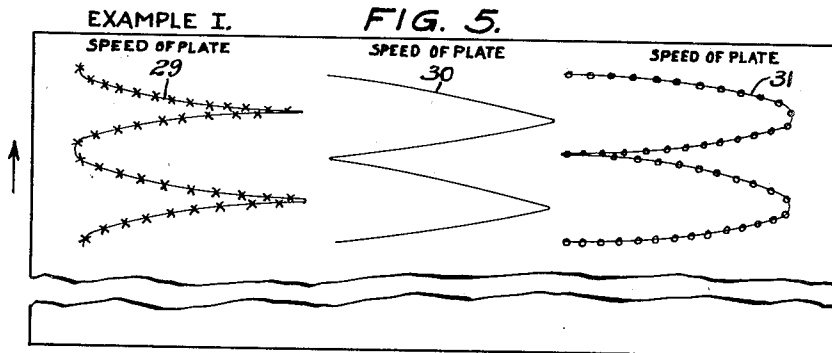
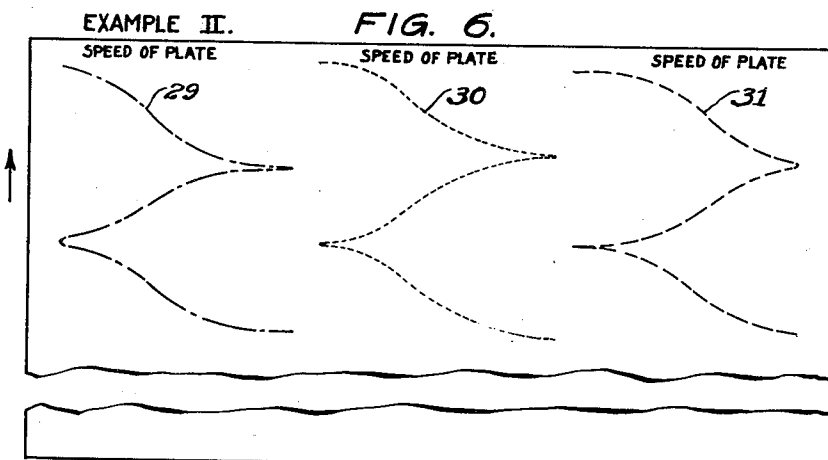


FIG. 6.



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UNITED STATES PATENT OFFICE

2,175,606

METHOD AND APPARATUS FOR ALLOYING
METAL

Robert Emerson Kinkead, Cleveland, Ohio

Application October 9, 1937, Serial No. 168,239

19 Claims. (Cl. 148—10)

This invention relates to apparatus and methods for alloying and heat treating metal bodies, and more particularly is concerned with improved methods and apparatus for treating slabs, ingots, or similar metal bodies so that selected exterior surfaces thereof may be formed of the desired composition.

It is the general object of my invention to provide apparatus of the general character which is particularly adapted to provide a uniform penetration of the alloying materials over the desired or entire surface of the metal body treated and wherein the alloyed metal in the treated body is uniformly welded to the body over the entire treated surface thereof and in which the physical characteristics of the alloying layer are uniform throughout.

Another object of my invention is the provision of an improved method for uniformly alloying the surface of a metal body such as a slab.

Another object of my invention is the provision in electric arc apparatus for alloying the surface of a slab of mechanism for effecting relative movement between the arc and the surface of the slab whereby the penetration of the alloying material is uniform and there are no overlapping alloyed portions.

The foregoing and other objects of my invention are achieved by preheating the body to a temperature above the magnetic range of the metal covering the surface of the body to be alloyed with a layer of alloy and a covering layer of flux, and melting portions of the surface of the body through the flux and alloy with an electric arc. The metal body and the arc are continuously moved relative to each other in one direction at a relatively slow speed and the body and the arc are repeatedly moved back and forth relative to each other at a faster speed in a direction substantially at right angles to the first-named direction. The last-named back and forth movement is faster in portions of the body having a relatively high residual heat and slower in portions of the body having a lower residual heat so that the penetration of the alloying material is uniform over the body, and the speed and extent of the several movements is controlled so that the alloying pool created by the arc engages only with molten portions of the body already alloyed. In other words, the molten pool of the arc is always moved from an alloyed towards an unalloyed portion of the body and is not passed a second time over a solidified portion of the body already alloyed.

The apparatus for surface alloying metal bodies in accordance with my invention includes means for supporting and moving the body in a substantially horizontal plane, and means for preheating the body to above its magnetic range and/or for maintaining its temperature substantially constant during the surface alloying operation. One or more electrodes are positioned substantially in alignment transversely of the line of movement of the body and in working relation with the body, and means are provided for independently moving the electrodes transversely of the line of movement of the slab and at a controlled and variable rate of speed so that the degree of penetration of alloying material placed on the surface of the body is substantially uniform and the body is alloyed progressively from one end to the other.

In the accompanying drawings Fig. 1 is a side elevation of apparatus comprising one embodiment of my invention; Fig. 2 is a vertical cross sectional view taken on the line II—II of Fig. 1; Fig. 3 is a partial plan view of the arc-moving mechanism as taken on line III—III of Fig. 1; Fig. 4 is a graphical representation of the movement of the electric arc-carrying means so that the alloying of the slab is effected uniformly over its entire surface; Fig. 5 is a diagrammatic plan view of the treated slab illustrating the paths of movement of the several electric arcs; Fig. 6 is a view similar to Fig. 5 but illustrates a modified form of movement; and Fig. 7 is a longitudinal cross-sectional view of improved means for preheating and maintaining the metal body treated at a uniform temperature.

While it should be understood that the principles of my invention are broadly applicable to the surface alloying and associated heat treating of metal bodies of various kinds, such as slabs, ingots, blooms, rolls, dies, and the like, they are particularly advantageous in the surface alloying of a metal slab and accordingly have been so illustrated in the accompanying drawings and will be so described.

Referring particularly to the embodiment of my invention illustrated in Figs. 1 to 4, the numeral 10 indicates generally a conveyor adapted to receive one or more slabs marked S. Associated with the conveyor 10 is a surface alloying unit, indicated generally at 12, and associated means for carrying the slabs in turn through the surface alloying unit. These slab-carrying means may obviously take a plurality of forms but I have specifically illustrated my invention as including one such means which comprises

a base 14 slidably carrying a table 16 for movement through the surface alloying apparatus 12.

I have found that the surface alloying of a metal body, such as the slab S, is facilitated by preheating the slab, and it is often difficult to surface alloy without preheating the slab. While the exact preheated temperature of the slab can be varied within relatively wide limits, as long as it is above the magnetic range of the metal, I have found that when the slab is preheated to a temperature of between about 600 and about 800° C., and preferably in the neighborhood of 690° C., that subsequent surface alloying operations are most successful. The preheating of the slab can be accomplished in a plurality of different ways, as for example by the use of auxiliary furnaces, or by placing a furnace 18 over the conveyor 10 so that the slabs in passing along the conveyor to the surface alloying apparatus 12 are brought to the desired temperature and immediately pass to the apparatus. I contemplate, however, mounting an auxiliary furnace on the reciprocating bed 16 which may be used to hold the slab at a preheated temperature, or which may comprise an insulating body surrounding the slab so as to hold it against heat losses when the slab is preheated elsewhere. Again, if the furnace is provided on the table 16 it may be used to bring the slab up from room temperature, although this method and apparatus are not preferred inasmuch as they do not adapt themselves to continuous production surface-alloying operations.

It is an important part of my invention to maintain all operating conditions as uniform as possible during the surface-alloying. Thus it is highly advisable and advantageous to keep constant the temperature of the metal body treated, such as the slab S. I may maintain the temperature substantially constant by preheating and thereafter surface alloying while controlling the temperature of the slab with burners whose operation may be governed by thermostats associated with the slab. Thus any heat lost by the slab or heat added thereto by the alloying arcs is compensated.

Another manner of keeping the temperature of the slab constant is illustrated in Fig. 7 wherein the table 16a mounted for sliding movement on the base 14a carries a tank 15 filled with molten lead 17 and heated by a burner 19. The slab S floats in or is surrounded by the molten lead which not only maintains the temperature of the slab quite constant but also serves as an excellent electrical connection to the slab as hereinafter described. Means, such as screws 21, are provided to hold the slab steady in the tank 15 for movement past the alloying apparatus.

The surface alloying apparatus, indicated generally at 12, includes a frame 22 having vertically adjustable brackets 24 slidably mounted thereon, and adapted to be adjusted as by screws 25. Mounted between the brackets 24 is a horizontally extending beam 23 which slidably carries a plurality of plates, as for example three, indicated at 29, 30 and 31, for horizontal movement in spaced relation transversely above the slab S. Mounted upon each plate 29, 30 and 31 is an electric welding head 32 of any desired known construction and including a carbon electrode 34 positioned closely above the upper surface of the slab S. The electric arc heads 32 are mounted in spaced relation to each other and are reciprocated back and forth on the beam 23 so that

the entire surface of the slab S is subjected to an alloying operation.

An important feature of my invention is the provision of means for reciprocating the electric welding heads whereby they not only heat the entire or desired surface of the slab but so that the heat is uniform over substantially the entire desired surface. I accomplish the desired reciprocating movement of each welding head 32 by providing a plurality of heart-shaped cams 39, 40 and 41 which are rotatably driven by a motor 42 operating through a gear box 44. The cam 41 extends into operating relation with the plate 31 which is provided with a cam follower, such as a roller 45, which is ordinarily mounted upon a bracket 46 secured to the top of the plate 31. A tension spring 47 secured at one end to the plate 31 and at its other end to a pin 43 carried by the beam 23, holds the cam follower roller 45 in firm engagement with the cam 41 regardless of the angular position of the cam. In a like manner, the cam 40 engages with a follower 49 carried by a bracket 50 and secured to the plate 30 and the cam 39 engages with a follower 51 carried by a bracket 52 secured to the plate 29. Springs 54 and 55 secured between the plates 29, 30 and 31 hold the cam followers against their respective cams. Thus, by operation of the motor 42 the plates 29, 30 and 31 are caused to reciprocate back and forth above the surface of the slab S.

Due to the shape of the cams 39, 40 and 41 the movement of the plates 29, 30 and 31 and the welding heads 32 over the surface of the slab is at a controlled speed so that the penetration of the alloying material is uniform or as desired over the treated surface of the slab. Two typical examples of the movement of the welding heads as effected by the cams is best evident from the graphical showing of the cams as seen in Fig. 4. I have found that in employing a direct current carbon arc which draws about 800 amperes that an average transverse speed of the carbon electrodes to effect a surface alloying operation approximately $\frac{3}{8}$ of an inch thick, should be in the neighborhood of $\frac{3}{4}$ of an inch per second where the slab is preheated to the temperature before described and is moved forwardly by the table at a speed of about one foot in seventeen minutes. The indicated transverse speed of the welding head 32 can be achieved by rotating each cam approximately three times per minute and adapting each to have a total stroke of $7\frac{1}{2}$ inches.

In Example I shown in Fig. 4 the speed of the plate 29 and its associated welding head is controlled by the cam 39 which is constructed to move the plate 29 with a starting speed of somewhat under $\frac{3}{4}$ of an inch per second which gradually accelerates to a speed of somewhat over $\frac{3}{4}$ of an inch per second at the low point of the cam. The speed then gradually decelerates to the high point of the cam. The resulting line of movement of the electrode 34 carried by the plate 29 over the slowly advancing slab is illustrated in exaggerated manner at the left hand side of Fig. 5. From the showing in Figs. 4 and 5 it will be recognized that the movement of the arc near the lateral edge of the slab is somewhat slower than $\frac{3}{4}$ of an inch per second and towards the center arc is slightly faster than $\frac{3}{4}$ of an inch per second. This is because the center arc has heated the center portion of the slab and in order to obtain uniform penetration the plate 29 and associated welding head are moved faster near the center of the slab. The plate and welding head

are also moved faster because the arc is returned over the portion of the slab it has just passed over and which is thus preheated to a considerable degree. It should be noted that the speed of plates 29, 30 and 31 drops to zero at the exact high and low points of the cams 39, 40 and 41 inasmuch as the direction of movement of the plates is changed at the high and low points of the cams. However, since the speed of the plates 29, 30 and 31 only drops to zero, as just explained, for a very small fraction of time, the diagrammatic showing of speed in Fig. 4 has not been complicated by illustrating thereon the instantaneous drops to zero speed.

The plate 31 and associated welding head, as seen in Figs. 4 and 5, are moved like plate 29 but just opposite in order to obtain uniform penetration of the alloy and the plate 30 and its welding head are moved at a uniform speed of $\frac{3}{4}$ of an inch per second all as controlled by the shape of the cams 41 and 40, respectively.

From the foregoing explanation of Example I of Figs. 4 and 5 it is believed that the movement of the arcs of Example II as seen in Figs. 4 and 6 will be understood. Suffice it to say that in Fig. 6 the longitudinal movement of the slab has been exaggerated to better illustrate the varying rate of transverse movement of the arcs to achieve uniform penetration.

Two typical examples of ways to obtain uniform penetration have been given, but it should be understood that these examples are not limiting but merely suggestive for the reason that the specific heat of the metal, its preheated temperature, the volume of current drawn by the arc, its exact speed of transverse movement, the longitudinal speed of the slab, and the character of the alloying metal added, are all factors which effect and influence the penetration of the metal and the path of movement of the arcs.

It should, moreover, be understood that by controlling the speeds of the arcs instead of uniform penetration of the alloying material to any desired depth, a controlled nonuniform penetration may be obtained. Specifically, by slowing up the travel of the arc the alloy penetrates more deeply so that certain portions of the slab, for example the edges or the center, may be formed with an alloying layer of greater depth.

It will be understood that as the welding heads are reciprocated back and forth by their associated cams the slab S is being moved at a uniform rate of speed through the surface alloying apparatus 12. This exact rate of speed can be varied dependent upon the amount of current drawn by the welding heads, the width of the reciprocations of the mechanisms and the particular alloying penetration desired. In the example given above I move the slab S longitudinally through the surface alloying apparatus 12 at a speed between about $\frac{1}{4}$ of an inch and about 2 inches per minute, ordinarily in the neighborhood of $\frac{3}{2}$ of an inch per minute. When the current drawn by each welding head is increased to 1200 amperes the slab can be moved through the apparatus at a speed of about $1\frac{3}{4}$ inches per minute and the same penetration obtained.

Any suitable means may be employed for moving the table 16 and the slab S through the surface alloying apparatus 12 but in the embodiment of my invention illustrated these means include racks 60 secured to the bottom of the table 16 which racks engage with gears 62 connected by suitable mechanism to a motor 64 mounted upon the frame 22.

While the particular type of alloying material and associated flux has been generally described in my referred-to application, I have found that instead of supplying the alloying material and flux in powder form to the top of the slab to be treated, it is often advantageous to form these materials in flat sheets with a suitable binder to hold them in shape. Thus, in Fig. 2 the numeral 66 indicates a layer of alloying material such as low carbon ferro-chrome and pure nickel, as for example in such proportions that the alloyed surface will contain about 18 per cent chromium and about 8 per cent nickel. The ferro-chrome and nickel may be in the form of a plurality of wires or rods which are laid side by side, or it can be in powder form with a suitable binder such as sodium silicate. Surrounding the layer of alloying material is a layer 68 of flux which is preferably composed of powder-fused finishing slag taken from an electric arc furnace in which 13 chrome and 8 nickel steel has been made. This fused slag is ground up and mixed with about 30 per cent clean sand and between about 5 to about 10 per cent ferro-silicon. A binder of suitable material, as for example sodium silicate, is added to the slag and is pressed into cake or layer form of the desired dimensions with or without the layer 66 of alloy material being pressed therewith.

Instead of using preformed cakes of alloying material and flux I may place the loose or separate materials in low carbon sheet metal pans, as shown at 71 in Fig. 7, which are placed on top of the slab.

In order to surface alloy completely to the sides of the slab S, I may provide boundary plates P at the sides of the slab which are held by any suitable means tightly in engagement with the sides of the slab with the layers of flux and alloying material extending over the plates P.

It is believed that the operation of my improved apparatus and the method of my invention will be evident from the foregoing description. Briefly summarizing, however, after preheating the slab S and while maintaining it at as uniform a temperature as possible it is positioned on the table 16 which is fed slowly through the surface alloying apparatus 12. The several welding heads are started after the positive side of the operating current is connected to the slab and the motor 42 is operated to reciprocate the heads back and forth across the surface of the slab. The combined reciprocating movement of the welding heads 32 and the forward feeding movement of the slab S effects a progressive melting of the slag 68, the alloying material 66, and the base metal of the slab across the entire width thereof. The movement of the slab through the apparatus effects the progressive surface alloying of the slab from end to end, all as particularly described in my referred-to copending application. There is no re-alloying of portions already alloyed since the reciprocating movement of the arcs is sufficiently rapid to melt a relatively large pool which pool, due to the forward movement of the slab, moves slowly from one end of the slab to the other without the arcs or arc ever striking a portion of the slab which has been alloyed but has solidified.

The process as just described can be continuous with the slabs being fed through the surface-alloying apparatus in abutting end-to-end relation, with layers of slag and alloying material, of course, being provided on the individual slabs before the surface alloying operation. Once

through the apparatus 12, the surface alloyed slab is allowed to cool after which the slag is cracked away so that the slab is ready for any desired finishing operation, such as rolling to sheets or strips.

Instead of the direct current carbon arc welding heads above specifically described I may use alternating current atomic hydrogen welding heads which are advantageous in certain operations inasmuch as the atomic hydrogen heads operate to decarburize the metal melted. I may also use gas or other welding heads which will provide the requisite heat for alloying, as will be understood.

From the foregoing it will be recognized that the objects of my invention have been achieved by the provision of improved methods and apparatus for surface alloying metal bodies, such as slabs, with the apparatus and methods effecting uniform or desired penetration of the alloying materials in the bodies treated. The apparatus and methods adapt themselves to commercial production and may be employed in conjunction with treatment of metal bodies of various kinds. The apparatus is relatively simple and inexpensive and is easily operated and maintained.

While in accordance with the patent statutes at least one embodiment of the invention has been specifically described and illustrated, it should be appreciated that my invention is not limited thereto or thereby but is defined in the appended claims.

I claim:

1. That method of alloying the surface of a metal body which comprises melting portions of the surface of the body with suitable means while providing a covering flux and alloy, continuously moving the body and the melting means relative to each other in one direction at a relatively slow speed and repeatedly moving the body and the melting means back and forth relative to each other at a faster speed in a direction substantially at right angles to the first-named direction.

2. That method of alloying the surface of a metal body which comprises covering the surface of the body to be alloyed with a layer of alloy and a covering layer of flux, melting portions of the surface of the body through the flux and alloy with an electric arc, continuously moving the body and arc relative to each other in one direction at a relatively slow speed and repeatedly moving the body and the arc back and forth relative to each other at a faster speed in a direction substantially at right angles to the first-named direction, said last-named back and forth movement being faster in portions of the body having a relatively high residual heat and slower in portions of the body having a lower residual heat so that penetration of the alloying material is uniform over the body.

3. That method of alloying the surface of a metal body which comprises preheating the body to a temperature above the magnetic range of the metal, covering the surface of the body to be alloyed with a layer of alloy and a covering layer of flux, melting portions of the surface of the body through the flux and alloy with heating means, continuously moving the body and heating means relative to each other in one direction at a relatively slow speed and repeatedly moving the body and the heating means back and forth relative to each other at a faster speed in

a direction substantially at right angles to the first-named direction.

4. That method of alloying the surface of a metal body which comprises preheating the body to a temperature above the magnetic range of the metal and at least about 600° C., covering the surface of the body to be alloyed with a layer of alloy and a covering layer of flux, melting portions of the surface of the body through the flux and alloy with a direct current carbon electrode electric arc having the positive connection to the body, continuously moving the body and arc relative to each other in one direction at a relatively slow speed and repeatedly moving the body and the arc back and forth relative to each other at a faster speed in a direction substantially at right angles to the first-named direction.

5. That method of alloying the surface of a metal body which comprises melting portions of the surface of the body with suitable means while providing a covering flux and an alloy, continuously moving the body and the melting means relative to each other in one direction at a relatively slow speed and repeatedly moving the body and the melting means back and forth relative to each other at a faster speed in a direction substantially at right angles to the first-named direction, said last-named back and forth movement being faster in portions of the body having a relatively high residual heat and slower in portions of the body having a lower residual heat so that penetration of the alloying material is uniform over the body, and controlling the speed and extent of the several movements so that the alloying pool created by the melting means engages only with molten portions of the body already alloyed.

6. That method of alloying the surface of a metal body which comprises preheating the body to a temperature above the magnetic range of the metal and between about 600 and about 900° C., covering the surface of the body to be alloyed with a layer of alloy and a covering layer of flux, melting portions of the surface of the body through the flux and alloy with a direct current carbon electrode electric arc having the positive connection to the body, continuously moving the body and arc relative to each other in one direction at a relatively slow speed, and repeatedly moving the body and the arc back and forth relative to each other at a faster speed in a direction substantially at right angles to the first-named direction, said last-named back and forth movement being faster in portions of the body having a relatively high residual heat and slower in portions of the body having a lower residual heat so that penetration of the alloying material is uniform over the body, and controlling the speed and extent of the several movements so that the alloying pool created by the arc engages only with molten portions of the body already alloyed.

7. The method of surface alloying slabs and the like which comprises moving the slab slowly beneath a plurality of substantially transversely aligned heating mechanisms, melting portions of the slab while mixing the alloying material therewith, and moving the heating mechanisms independently of each other transversely back and forth of the slab so that together with the first-named movement, the surface of the slab is rendered molten and is alloyed progressively from end to end.

8. The method of surface alloying slabs and

the like which comprises covering the portion of the slab to be alloyed with a layer of alloying material, covering the surface of the alloying material with a layer of flux, moving the slab slowly beneath a plurality of substantially transversely aligned arc electrodes, starting the arcs to melt portions of the slab and mix the alloying material therewith, and moving the arcs independently of each other transversely back and forth of the slab so that together with the first-named movement the surface of the slab is rendered molten and is alloyed progressively from end to end, and controlling the independent movement of the arcs so that the surface of the slab is melted and alloyed to a substantially uniform depth.

9. The method of surface alloying slabs and the like which comprises preheating the slab to a temperature above its magnetic range, moving the slab slowly beneath a plurality of substantially transversely aligned heating mechanisms, starting the mechanisms to melt portions of the slab, mixing an alloying material therewith, moving the mechanisms transversely back and forth of the slab so that together with the first-named movement the surface of the slab is rendered molten and is alloyed progressively from end to end, and controlling the movement of the mechanisms so that the surface of the slab is melted to a substantially uniform depth.

10. The method of surface alloying slabs and the like which comprises preheating the slab to a temperature above its magnetic range, moving the slab slowly beneath a plurality of substantially transversely aligned heating mechanisms, starting the mechanisms to melt portions of the slab, mixing an alloying material therewith, moving the mechanisms transversely back and forth of the slab so that together with the first-named movement the surface of the slab is rendered molten and is alloyed progressively from end to end, controlling the movement of the mechanisms so that the surface of the slab is melted to a substantially uniform depth, and maintaining the preheated temperature of the slab substantially constant during the alloying operation.

11. The method of surface alloying slabs and the like which comprises covering the portion of the slab to be alloyed with a layer of alloying material, covering the surface of the alloying material with a layer of flux, preheating the slab to a temperature above its magnetic range, moving the slab slowly beneath a plurality of substantially transversely aligned direct current carbon arc electrodes having their positive connections to the slab, starting the arcs to melt portions of the slab and mix the alloying material therewith, and moving the arcs independently of each other transversely back and forth of the slab so that together with the first-named movement the surface of the slab is rendered molten and is alloyed progressively from end to end, controlling the independent movement of the arcs so that the surface of the slab is melted to a substantially uniform depth, and maintaining the preheated temperature of the slab substantially constant during the alloying operation.

12. Apparatus for surface alloying metal bodies which comprises means for supporting and moving the body in a line in a substantially horizontal plane, a plurality of heating mechanisms positioned substantially in alignment transversely of the line of movement of the body and in working relation with the body, means for independently and continuously moving each heating mecha-

nism transversely of the line of movement of the slab so that the degree of penetration of alloying material placed on the surface of the body is as desired.

13. Apparatus for surface alloying metal bodies which comprises means for supporting and moving the body in a substantially horizontal plane, a plurality of electric arcs positioned substantially in alignment transversely of the line of movement of the body and in working relation with the body, means for independently moving the arcs transversely of the line of movement of the slab and at a controlled and variable rate of speed so that the degree of penetration of alloying material placed on the surface of the body is substantially uniform and the body is alloyed progressively from one end to the other.

14. Apparatus for surface alloying metal bodies which comprises means for supporting and moving the body in a substantially horizontal plane, means for preheating the body to above its magnetic range, a plurality of electric arcs positioned substantially in alignment transversely of the line of movement of the body and above and in working relation with the body, the electrically positive connection of the arcs being made to the body, means for independently moving the arcs transversely of the line of movement of the slab and at a controlled and variable rate of speed so that the degree of penetration of alloying material placed on the surface of the body is substantially as desired and the body is alloyed progressively from one end to the other.

15. Apparatus for surface alloying metal bodies which comprises means for supporting and moving the body in a substantially horizontal plane, means for preheating the body to above its magnetic range and for maintaining its temperature substantially constant during the surface alloying operation, a plurality of heating mechanisms positioned substantially in alignment transversely of the line of movement of the body and in working relation with the body, means for independently moving the heating mechanisms transversely of the line of movement of the body and at a controlled and variable rate of speed.

16. Apparatus for surface alloying metal bodies which comprises means for supporting and moving the body in a substantially horizontal plane, means for preheating the body to above its magnetic range and for maintaining its temperature substantially constant during the surface alloying operation, a plurality of direct current carbon arc electrodes positioned substantially in alignment transversely of the line of movement of the body and above and in working relation with the body, the electrically positive connection of the arcs being made to the body, means for independently moving the arcs transversely of the line of movement of the body and at a controlled and variable rate of speed so that the degree of penetration of alloying material placed on the surface of the body is substantially uniform and the body is alloyed progressively from one end to the other.

17. In surface alloying apparatus for treating slabs and the like the combination of a tank adapted to receive a slab, molten metal in the tank, means for maintaining the molten metal molten and at a constant temperature, an electric arc for melting the surface of a slab received in the tank, the positive side of the arc circuit being connected to the tank, and means for effecting relative movement between the arc and the tank for surface alloying a slab carried in the tank.

18. That method of surface alloying a slab or the like which includes the steps of preheating the slab to a temperature about 600° C. prior to the surface-alloying operation, and maintaining
5 the slab substantially at its preheated temperature during the surface-alloying operation.

19. That method of surface alloying a slab or the like which comprises heating the slab to

form a molten pool thereon, adding alloying material to the pool, and covering the pool at least during the alloying operation with a layer of slag taken from an electric arc furnace in which chrome nickel steel has been made, the
5 slag including small amounts of silica and ferro-silicon.

ROBERT EMERSON KINKEAD.

CERTIFICATE OF CORRECTION.

Patent No. 2,175,606.

October 10, 1939.

ROBERT EMERSON KINKEAD.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, first column, line 3, claim 18, before the word "about" insert above; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of November, A. D. 1939.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.