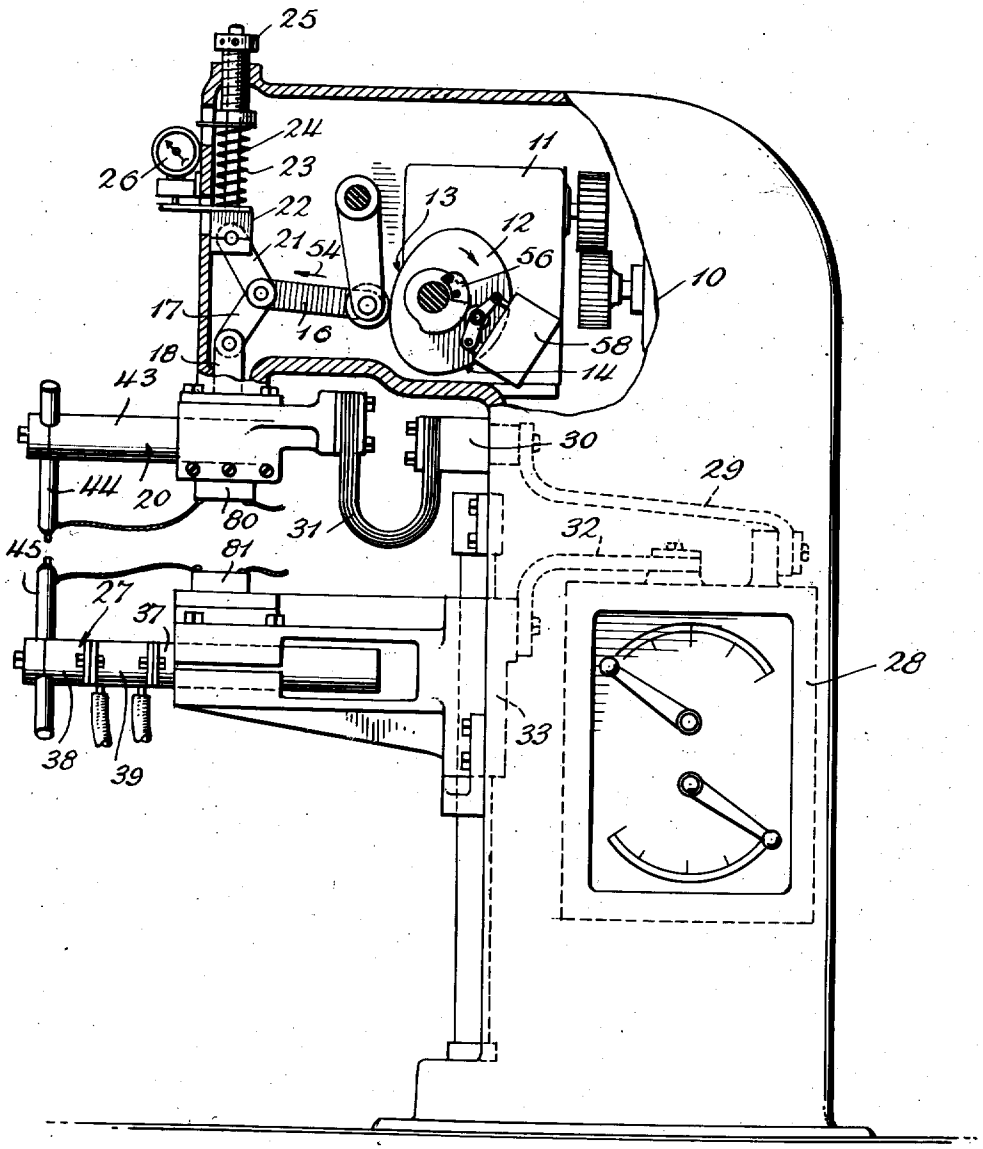
Feb. 18, 1936. N. F. MALLEY 2,030,906

METHOD AND MEANS FOR SPOT WELDING ALUMINUM AND ALUMINUM ALLOYS

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Fig. 1.



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METHOD AND MEANS FOR SPOT WELDING ALUMINUM AND ALUMINUM ALLOYS

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Fig. 2.

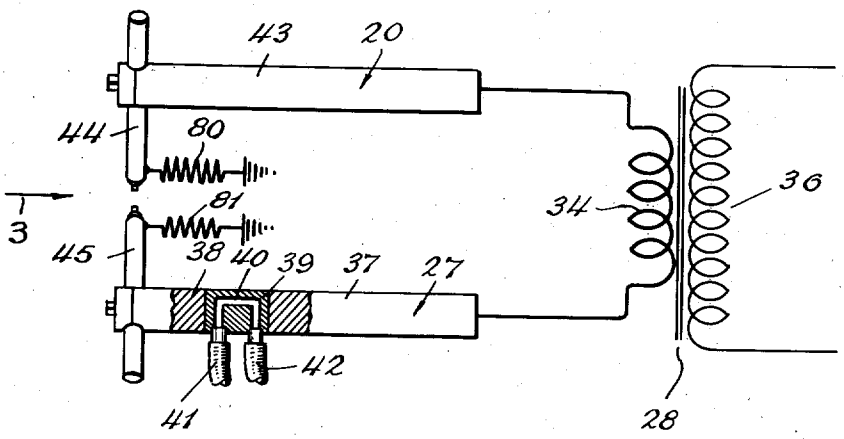


Fig. 3.

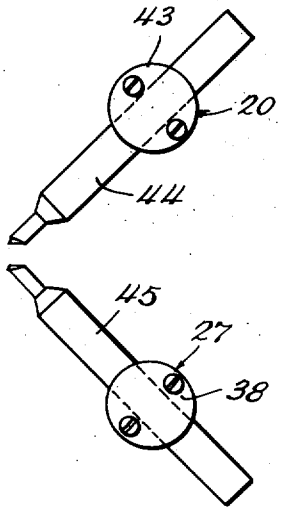
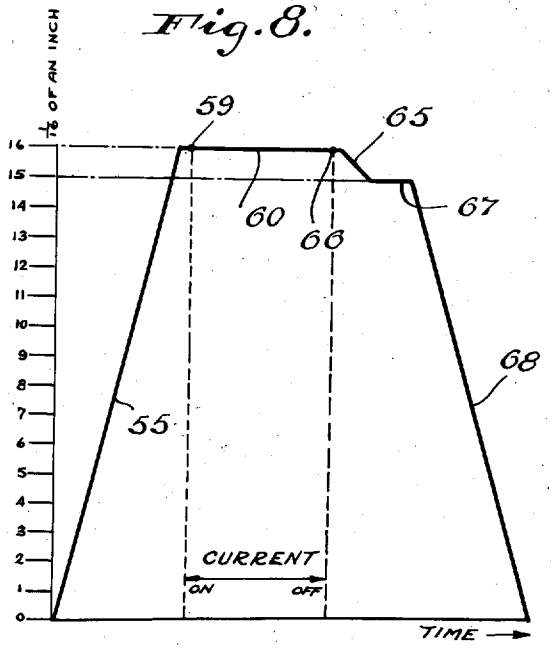


Fig. 8.



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METHOD AND MEANS FOR SPOT WELDING ALUMINUM AND ALUMINUM ALLOYS

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Fig. 4.

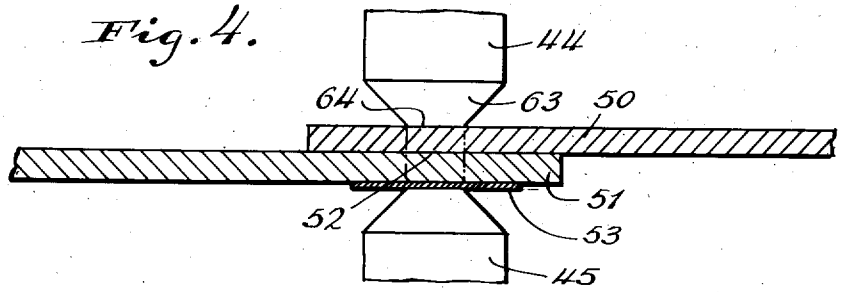


Fig. 5.

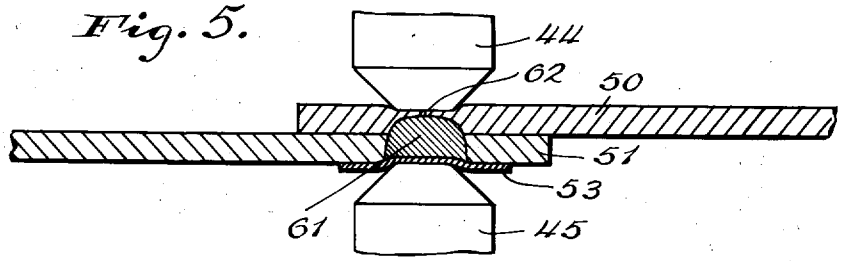


Fig. 6.

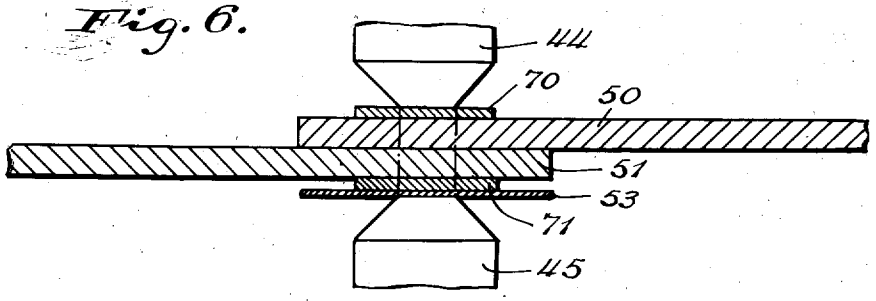
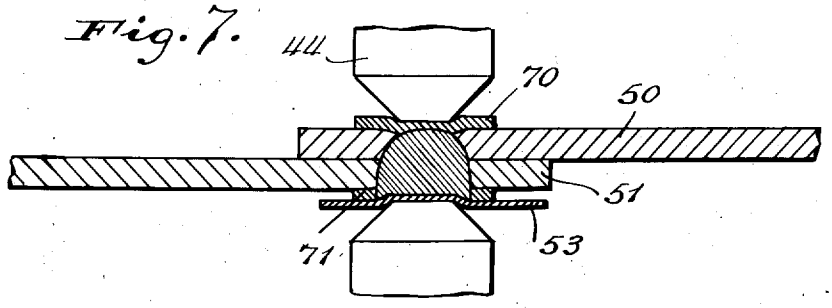


Fig. 7.



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Fig. 10.

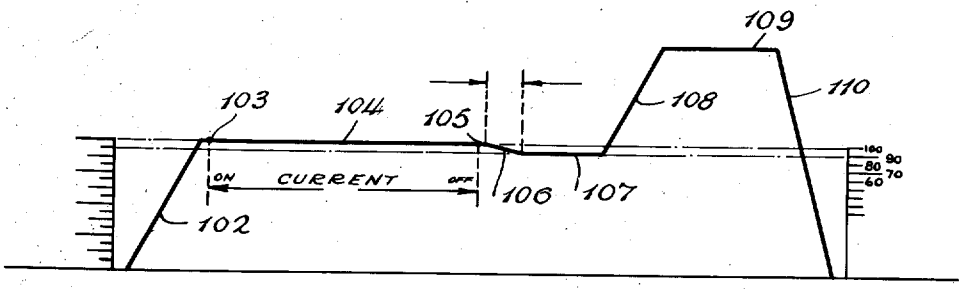
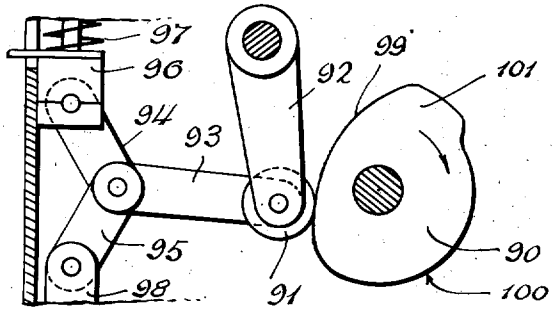


Fig. 9.



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Patented Feb. 18, 1936 2,030,906

UNITED STATES PATENT OFFICE

2,030,906

METHOD AND MEANS FOR SPOT-WELDING ALUMINUM AND ALUMINUM ALLOYS

Nelson F. Malley, Brooklyn, N. Y., assignor to Aluminum Alloys Welding Corporation, a corporation of New York

Application September 10, 1935, Serial No. 39,878

8 Claims. (Cl. 219—4)

This invention relates to a method and means for spot-welding aluminum and aluminum alloys.

Heretofore aluminum plates and the like were welded by the so-called resistance spot-welding process which consists in placing the plates or articles to be welded between two electrodes and causing an electrical current to circulate between these electrodes. This process is essentially a resistance process, since it relies upon the resistance of elements situated in the path of the electrical current to generate the entire heat necessary for the purpose of obtaining a welded spot. It was suggested to use two steel plates placed between the electrodes and the plates to be welded, for the purpose of generating an amount of heat sufficient to transform the intermediate portions of aluminum into a plastic or plastic and molten state, and thus cause a spot-welding or fusion of the aluminum plates.

It is a matter of common knowledge that aluminum is an excellent conductor of electricity, namely, it has the very low electrical resistance of 2.828 microhms per cm. cube at a temperature of 20° C.; in the liquid state, at a temperature of 700° C. it has a resistance of only 26.2 microhms per cm. cube. Furthermore, it changes rapidly from the solid state to a molten liquid state when subjected to the influence of heat and when at a temperature of 658.7° C. might be in the liquid or in the solid state. Due to these peculiar characteristics of aluminum, it was found impossible in prior art to weld by the above-described method aluminum plates of any substantial thickness. It was found that as soon as attempts were made to spot-weld aluminum plates having a thickness of ⅛ of an inch each, or a greater thickness, the spot-welding usually resulted in a large hole at the spot where the electrodes were applied, while molten aluminum would pour out and be blown out of the hole by an explosive effect caused by parasitic voltages.

The resistance welding consisting in the application of external heat has the further disadvantage that a large area of the metal is heated around the spot which is to be welded. A portion of this area is heated to the so-called germinative temperature which results in grain growth in the structure of the metal, causing a weakening thereof.

It is customary to support aluminum plates by the two electrodes which carry out the spot-welding process. If aluminum is permitted to become molten throughout its entire thickness, the electrodes will crush through the molten metal, with the result that large holes are formed instead of the welded spot. A blowing out or an explosive effect will also occur if the pressure is insufficient or fails to remain sufficient.

All of the above drawbacks rendered it exceedingly difficult to apply the resistance spot-welding process known in prior art for the purpose of spot-welding aluminum plates having a thickness of more than ⅛ of an inch.

An object of the present invention is the provision of a new method, through the use of which comparatively thick plates consisting of aluminum or aluminum alloys can be easily and conveniently welded.

Another object is the provision of a device for spot-welding aluminum plates which may be more than ⅛ of an inch thick, said device being comparatively inexpensive and easy to manufacture and being adapted to spot-weld plates consisting of other materials.

The above and other objects of the present invention may be realized through the provision of a new process for spot-welding aluminum which may be described as a conductivity spot-welding process.

One of the important distinctions between this new process and the process known in prior art consists in that, while in prior art the resistance of certain elements other than the plates to be welded to the passage of the electrical current was utilized for the purpose of generating the major portion of heat for melting the aluminum plates, in accordance with the present process aluminum is made plastic, or plastic and molten not by the heat generated by some other element, but by the actual passage of an electrical current of high amperage through the aluminum.

In accordance with the present process, the electrical current which is caused to flow through the two plates to be welded is sufficiently great to melt the metal between the electrodes. Therefore, in the course of the present process the temperature of the aluminum plates is caused to rise substantially by the electrical current itself, and not by externally developed heat. In order to eliminate parasitic voltages, I have found is advisable to connect each of the electrodes with a separate grounded resistance.

Another important feature of the present invention is the regulation of the amount of pressure which is applied by the electrodes upon the aluminum plates to be welded. It is essential that the pressure be maintained substantially constant while the electrical current is being maintained. While a slight penetration of an electrode into the softened underlying portion of the aluminum

is practically unavoidable, in prior art such penetration caused a considerable drop in pressure. In accordance with the present invention, the pressure is regulated so that a penetration of the electrode will cause merely a slight drop in pressure.

The invention will appear more clearly from the following detailed description, when taken in connection with the accompanying drawings, showing by way of example preferred embodiments of the inventive idea.

In the drawings:—

Figure 1 shows a spot-welding machine in side elevation and partly in section;

Figure 2 is a diagrammatic view illustrating the electrical circuit containing the electrodes;

Figure 3 is a front view of the electrodes;

Figures 4 and 5 illustrate diagrammatically the welding process carried out by means of the machine shown in Figure 1;

Figures 6 and 7 are similar to Figs. 4 and 5 and illustrate a somewhat different welding process, wherein two slugs are employed;

Figure 8 is a diagram illustrating the pressure of an electrode upon the aluminum plates and the amount of penetration of the electrode into the aluminum plate in the course of the welding process, as a function of time;

Figure 9 shows a portion of a spot-welding machine comprising a different pressure cam;

Figure 10 is a diagram similar to that shown in Figure 8 and illustrates the operation of the device shown in Figure 9.

The welding machine illustrated in Figure 1 of the drawings comprises a motor 10 driving through the medium of a speed reducing transmission box 11, a cam 12 provided with a substantially flat surface 13, and a substantially cylindrical surface 14. A roller 15 is in contact with the cam surfaces 13 and 14 and is mounted in a link 16 which is connected to the toggle levers 17 and 21. The link 18 connects the toggle lever 17 to the electrode 20. The toggle lever 21 is connected with a block 22 serving as a support for a coil spring 23 surrounding a rod 24 which is movable along with the block 22 and the toggle lever 21. A pressure adjusting nut 25 surrounds the free end of the rod 24 and is used for the purpose of adjusting the pressure of the electrode 20 upon the aluminum plates situated underneath the electrode. The actual amount of pressure exerted upon the plates may be conveniently measured by a pressure gauge 26.

The electrical circuit containing the electrodes 20 and 27 comprises the usual transformer 28, a cable 29 connecting the secondary winding 34 of the transformer 28 with the support 30, and a cable 31 connecting the support 30 with the electrode 20.

A cable 32 connects the opposite end of the secondary winding 34 of the transformer 28 with the support 33 which carries the electrode 27.

The primary winding of the transformer is connected to any suitable source of electrical energy not shown in the drawings.

The electrode 27 may consist of two copper pieces or blocks 37 and 38 which are separate from each other and which are interconnected by a block 39 made of steel or the like, so that an electrical current flowing through the electrode 20 and the aluminum plates to the copper block 38 is obliged to pass through the steel block 39 having an exceedingly great resistance, before it can reach the copper piece 37 of the electrode 27. The object of the steel block is to increase the stability of the electrical current flowing through the aluminum plates. When comparatively thin plates are to be welded, the steel block might be eliminated entirely. A passage 40 is provided in the steel block 39 and is used for circulating a cooling medium such as water through the block. The water enters through a pipe 41 and leaves through the pipe 42.

Figure 3 illustrates the position of the electrodes, viewed in the direction of the arrow 3 in Figure 2. The electrodes 20 and 27 comprise, in addition to the copper pieces 43 and 38, two copper rods 44 and 45. The rod 44 is carried in a suitable opening provided in the block 43, while the rod 45 is held in an opening formed in the piece 38. It will be noted that the rods 44 and 45 are inclined in relation to the pieces 43 and 38 and that their central lines form an acute angle with each other in the example illustrated.

One end of a suitable resistance 80 is connected to the electrode 44, while the opposite end of this resistance is grounded. A similar grounded resistance is connected to the electrode 45. The object of the resistances 80 and 81 is to facilitate the dissipation of parasitic voltages. They may be eliminated if sufficient pressure is maintained at all times.

The process of spot-welding comparatively thick aluminum pieces is shown in Figures 4 and 5 and illustrated in the diagram shown in Figure 8.

Figures 4 and 5 show two aluminum plates 50 and 51 which overlap each other and which are placed between the rods 44 and 45 in such manner that the area 52 to be welded is situated exactly between the two rods. A thin steel plate 53 is placed between the rods 45 and the aluminum plate 51.

While in prior art the purpose of utilizing steel plates was to generate heat sufficient to melt the two aluminum plates, the steel plate 53 in the process according to the present invention serves the purpose of preventing the penetration of the rod 45 into the aluminum and generates only a small additional supply of heat, the main heat being supplied by the conduction of the electrical current itself.

The electrical current and the voltage to be applied in the spot-welding process vary depending upon the thickness of the plates to be welded and the materials of which they consist. I prefer to use a voltage of six volts and an electrical current which may vary from 35,000 amperes to 100,000 amperes depending upon the thickness of the plates, their composition and the time used for welding. In order to weld two plates of 51S material, each of which is $\frac{1}{8}$ of an inch thick, I prefer to use an amperage of 40,000 amperes, the welding time being approximately $\frac{3}{4}$ of a second. The actual amount of amperage necessary for plates of each particular thickness and composition can be easily determined by the operator after some tests.

As shown in Figures 4 and 5, the rods 44 and 45 actually grip the two plates 50 and 51 and hold these plates in position, while the process of spot-welding is carried out. The pressure which the rods 44 and 45 exert upon the aluminum plates 50 and 51 has been found to be a very important feature, if the welding of thick aluminum plates is to be carried out successfully. It is essential that the pressure of the rods upon the aluminum plates should be maintained as constant as possible in the course of the welding operation. This is carried out by suitably shap-

ing the cam 12 which is in contact with the roller 15. As shown in Figure 1, the cam 12 is provided with a substantially uniform flat surface 13 and a substantially cylindrical surface 14. When in the course of rotation of the cam the roller 15 is brought into contact with the surface 14 the link 16 is moved in the direction of the arrow 54, with the result that the toggle lever 17 exerts a pressure which is directed substantially downwardly, while the toggle lever 21 exerts a pressure directed substantially upwardly (looking in the direction of Figure 1). The upward pressure of the lever 21 is balanced by the counter-pressure of the spring 23, while the downward pressure of the lever 17 is transmitted to the electrode 26 and to its rod 44.

The diagram of Figure 8 shows the pressure as a function of time. It will be noted that due to the shape of the cam 12 the pressure increases gradually in the form of a straight line 55 until a maximum is reached. It is important that this maximum be reached before the electrical current is caused to flow through the electrodes 26 and 27.

The pressure which is to be applied to the aluminum plates in the course of the welding process should be carefully selected. If the pressure is too heavy, there is the danger that the electrodes will pass through the molten aluminum and cause aluminum to blow out, with the result that a hole will be formed instead of a welding spot. If the pressure is too light, an explosion within the aluminum might also occur, resulting in the formation of an opening instead of a welded spot. Obviously, different pressures should be used for different types of material and for plates of different thicknesses. For duraluminum plates having a thickness of ¼ of an inch, I prefer to employ a pressure of 80 pounds or 100 pounds, while for softer material of the same thickness, the pressure may be as low as 60 pounds. The operator will, of course, adjust the pressure of the nut 25 depending upon the material and the thickness of the welded plates.

The electrical current can be switched on and off automatically through the provision of a contact piece 56 which is rotatable along with the cam 12 (Figure 1). In the course of rotation of the cam 12 this piece 56 comes in contact with the switch 58, switching on the electrical current which is automatically switched off as soon as the piece 56 passes out of contact with the switch 58.

The time during which the electrical current is maintained depends upon the type of material and the thickness of the plates. In the diagram shown in Figure 8, the time at which the current is switched on is indicated by the numeral 59. It will be noted that at the time the current is switched on the electrode 26 has reached its maximum pressure and has maintained this pressure for a certain length of time. This constant pressure of the electrode 26 upon the underlying aluminum plate is indicated by the horizontal line 60 in Figure 8.

The great currents of electricity flowing between the rods 44 and 45 soften the intermediate portions of the aluminum plates 50 and 51. As shown in Figure 5, a part 61 of the aluminum is molten, while a thin plastic crust 62 remains between the rod 44 and the molten portion 61. The rod 44 sinks somewhat into the plate 50, while on the other hand, the pressure of the rod 45 causes a bending of the steel plate 53, which also penetrates somewhat into the molten portion 61.

In accordance with the principles of the present invention, it is essential that the penetration of the rod 44 into the aluminum plate 50 should not cause any substantial drop in pressure. This may be carried out, in the first place, by a suitable adjustment of the adjustment nut 25 (Figure 1), and in the second place, by suitably shaping the ends of the rods 44 and 45. As shown in Figures 3 to 7, each of the rods has a conical end portion 63 terminating in a surface 64 (Figure 4).

In the diagram illustrated in Figure 8 of the drawings, the drop in pressure caused by the penetration of the rod 44 into the plate 50 is illustrated by the slanting line 65. In the case of duraluminum having a thickness of ¼ of an inch, the pressure which was originally 100 pounds should not drop below 80 pounds. In the case of softer aluminum plates having the same thickness, the original pressure of 60 pounds should not drop below 45 pounds.

The electrical current should be preferably switched off before the drop in pressure has occurred. If the current is maintained while the pressure falls below a predetermined amount, the electrode will sink too deeply into the molten aluminum, with the result that the crust 62 may be broken, the liquid aluminum 61 will pour out and blow out and a hole will be formed. In the diagram shown in Figure 8, the time at which the current is switched off is indicated by the numeral 66. It will be noted that the current is switched off before the drop in pressure begins and before a constant pressure is maintained, said constant pressure being indicated by the line 67 in Figure 8.

The diagram shown in Figure 8 also shows the movements of the electrode 26 as a function of time. Prior to the beginning of the welding process the aluminum plates 50 and 51 are placed upon the lower rod 45 and the rod 44 is moved toward the plate 50. This movement is indicated by the line 55 in Figure 8. Then the rod 44 remains stationary, while the welding process is carried out. This is shown by the horizontal line 68 in Figure 8. When the underlying crust 62 formed in the aluminum plate 50 becomes soft, the rod 44 penetrates slightly into the aluminum plate 50. This is shown by the slanting line 69 in Figure 8. The current is switched off at the point 66, before the penetration of the rod 44 into the plate 55.

Then the pressure of the rod 44 upon the aluminum plate is gradually diminished. This is shown by the straight line 68 in Figure 8. Finally, the aluminum plates 50 and 51 are removed and slight mechanical pressure will suffice to separate the steel plate 53 from the plate 51. The plates may be quenched after the completion of the described method.

Practical experience has shown that through the use of the above described process, it is possible to spot-weld plates consisting of very hard aluminum alloys which usually contain from 92% to 95% aluminum such as 17 S, 24 S, and other alloys containing, in addition to aluminum, manganese, magnesium, copper and the like. Plates having a thickness of ¼, ½ inch, or even thicker plates may be conveniently and safely spot-welded by the described process.

Figures 6 and 7 illustrate a welding process wherein, in addition to the steel plate 53, two slugs 70 and 71 are employed. The slug 70 is situated between the rod 44 and the plate 50, while the slug 71 is situated between the aluminum plate 51 and the steel plate 53. The two slugs 70 and 71 which consist of the same ma-

terial as the plates 50 and 51 remain in the welded aluminum plates after the spot-welding has been completed. The welding process in this case is substantially similar to that already described. The object of the slugs 70 and 71 is to increase the thickness of the spot to be welded, thereby increasing the strength.

The process of spot-welding carried out in accordance with the principles of the present invention may be conveniently combined with the process of hardening or tempering aluminum plates. This spot-welding is carried out in substantially the same manner as that already described.

It is advisable to increase the current when making the second spot after the completion of the first spot. This is necessary in many instances, since, if the current passing through the second spot is the same as the current which has passed through the first spot, said current might be caused to flow through the first spot, thereby preventing the formation of the second spot.

Figure 9 shows a spot-welding machine provided with a cam 90 which is in contact with a roller 91 carried by a lever 92 and transmitting its movement through the link 93 to the toggle levers 94 and 95. The link 96 connects the toggle lever 95 to the electrode (not shown). The toggle lever 94 is attached to the block 96 which is in contact with the spring 97. The cam 90 is provided with substantially round surfaces 99 and 100 and a projection 101. Due to this shape of the cam the pressure of the electrode upon the aluminum plates will vary in accordance with the diagram shown in Fig. 10. The pressure will first increase along the line 102, then remain constant when the current is on (line 104) and then drop slightly as illustrated by the line 106. Then, due to the provision of the projection 101 the pressure after having remained constant for a while, as shown by the line 107, increases along the line 108 and is maintained on a higher level as indicated by the line 109, until it is finally reduced, as shown by the line 110.

What is claimed is:—

1. The spot-welding process, which comprises placing at least two partly overlapping aluminum containing plates between two electrodes, causing said electrodes to press with a constant pressure against said plates, causing an electrical current to flow through said electrodes and the underlying portions of said plates, while said constant pressure is being maintained, interrupting the flow of the electrical current, diminishing said constant pressure until a predetermined lower pressure is attained, and then increasing said lower pressure while the material is still hot.

2. In a device for spot-welding aluminum and aluminum alloys, an electrical circuit comprising a source of electrical energy, a pair of electrodes, means connecting one of said electrodes with said source of electrical energy, a comparatively high resistance connected in series with the other of said electrodes, and means connecting said resistance with said source of electrical energy.

3. A device for spot-welding aluminum and aluminum alloys, which comprises an electrical circuit comprising a source of electrical energy, a pair of electrodes, each of said electrodes comprising a rod and a block carrying said rod; means connecting the blocks of said electrodes with said source of electrical energy, and a separate grounded resistance connected with each of said rods.

4. In a machine for spot-welding aluminum and aluminum alloys, a pair of electrodes situated substantially opposite each other, a cam, said cam comprising a substantially flat surface to increase the pressure of said electrodes, a substantially cylindrical surface forming a continuation of said flat surface to maintain the increased pressure of the electrodes constant, and a projecting surface forming a continuation of said cylindrical surface to further increase the pressure of the electrodes, means connected with one of said electrodes and in contact with said cam surfaces to cause said electrode to exert a pressure upon plates inserted between said electrodes, said pressure being varied depending upon said surfaces, a source of electrical energy, and means for connecting said source of electrical energy with said electrodes.

5. In a machine for spot-welding aluminum and aluminum alloys, a pair of electrodes situated substantially opposite each other, a cam having operative surfaces, means connected with one of said electrodes and in contact with said cam surfaces to cause said electrode to exert a pressure upon plates inserted between said electrodes, a source of electrical energy, means connecting said source of electrical energy with one of said electrodes, a steel block connected with the other of said electrodes, and means connecting said steel block with said source of electrical energy.

6. In a machine for spot-welding aluminum and aluminum alloys, a pair of electrodes situated substantially opposite each other, a cam having operative surfaces, means connected with one of said electrodes and in contact with said cam surfaces to cause said electrode to exert a pressure upon plates inserted between said electrodes, a source of electrical energy, the first-mentioned electrode comprising a rod and a block carrying said rod; the second-mentioned electrode comprising a rod, a block carrying said rod, another block having a greater resistance than the second-mentioned block and connected in series with the second-mentioned block, and a further block connected in series with the third-mentioned block; means connecting the last-mentioned block with said source of electrical energy, and means connecting the first-mentioned block with said source of electrical energy.

7. The spot-welding process, which comprises placing at least two partly overlapping aluminum containing plates between two electrodes, causing said electrodes to press with a constant pressure against said plates, causing an electrical current to flow through said electrodes and the underlying portions of said plates while said constant pressure is being maintained, interrupting the flow of the electrical current, and then diminishing said constant pressure until a predetermined lower pressure is attained.

8. The spot-welding process, which comprises placing at least two aluminum containing plates between two electrodes, causing said electrodes to press with a constant pressure against said plates, and causing a stabilized electrical current of a substantially constant amperage to flow through said electrodes and the underlying portions of said plates while said constant pressure is being maintained to weld said plates.

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