United States Patent

[11] 3,614,375

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[21] Appl. No. **823,077**
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[45] Patented **Oct. 19, 1971**
[32] Priority **May 8, 1968, May 28, 1968, Aug. 19, 1968, Sept. 3, 1968, Jan. 17, 1969, Sept. 17, 1968**
[33] **Germany**
[31] **P 17 65 366.6, P 17 65 489.6, P 17 65 970.0, P 17 90 058.2, P 19 02 569.5 and P 17 90 142.7**

[54] **WELDING OF SHEET METAL COATED WITH LAYERS**
7 Claims, 41 Drawing Figs.

[52] **U.S. Cl.** **219/91,** 219/92
[51] **Int. Cl.** **B23k 9/28,** B23k 11/10
[50] **Field of Search** 219/91, 92, 113, 117, 106, 10.43, 123, 86, 87, 93, 94, 118

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Primary Examiner—J. V. Truhe
Assistant Examiner—Hugh D. Jaeger
Attorneys—Keith Misegades and George R. Douglas, Jr.

ABSTRACT: A method for the connection of sheet metal panels coated on at least one surface with an insulating layer by the electrical fusion of a metal, wherein the improvement comprises the steps of supplying an electric current for the fusion of metal indirectly along the sheet metal of at least one panel to the zone at which said panels are to be connected to each other, and keeping the temperature of an outer insulating layer of at least one of said panels below the melting point of said layer.

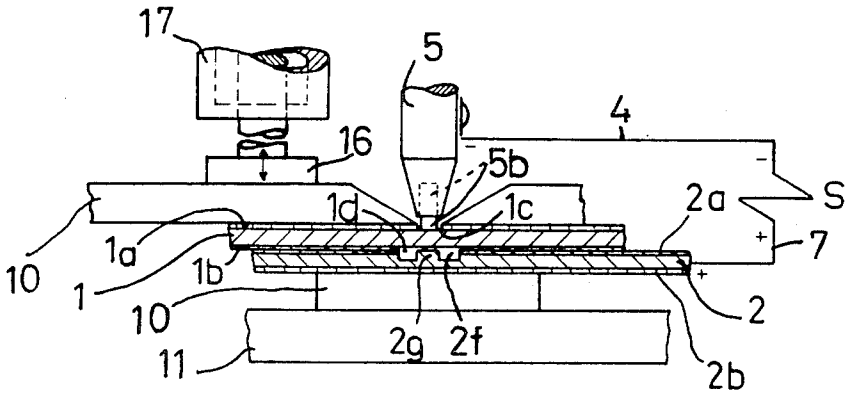


Fig.1

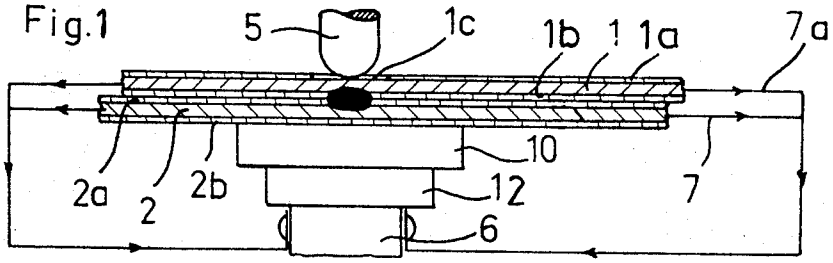


Fig. 2

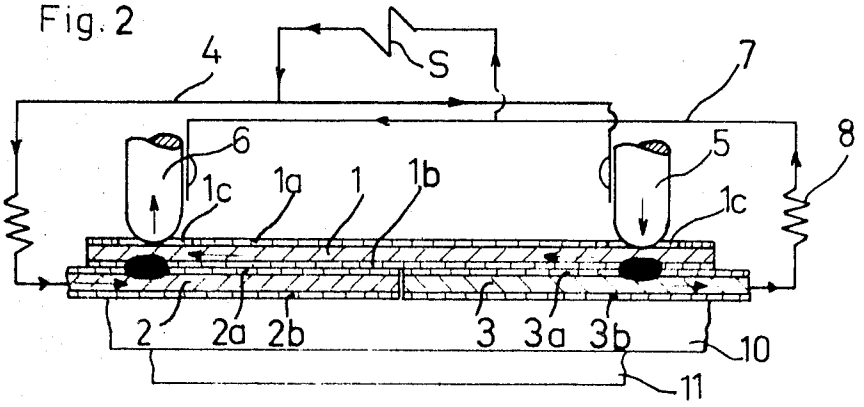


Fig. 3

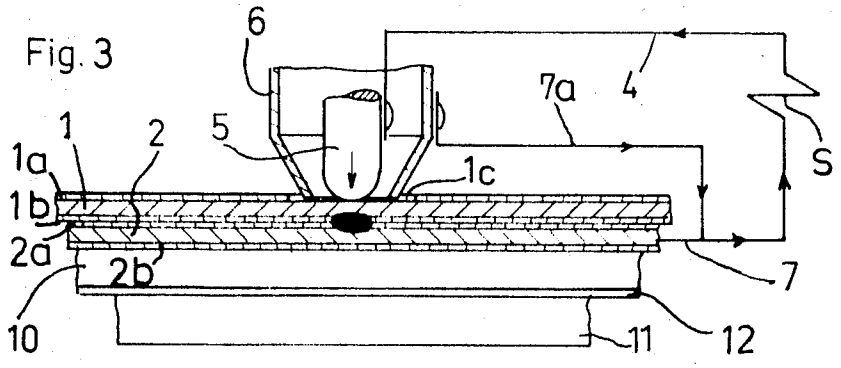


Fig.4

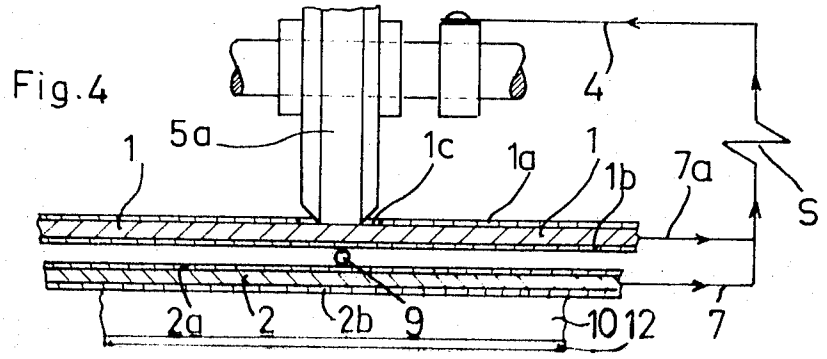


Fig. 5

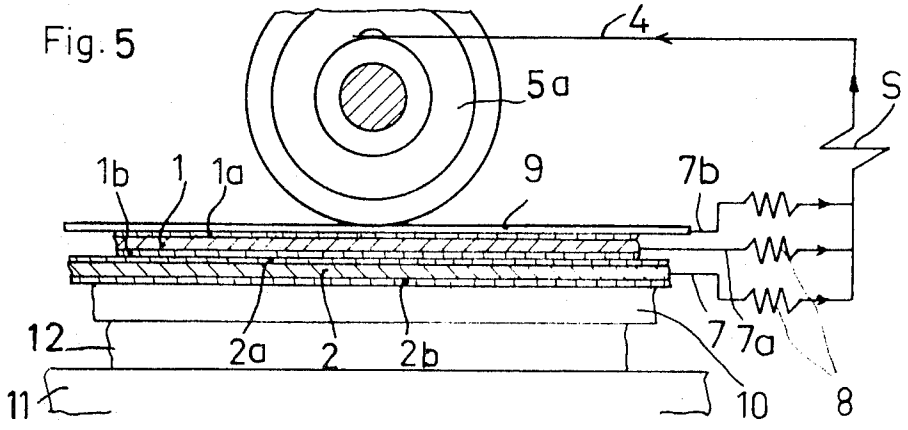

4
5a
S
1b
1
1a
9
7b
12
2a
2
2b
7
7a
11
10
8

Fig. 6

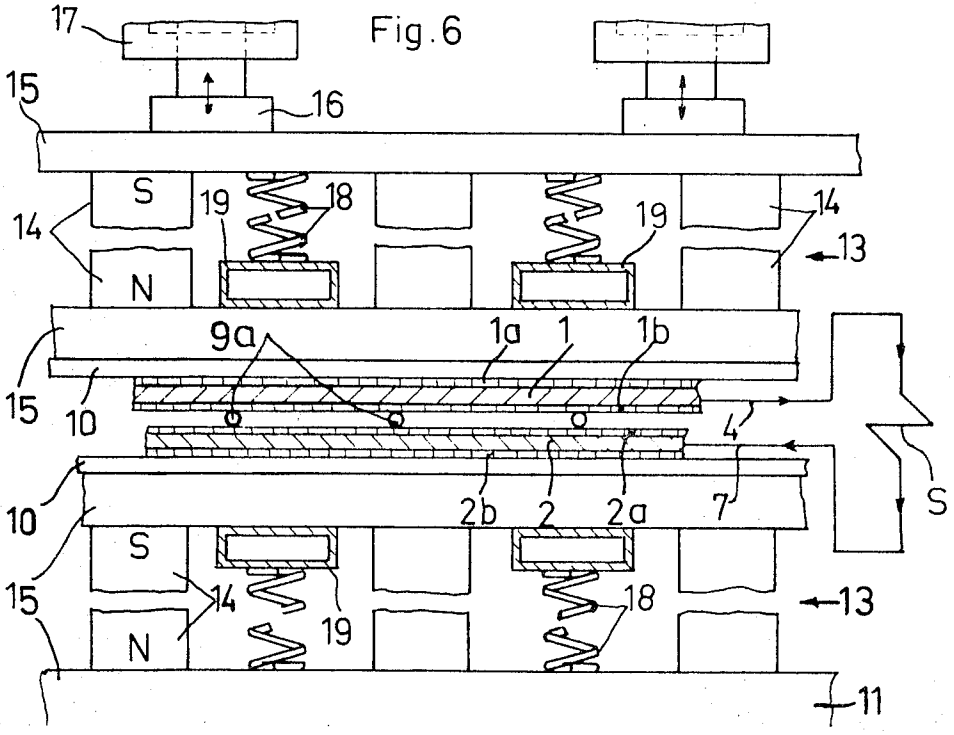

17
15
16
S
19
18
14
N
13
9a
1a
1
1b
10
4
2b
2
2a
7
11

Fig. 7

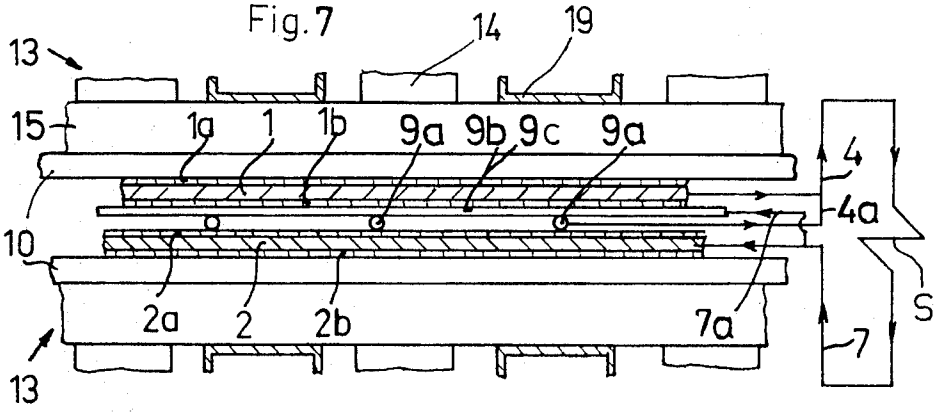


Fig. 8

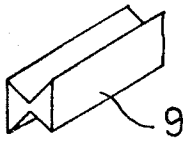


Fig. 9

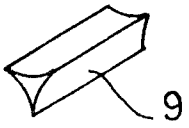


Fig. 10

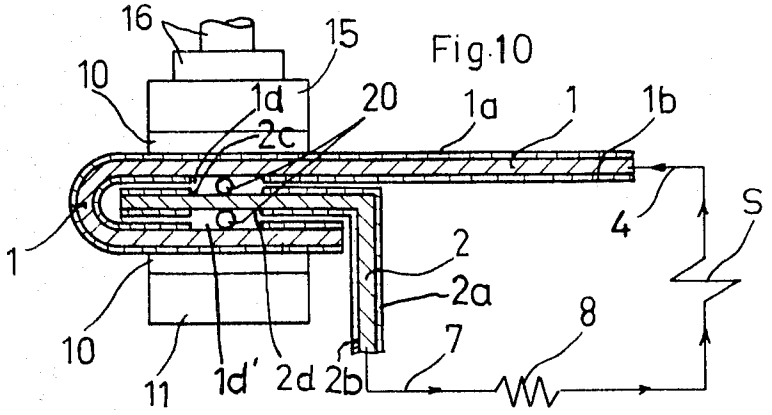


Fig. 11

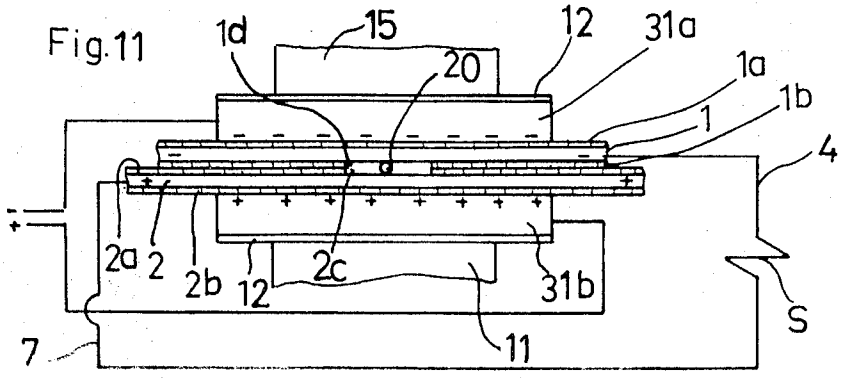


Fig.12

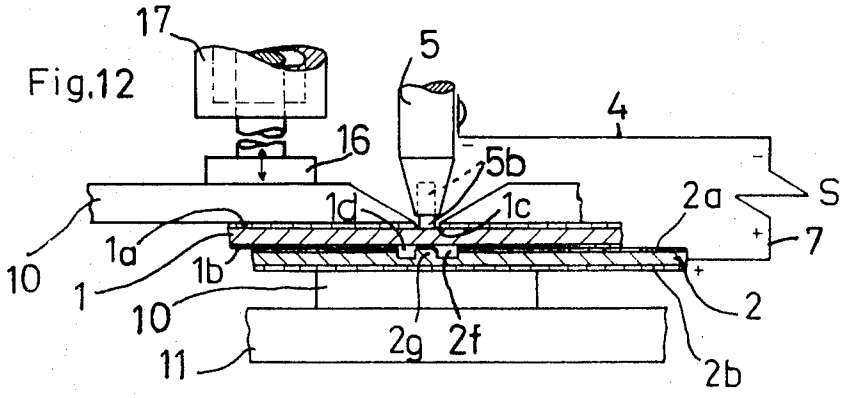


Fig.13

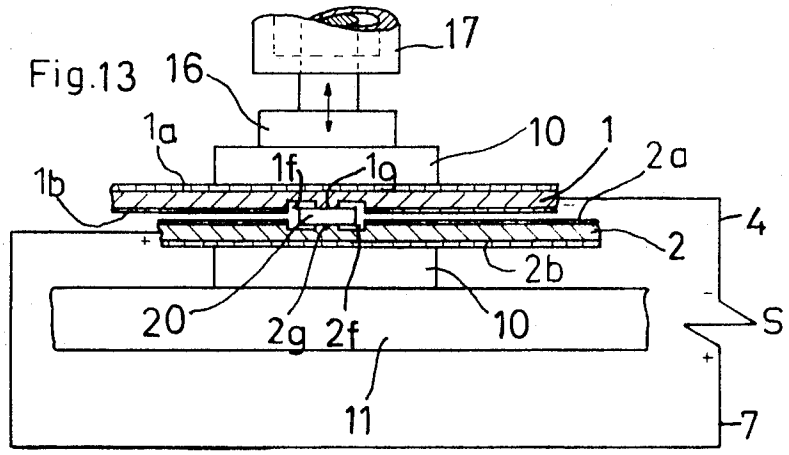


Fig.14

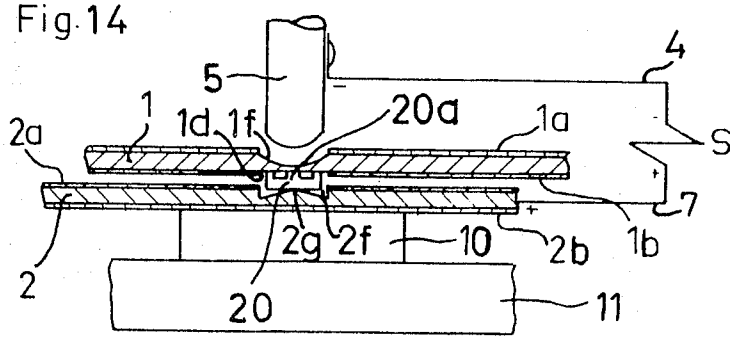


Fig.15

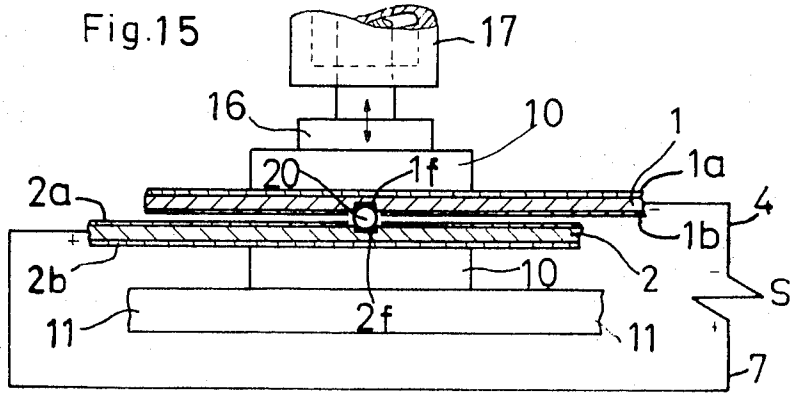


Fig.16

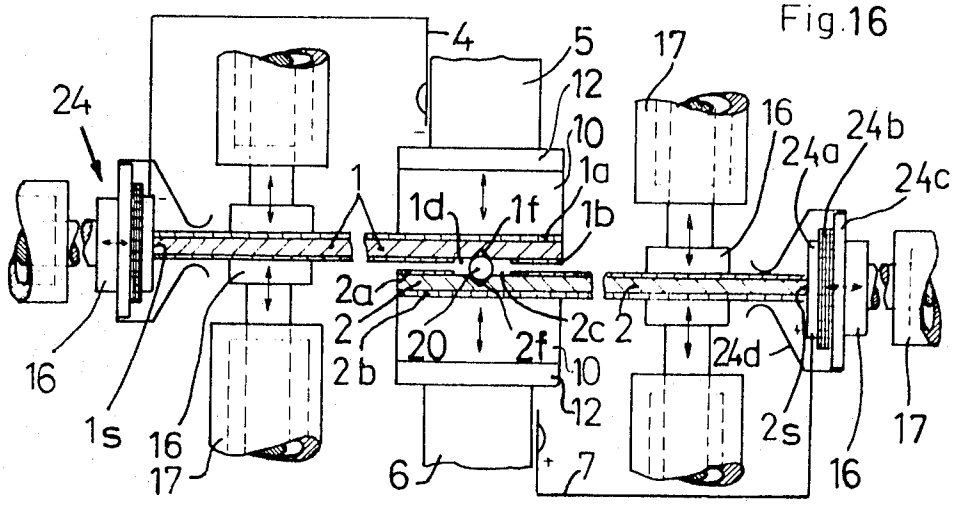


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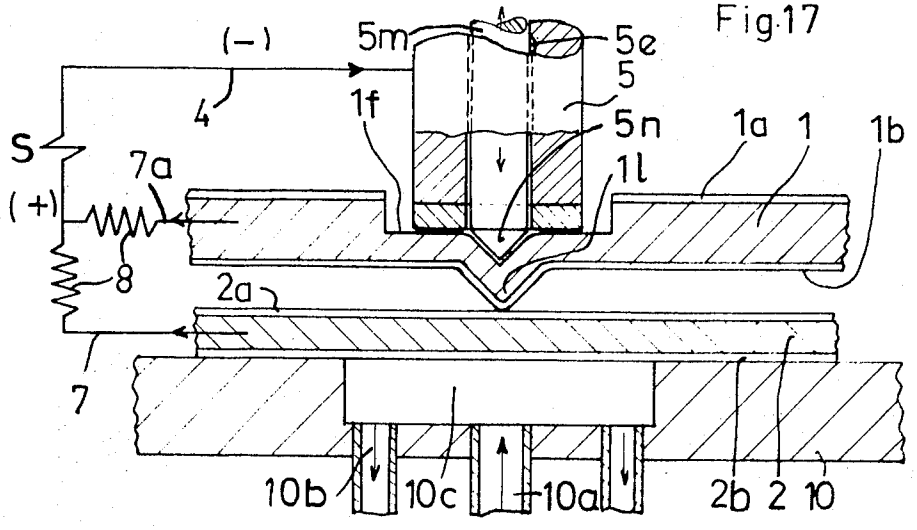


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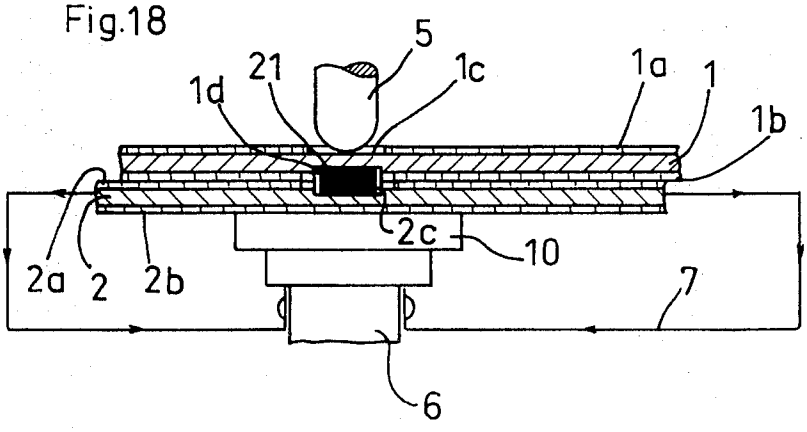


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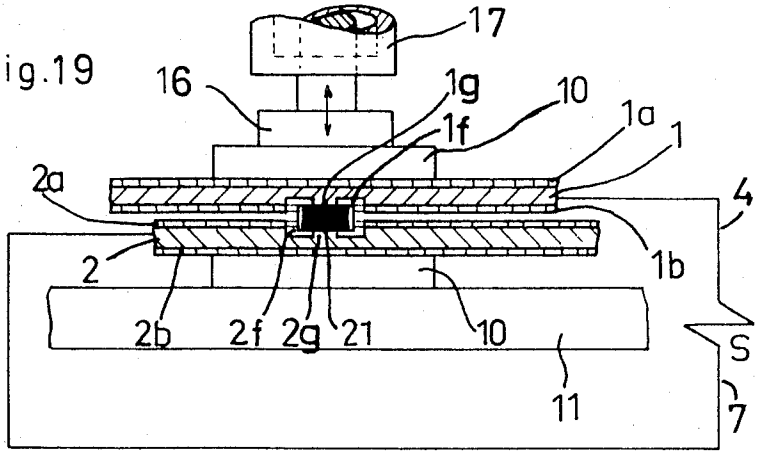


Fig.20

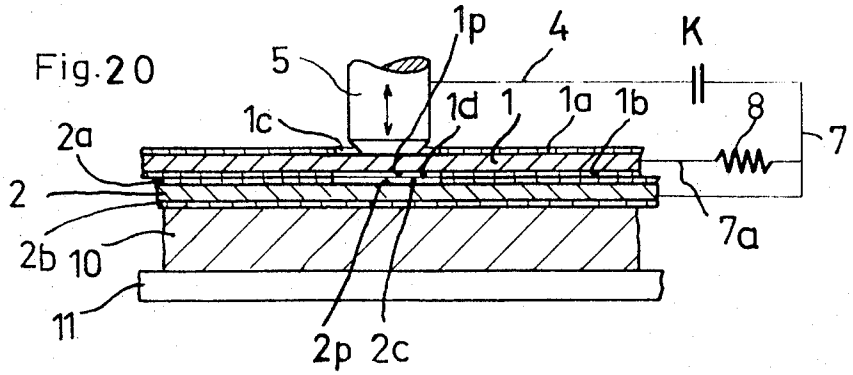


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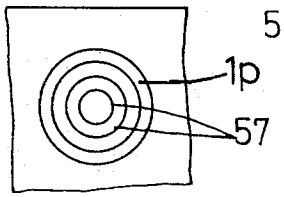


Fig.22

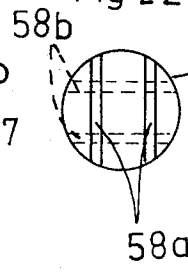


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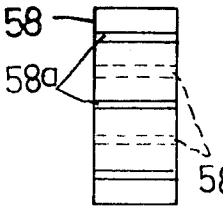


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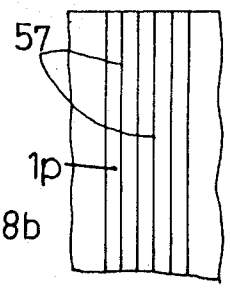


Fig.25

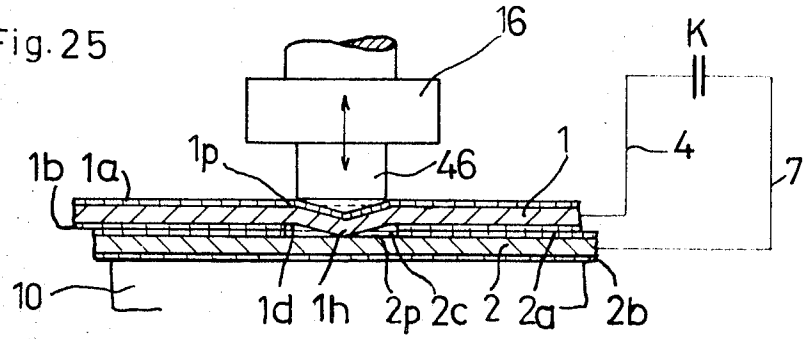


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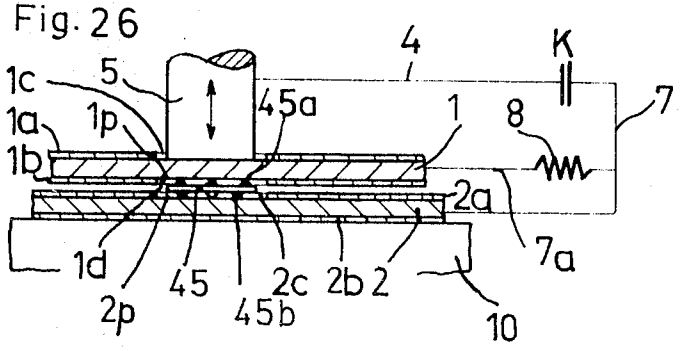


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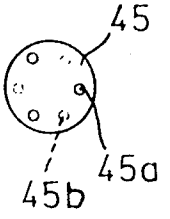


Fig.28

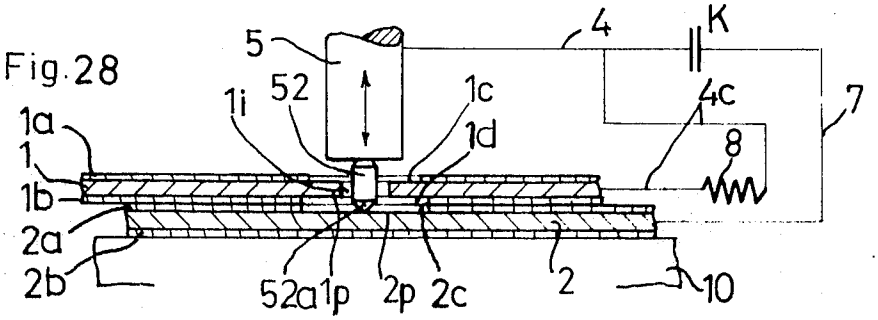


Fig. 29

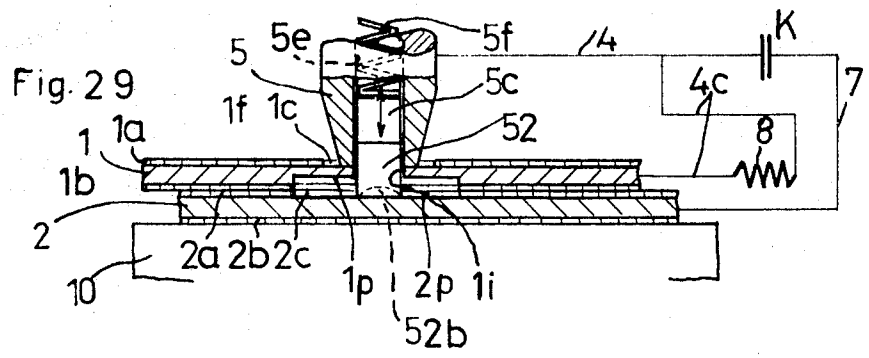


Fig. 30

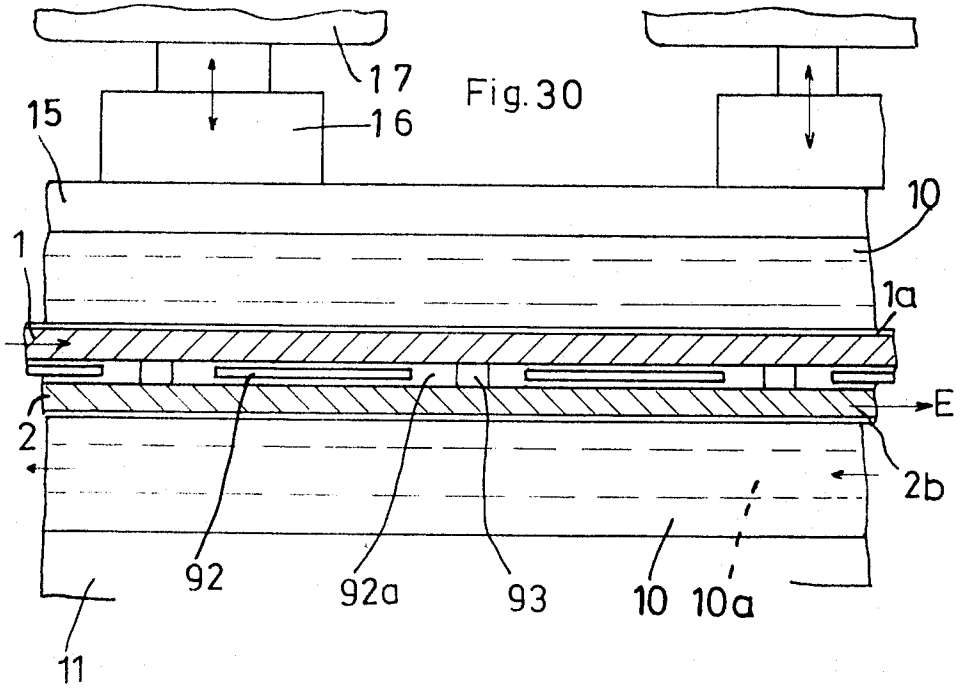


Fig. 31

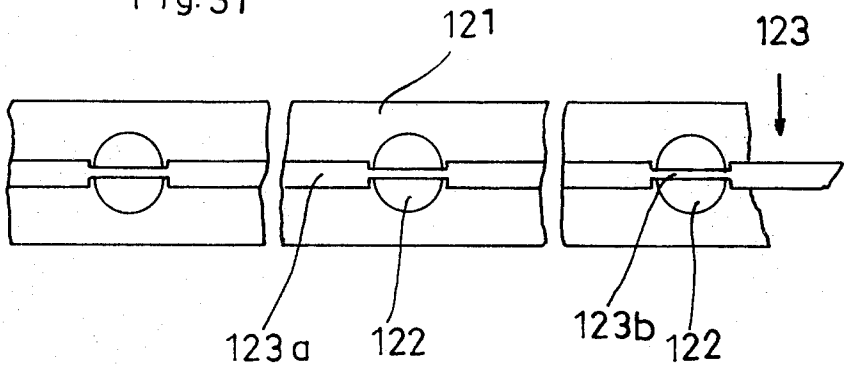


Fig. 32

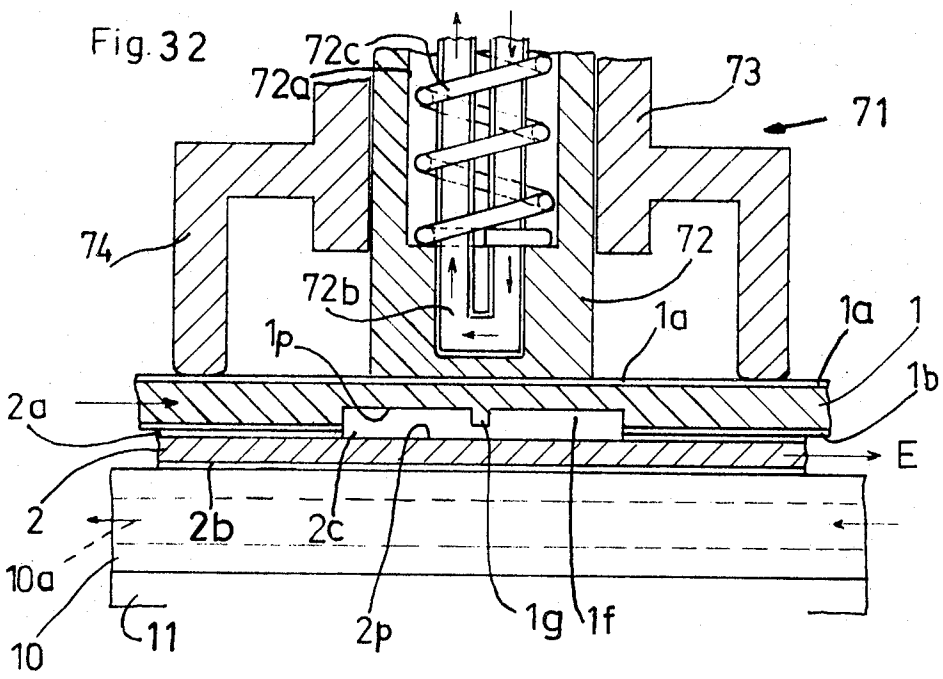

72c
72a
73
71
74
72
72b
1a
1a
1
1p
1b
2a
E
2
2b
2c
10a
10
11
2p
1g
1f

Fig. 33

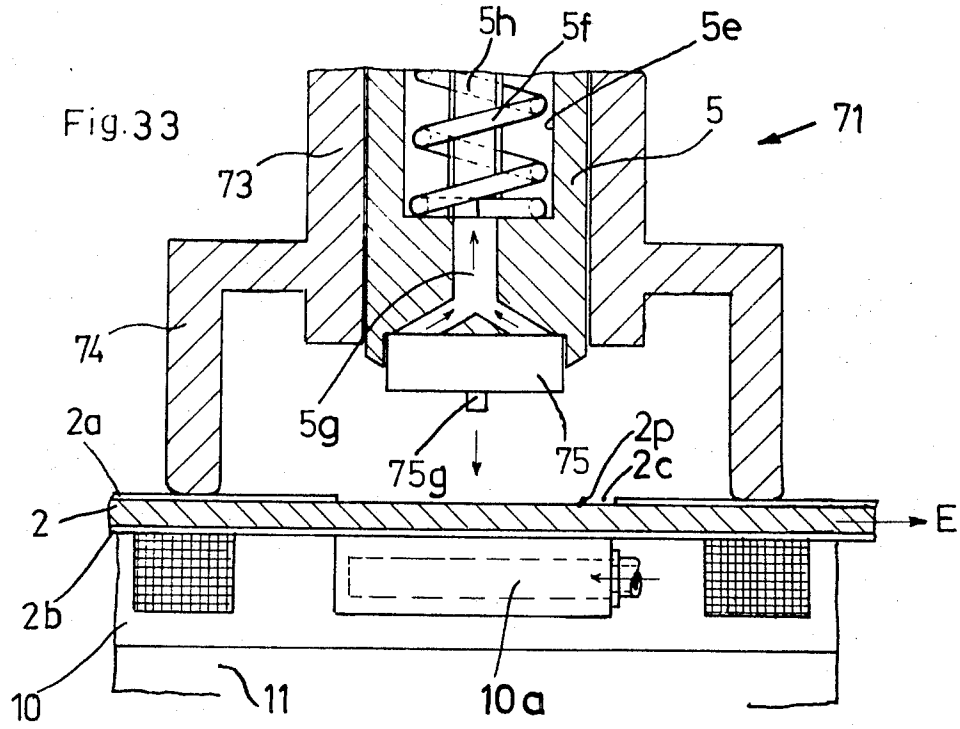

5h
5f
5e
5
71
73
74
2a
5g
75g
75
2p
2c
E
2
2b
10
11
10a

Fig. 34

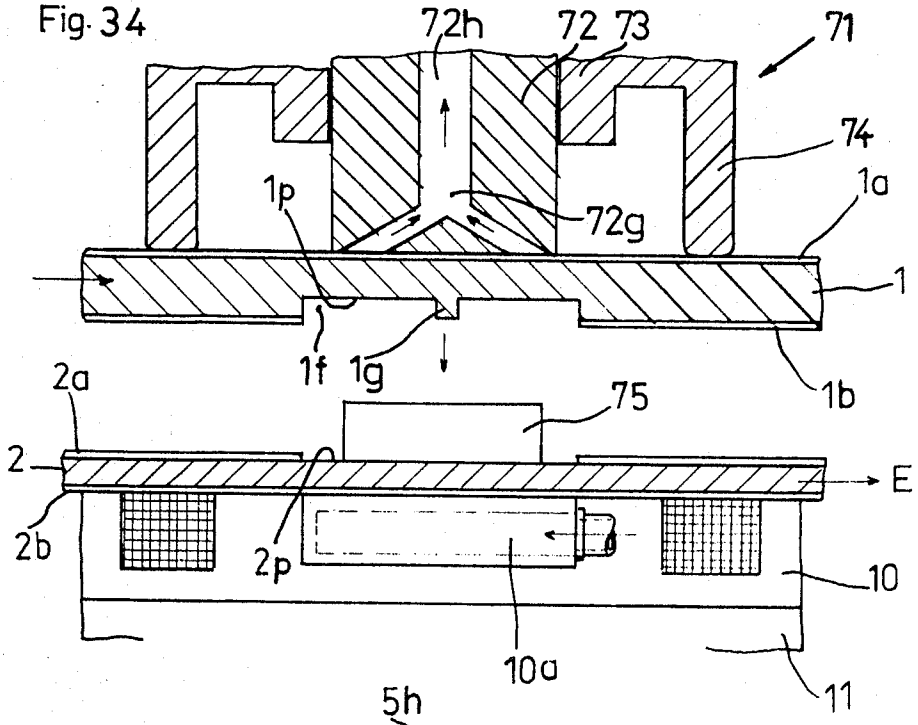

72h
72 73
71
74
1a
1p
72g
1
1f 1g
1b
2a
75
2
E
2b
2p
10
10a
11

Fig. 35

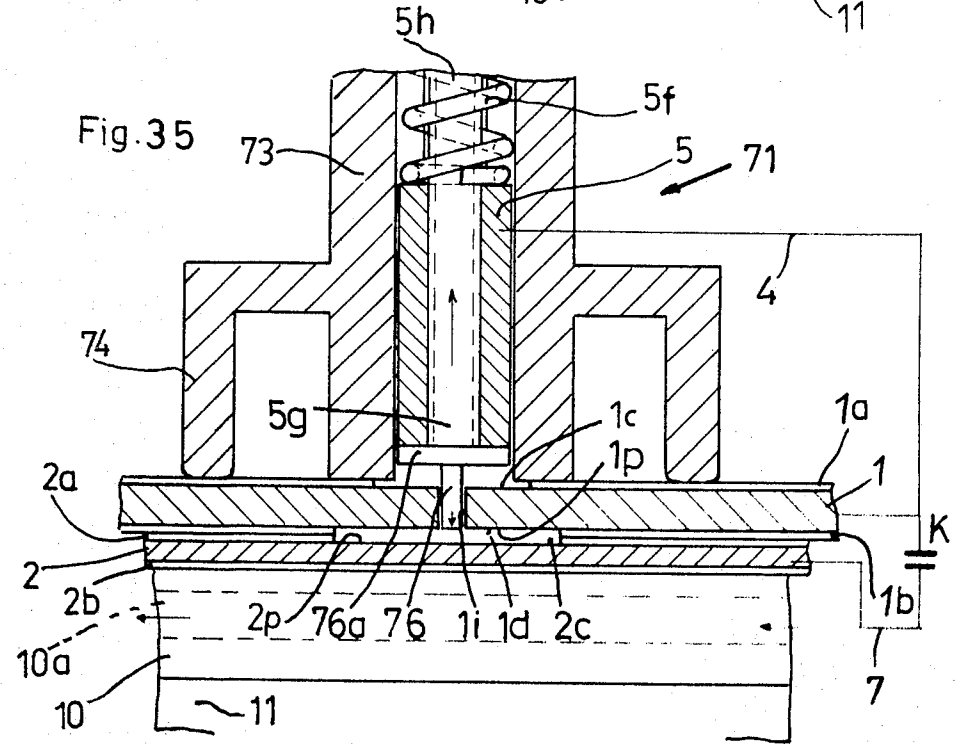

5h
5f
73
5
71
4
74
5g
1c
1a
1p
1
2a
K
2
2b
1b
2p 76a 76 1i 1d 2c
10a
7
10
11

Fig. 36

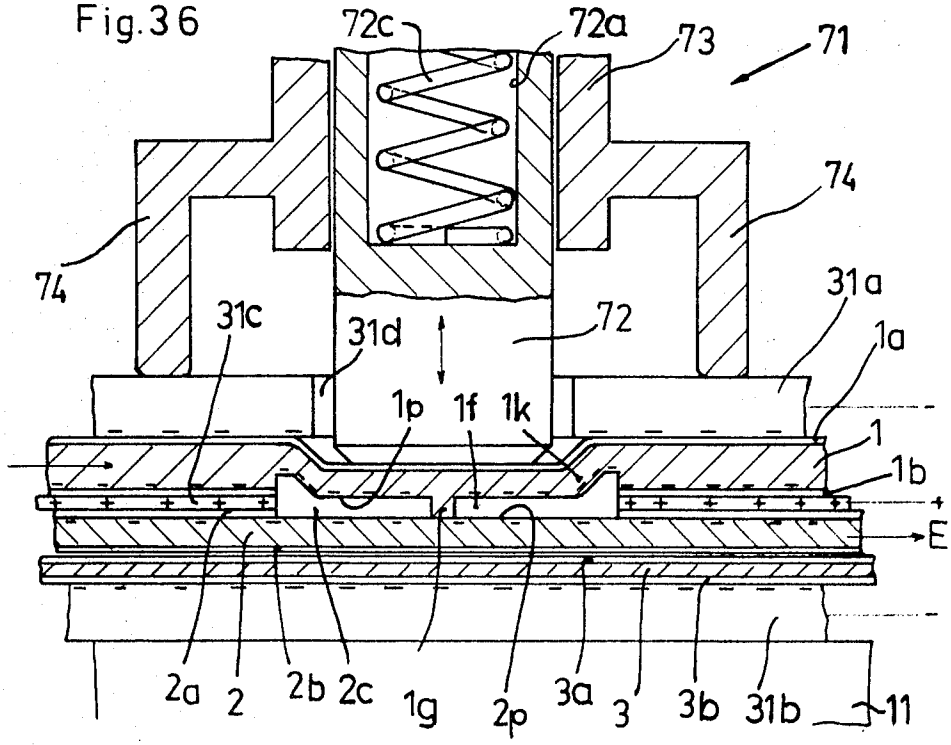

72c
72a
73
71
74
74
31a
31c
31d
72
1a
1p
1f
1k
1
1b
E
2a
2
2b
2c
1g
2p
3a
3
3b
31b
11

Fig. 37

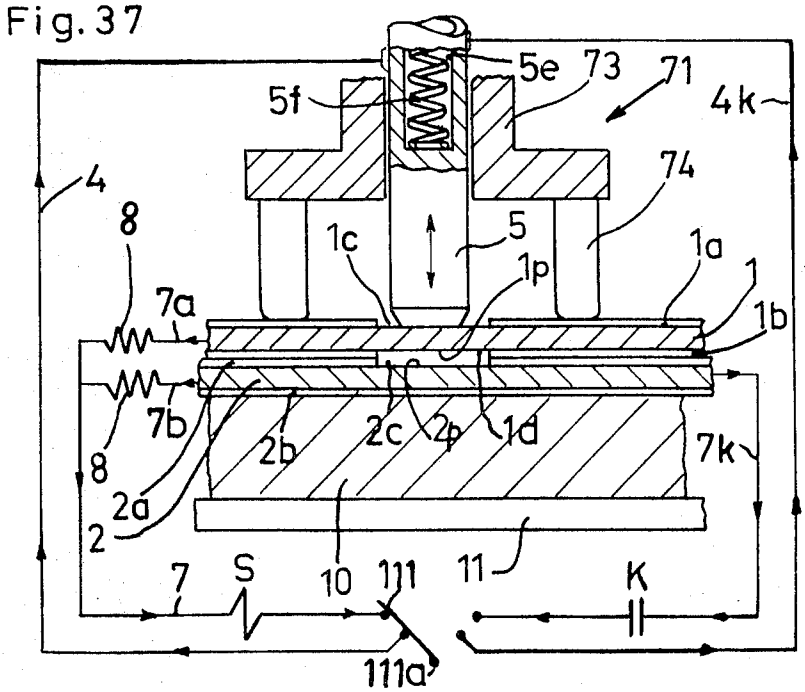

5e
73
71
4k
5f
4
74
8
1c
5
1a
1
1p
1b
7a
7b
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2
7
S
10
111
11
K
111a

Fig. 38

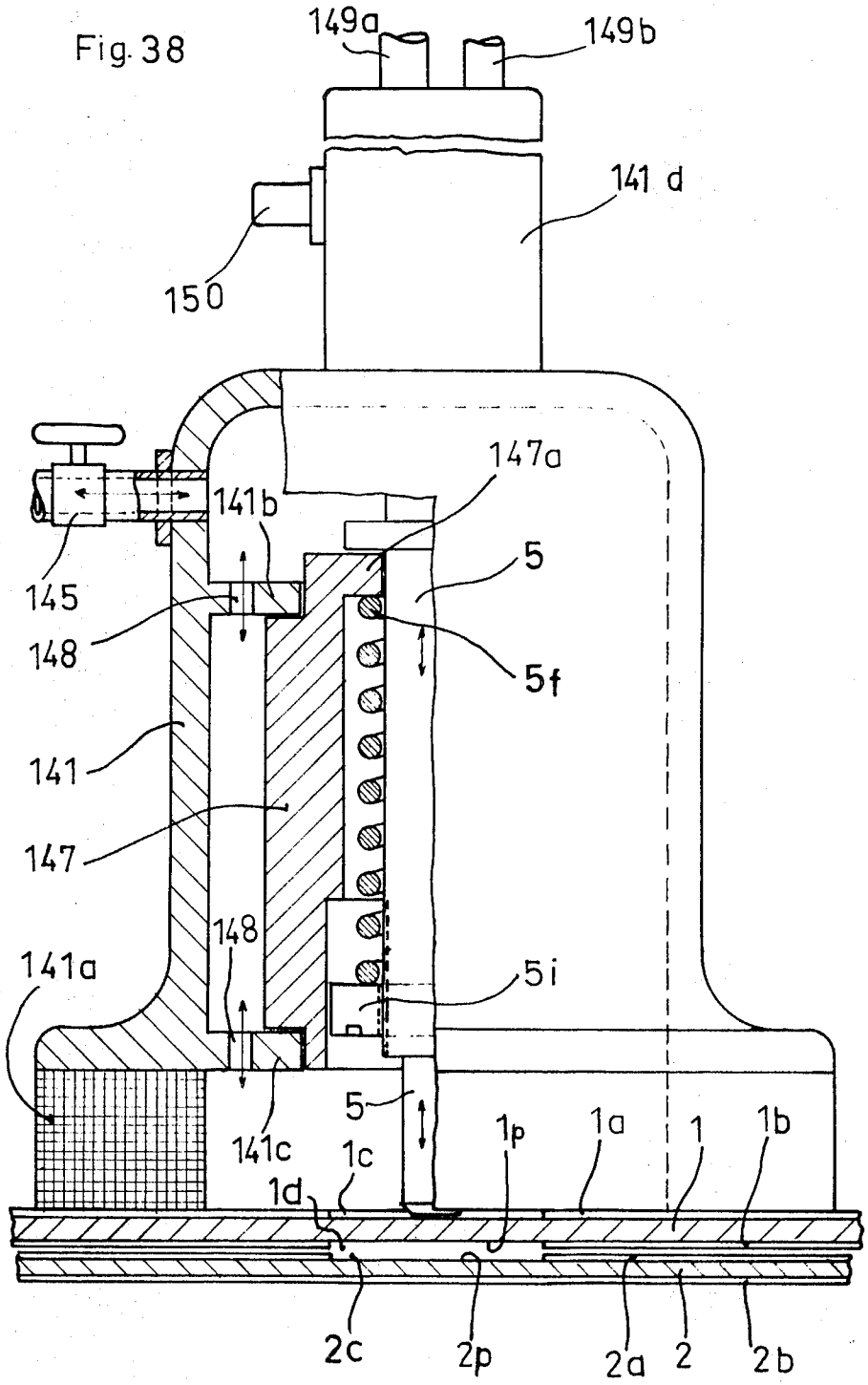

149a
149b
141 d
150
147a
141b
5
145
148
5f
141
147
148
141a
5i
5
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2a
2
2b

Fig.39

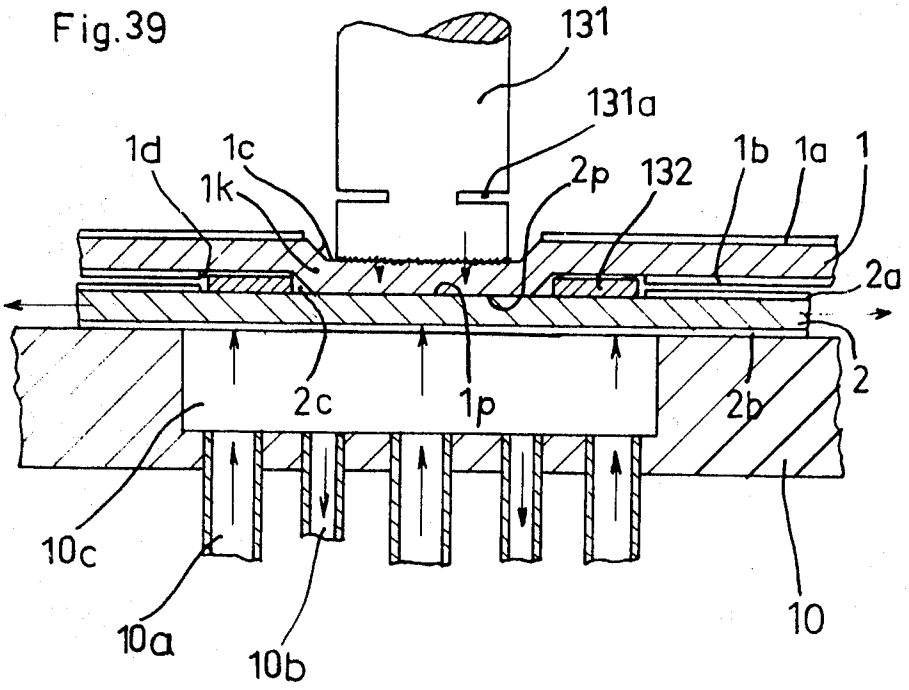


Fig. 40

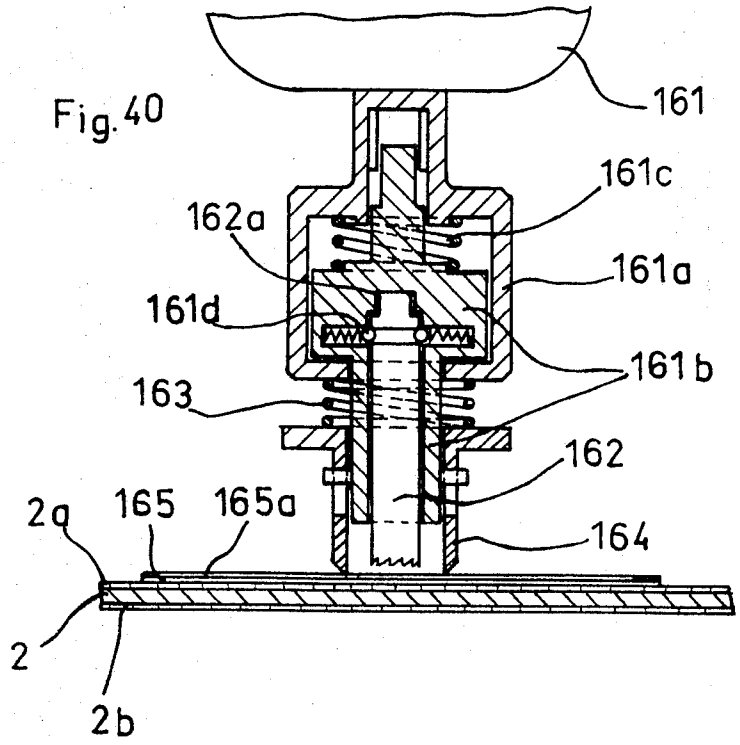
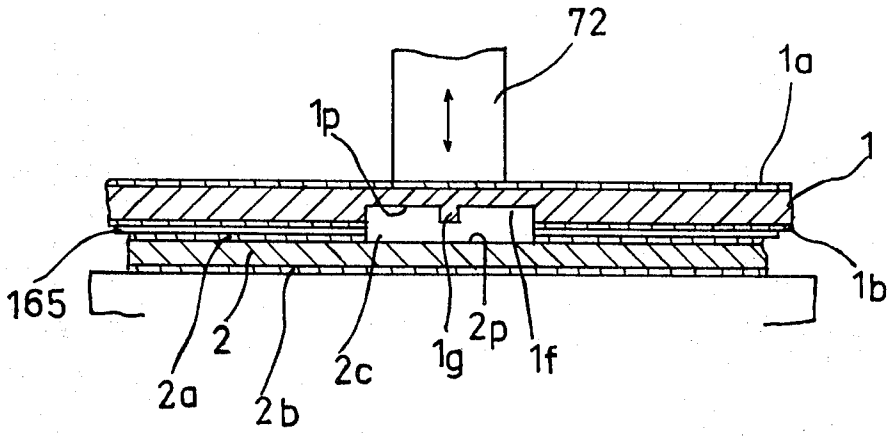

161
161c
162a
161a
161d
161b
163
162
2a
165
165a
164
2
2b

Fig. 41


72
1a
1p
1
165
1b
2
2a
2b
2c
1g
2p
1f

WELDING OF SHEET METAL COATED WITH LAYERS

CROSS-REFERENCE TO RELATED APPLICATIONS

Johann Karl Wefers and Otto Alfred Becker, Ser. No. 681,694 filed Nov. 9, 1967; Otto Alfred Becker, Ser. No. 704,684 filed Feb. 12, 1968.

BACKGROUND OF THE INVENTION

Sheet metal panels coated with synthetic substances are desirable owing to their rust-free, insensitive surfaces available in many patterns and colors. However, such sheet metal panels cannot be connected to each other by spot or roller welding in the usual manner. According to specification Ser. No. 668,414 the sheet metal panels are stripped at the places to be welded in such a manner that an electrical contact is established when the sheet metal panels are pressed upon each other. With comparatively thick layers of synthetic substances and likewise with comparatively thick sheet metal panels the cavities formed by stripping the coating layers may be filled by inserted intermediate welding pieces. In this manner faultless welded connections can be produced with the usual welding machines on sheets of steel, chromium-nickel steel, aluminum or other metals coated with synthetic substances, lacquers or other materials. However, the outer layers of the stripped sheet metal panels are destroyed by stripping or melting under the electrodes.

The present invention has the object of preventing the destruction of at least one outer layer when welding.

BRIEF SUMMARY OF THE INVENTION

In a method according to the invention for the resistance welding of sheet metal panels coated preferably with synthetic substances the welding current for at least one of the coated sheet metal panels is conducted indirectly to the welding zone through the sheet metal. Therefrom the advantage results that the outer coating of at least one of the sheet metal panels remains undamaged, and that the welding is performed as an internal welding of the juxtapositioned surfaces of the sheet metal panels.

For welding two sheet metal panels to one another, which are coated on both sides, the upper sheet metal panel may be stripped on top of its coating for placing an electrode on it, while the lower sheet metal panel rests through a cooling plate and an insulator on the lower electrode. This lower electrode is connected by a cable to the lower sheet metal as well as to the upper sheet metal. When switching on the current the same flows firstly from the upper electrode through the upper sheet metal to the lower electrode, whereby the sheet metal is heated and the layer between the sheet metals melts. Under the pressure of the upper electrode the heated upper metal bulges and comes into contact with the lower sheet metal. The current then flows to the lower electrode also through the lower sheet metal, and welds the two sheet metals to one another.

For welding an upper sheet metal panel to two lower sheet metal panels lying side by side, two separate electrodes may be used which are applied to stripped zones of the upper sheet metal panel. The lower sheet metal panels lying on a cooling plate are indirectly connected by cables to an opposite electrode. When switching on the current, firstly a heating current flows horizontally in the upper sheet metal, and after the melting of the coating layers a current flows perpendicularly through the two sheet metals whereby these panels are connected simultaneously on two points to each other.

When using an electrode and opposite annular electrode arranged coaxially to each other for welding, a common stripped zone is provided in the upper sheet metal panel. Moreover, the opposite electrode is connected to the lower sheet metal panel through cables. When switching on the current, firstly a heating current flows horizontally between the electrodes, and after the melting of the coating layers a welding current flows perpendicularly through the two sheet metal panels and welds the same to one another. The annular electrode limits the heating of the upper sheet metal panel to a small area.

For the purpose of roller welding, the upper sheet metal panel is stripped over an elongated zone for the roller electrode, and between the sheet metal panels coated on both surfaces a wire is inserted along the weld seam to be produced. Both sheet metal panels are connected by cables to the opposite pole of the current source. When switching on the current, a heating current flows horizontally through the upper sheet metal until the internal coating layers are melted; then the wire establishes contact between the sheet metal panels and a welding current welds the wire to the sheet metal panels. The wire may be additionally connected to the said opposite pole.

In accordance with a modification, the wire may be interposed between the welding roller and the upper layer of the upper sheet metal panel, and may be connected like the sheet metal panels through regulating resistors to the said opposite pole. This method has the advantage that any stripping is dispensed with.

Alternatively both sheet metal panels may be connected indirectly to the poles of a secondary circuit, placed between cooling plates and pressed against each other by presser means. Between the sheet metal panels a row of wires may be interposed and connected at their ends each to one of said poles. According to a modification two rows of wires crossing one another may be interposed and electrically connected at opposite polarity. When the current is switched on, firstly a heating current flows, and after the melting of the coating layers a welding current. By applying a single pressure means a plurality of welding seams can thus be produced simultaneously. Both outermost coatings thus remain undamaged. Upper and lower vibrator devices may be provided for assisting the welding operation.

On the same principle the angled ends of sheet metal panels may be welded, e.g. those of partition walls. For this purpose the inner welding areas are to be stripped, welding pieces are to be inserted, and each sheet metal is to be connected to a pole of a secondary circuit. When switching on the current and the presser means, the sheet metal panels are welded to each other while the outer coatings remain undamaged.

The sheet metal panels to be welded to one another may moreover be placed between the upper and lower plates of a capacitor, in order to force the welding current flow towards the interior. Thus the warming of the external coatings of the sheet metal panels may be reduced.

According to a further embodiment of the method according to the present invention at least the indirectly connected sheet metal panel may be provided with milled recesses for leaving undamaged another outer coating. In a first example the milled recess leaves a small welding pin in existence, against which the stripped upper sheet metal panel is pressed by a small electrode, and is thus welded to it. In a second example both sheet metal panels are provided with welding pins, connected indirectly to a current source, and welded to each other through an interposed intermediate welding piece. In a third example the milled recess of the indirectly connected sheet metal panel leaves a central point standing, the intermediate welding piece is provided on top with a pin or with an annular edge, and the thickness of the upper sheet metal panel is reduced underneath the electrode. In a fourth example both inner surfaces of the sheet metal are provided with milled recesses of square cross section; in a fifth example with a recess of triangular cross section for connecting a round intermediate welding piece. Thereby the contact areas are reduced practically to contact points or lines only, whereby the resistance of transition is increased, and the size of the welding zone as well as its warming are reduced.

In accordance with a further embodiment an upper milled recess of the upper sheet metal panel may be provided with a dimple having a downwardly directed point, For this purpose a single milled recess only is to be provided. Moreover the outer layer lying underneath the welded area may be bought into direct contact with a coolant, apart from the use of cooling plates.

According to a further embodiment intermediate welding pieces of a low melting point material, e.g. of hard or soft solder, are used. Thus the panels need not be heated to the welding temperature of the sheet metal and their warming is reduced.

For the use of capacitor pulse welding, blank metal surfaces may be formed on the internal welding areas, and thus the narrow gaps required for igniting an arc may be established. In the simplest case the two locally stripped internal coatings have together a thickness which corresponds to the gap required. With thicker coatings the gap may be established by impressing a pointed pressure punch. Moreover intermediate welding pieces having points or ribs projecting downwardly and upwardly may be inserted into the cavity formed by stripping, and the sheet metal panels themselves may be provided with sharp-edged ribs where they are being stripped. Through a bore in the upper sheet metal panel a pointed welding pin or a welding pin having an annular edge may be inserted, and pressed into the cavity during welding by a resilient pusher pin. Thus the cavity is filled. The upper sheet metal panel consequently remains plane.

For sheet metal panels coated on one side only, particularly of light metal, cavities are formed by the insertion of an insulating layer having holes for the insertion of very small intermediate welding pieces of high electrical resistance. These small welding pieces may consist of wire squeezed flat between the welding areas, and may be stuck to the perforated insulating strip.

The igniting of the electric arc may be initiated by the aid of welding pins as will be shown with reference to portable manual welding appliances. In accordance with a first embodiment the upper sheet metal panel is provided with a milled out recess leaving a welding pin standing. The welding appliance capable of being placed on top by means of a tripod comprises a spring-loaded presser punch, by the impact of which on the sheet metal the electric arc is ignited and the welding is performed.

In accordance with a second embodiment firstly an intermediate welding piece with a welding pin is welded to the lower sheet metal panel by means of a spring-loaded electrode, and subsequently an upper sheet metal panel provided with welding pins is welded to the intermediate welding piece. The sheet metals are thus kept spaced apart.

In accordance with a third embodiment a welding pin having a holder flange is inserted into the cavity formed by the stripping through a bore in the upper sheet metal panel, and is welded on by the aid of a spring-loaded electrode.

In order to displace the flow of current towards the inner welding zone, the external surfaces of the sheet metal panels may be arranged between capacitor plates and the inner sheet metal surfaces may be separated by a capacitor foil of opposite polarity. Thus the warming of the outer coatings is reduced.

According to a further embodiment of the method according to the invention a welding area may be firstly warmed by resistance heating, and subsequently welded by the capacitor pulse method by a changeover switch. The warming of the outing coating is thus reduced and the same is kept undamaged.

Finally the welding appliance may be placed within a vacuum bell and sealed about the zone to be welded in an airtight manner by an interposed rubber ring. The contact pressure is then not limited to manual force.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Various embodiments of the method according to the present invention and the appliances required for performing the same will now be described by way of example with reference to the accompanying drawings, in which:

FIG. **1** is a section of a welded spot of two sheet metal panels each coated on both sides, their outer coatings left undamaged, and having two indirect supplies of welding current and a direct one through an electrode.

FIG. **2** shows two welded spots of three sheet metal panels, each coated on both sides, with two indirect current supplies and two direct supplies of current through two separate electrodes.

FIG. **3** shows a welded spot of two sheet metal panels each coated on both sides with indirect current supply and a direct supply of current through an inner and an outer electrode.

FIG. **4** is a transverse section of a prepared weld seam for two sheet metal panels, each coated on both sides and separated by a welding wire, with indirect current supplies and a direct supply of current through a welding roller.

FIG. **5** is a longitudinal section of a prepared weld seam for two sheet metal panels each coated on both sides, with s superimposed welding wire, having indirect current supplies and one direct supply of current through a welding roller.

FIG. **6** is a section of a prepared seam welding for two sheet metal panels, each coated on both sides, separated by wires with indirect current supplies, enclosed within a vibrator device.

FIG. **7** is a section of a prepared seam welding for two sheet metal panels, each coated on both sides, separated by crossed wires with indirect current supplies.

FIG. **8** is a perspective illustration of a welding wire having an hourglass-shaped cross section.

FIG. **9** is a perspective illustration of a welding wire having a cusped triangular cross section.

FIG. **10** is a section of a prepared welding spot for a U-shaped folded-over margin and an angled margin engaged therein of two sheet metal panels, respectively, each coated on both sides, with intermediate welding pieces and indirect current supply.

FIG. **11** is a section of a prepared welding spot of two sheet metal panels, each coated on both sides, with an intermediate welding piece and indirect current supply, enclosed between capacitor plates.

FIG. **12** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, the lower panel having a milled-out welding pin on its inner surface.

FIG. **13** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with milled-out welding pins and an intermediate welding piece interposed between them.

FIG. **14** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with milled recesses and an intermediate welding piece.

FIG. **15** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with milled recesses of rectangular cross sections and a round intermediate welding piece.

FIG. **16** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with milled recesses of triangular cross sections, a round intermediate welding piece and a current supply device.

FIG. **17** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, the upper panel having an external milled recess and a downwardly directed point, and the lower panel being cooled at the welding zone.

FIG. **18** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with a low melting point intermediate welding piece.

FIG. **19** is a modification of FIG. **18** with milled out welding pins.

FIG. **20** is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with internal stripping for arc welding.

FIG. **21** is a plan view of a stripped zone with circular ribs.

FIG. **22** shows an intermediate welding disc having ribs on both sides.

FIG. **23** shows an intermediate welding strip having ribs on both sides.

FIG. **24** shows an elongated stripped zone with ribs.

FIG. 25 is a cross section of a prepared welding spot with a downwardly pointed embossed dimple underneath the electrode.

FIG. 26 shows a prepared welding spot with an intermediate welding piece having points directed upwardly and downwardly.

FIG. 27 is a plan view of the welding piece of FIG. 26.

FIG. 28 shows a prepared welding spot with a welding pin inserted.

FIG. 29 shows a modification of FIG. 28 with a welding pin capable of being advanced.

FIG. 30 is a section of a prepared welding zone for two sheet metal panels, each coated on one side, with an insulating insert layer and intermediate welding pieces.

FIG. 31 is a plan view of an insulating strip with a welding wire stuck on.

FIG. 32 is a section of a prepared welding spot with a welding device superimposed.

FIG. 33 is a section of a prepared welding spot for a lower sheet metal panel with an intermediate welding piece held by the welding device.

FIG. 34 is a similar section with an upper sheet metal panel to be welded to the intermediate welding piece.

FIG. 35 is a section of a prepared welding spot with a welding pin to be welded in.

FIG. 36 is a section of a prepared welding spot for two sheet metal panels, each coated on both sides, with a current displacement device comprising capacitor plates and foil, with the welding device superimposed.

FIG. 37 is a section of a prepared welding spot with a welding device superimposed and a prewarming device.

FIG. 38 shows a prepared welding spot with superimposed welding device within a vacuum bell.

FIG. 39 shows a prepared welding zone for welding by the aid of lifter pin of a pin welding appliance.

FIG. 40 shows the preparation of the welding area of a lower panel with the aid of a sealing foil stuck to it.

FIG. 41 shows the welding of a lower panel with a sealing foil stuck to it to an upper panel, by the aid of a welding pin.

DETAILED DESCRIPTION OF THE INVENTION

In FIG. 1 a sheet metal panel is illustrated having an upper coating 1*a* and a lower coating 1*b*, which panel is to be welded to a second panel having an upper coating 2*a* and a lower coating 2*b*. When welding, one of the outer coatings, namely the lower coating 2*b* of the panel 2 should remain undamaged. For this purpose the panel 1 has a stripped area 1*c* at the welding zone, so that an upper electrode 5 comes into contact with the metal sheet of panel 1. The panels 1 and 2 are connected by cables 7*a*, 7 to a lower counterelectrode 6. The lower coating 2*b* rests on a cooling plate 10, and the latter rests through an insulator 12 on the flat counterelectrode 6. When switching on the current, the same flows from the upper electrode 5 through the sheet metal 1 and the cable 7*a* to the counterelectrode 6. Thereby the panel 1 is warmed underneath the upper electrode 5; the two internal coatings 1*b*, 2*a* melt; contact is established with the sheet metal 2; current flows through the sheet metal 2 and cable 7 to the counterelectrode and welds the two sheet metal panels to one another under the pressure of the upper electrode. The welding data are so adjusted and the operation is so controlled that the lower decorative coating 2*a* does not melt. In order that this coating be not affected even during the cooling of the weld spot, it rests on the cooling plate 10, which in turn rests through an insulator 12 on the counter electrode.

FIG. 2 shows a further example, wherein two electrodes are connected in series side by side. Thus an upper panel 1 having coatings 1*a*, 1*b* can be connected simultaneously to two lower panels 2,3 having coatings 2*a*, 2*b* and 3*a*, 3*b*, respectively. The upper panel 1 has stripped zones 1*c* underneath the right-hand side electrode 5 and underneath the left-hand side electrode 6. The lower panels rest on a cooling plate 10, which rests on a table 11. From the right-hand side electrode 5 a cable 4 leads to the left-hand side panel 2, and from the electrode 6 a cable 7 leads to the right-hand side panel 3, a regulating resistor 8 being connected in each of these cables. When switching on the current, the same flows from the electrode 5 through the sheet metal 1 to the counterelectrode 6. Thereby the panel is heated at the welding zones; the coatings 1*b*, 2*a* and 1*b*, 3*a*, respectively, melt; contact is established to the sheet metals 2 and 3. Part of the current then flows from the right-hand side electrode 5 through the sheet metal panels 1,3 and the cable 7 to the counterelectrode 6, and through the cable 4, the sheet metal panels 2, 1 to the counterelectrode 6, and welds the two sheet metal panels simultaneously on both spots. The coatings 2*b*, 3*b* resting on the cooling plate remain undamaged.

In accordance with FIG. 3, welding may be performed by means of an annular counterelectrode. An upper panel 1 having coatings 1*a*, 1*b*, has a comparatively large stripped area 1*c* at the welding zone. The lower panel 2 having coatings 2*a*, 2*b* rests on a cooling plate 10 which rests through an insulation 12 on a table 11. The inner electrode 5 is surrounded by an outer annular counterelectrode 6. Both electrodes contact the sheet metal 1 within the stripped area 1*c*. The inner electrode 5 is connected to one pole of a secondary circuit S of the welding plant by a cable 4, and the outer electrode 6 is connected by a cable 7*a* to the opposite pole of this circuit. When switching on the current the same flows from the inner electrode 5 through the sheet metal 1 to the outer counterelectrode 6; the panel 1 is warmed at the welding zone; the coatings 1*b*, 2*a* melt; contact is established between the sheet metals 1 and 2; the current then flows from the electrode 5 through the sheet metals 1,2 and the cable 7 back to the current source; and the two sheet metals are welded to one another. The coating 2*b* resting on the cooling plate remains undamaged.

The method of the present invention is applicable also to roller seam welding. In accordance with FIG. 4 an upper panel 1 having the coatings 1*a*, 1*b* is provided with an elongated stripped area 1*c*. A lower panel 2 having the coatings 2*a*, 2*b* rests on a cooling plate 10 and an insulator 12. Between the panels or rather their coatings 1*b*, 2*a* a wire 9 is stretched out where the weld seam is to be formed, in order to facilitate the formation of contact. A welding roller 5*a* is connected by a cable 4 to one of the secondary circuit S of a welding plant, the other pole of which is connected by a cable 7 to the sheet metal 1. When switching on the current the same flows through the cable 4, the welding roller 5*a* and the sheet metal 1 to the cable 7*a;* the panel 1 is warmed; the coating 1*b* melts; the wire 9 establishes contact with the sheet metal 1; the coating 2*a* melts; the wire establishes contact with the sheet metal 2; the current flows through the sheet metal 2 and the cable 7, and welds the wire to the two sheet metals. The coating 2*b* resting on the cooling plate remains undamaged.

The wire 9 may be alternatively connected to the cable 4, or its ends may be connected with opposite polarity to the cables 4 and 7, respectively.

Welding may even be performed without any stripping 1*c*. For this purpose an upper panel 1 (FIG. 5) having the coatings 1*a*, 1*b* rests directly on a lower panel 2 having the coatings 2*a*, 2*b* and resting on a cooling plate 10, which is supported on a table 11 by an insulator 12. A wire 9 is stretched out underneath the welding roller 5*a* and above the coating 1*a*. The secondary circuit S of the welding plant has one pole connected by the cable 4 to the welding roller, and the other pole connected by the cable 7 to the sheet metal 2, by the cable 7*a* to the sheet metal 1, and by a cable 7*b* to the wire 9. Regulating resistors 8 are connected in the cables 7, 7*a*, 7*b*. When switching on the current, the same flows from the welding roller 5*a* through the wire 9 and cable 7*b;* the wire 9 is warmed, the layer 1*a* melts; the wire 9 establishes contact with the sheet metal 1 and the cable 7 and fuses itself, whereby also the coatings 1*b*, 2*a* are melted, and welding of the sheet metals 1 and 2 to each other is effected through the cable 7. The coating 2*b* resting on the cooling plate 10 remains undamaged.

According to a further embodiment of the method of the present invention both outer coatings of the panels may remain undamaged and at the same time a plurality of welding spots may be established simultaneously.

In accordance with FIG. 6 parallel wires 9*a* are stretched out between an upper panel 1 having the coatings 1*a*, 1*b* and a lower panel 2 having the coatings 2*a*, 2*b*. On top of the upper panel 1 and underneath the lower panel 2 cooling plates 10, respectively, are arranged. Each of the cooling plates may be followed by a vibrator device 13 comprising an electromagnet and a hand plate or footplate 15 connecting the magnets. For the cooling of the magnet plates 15 contacting the coatings, coolant pipes 19 are provided, which are pressed on the plates 15 by springs 18. The lower vibrator device rests on a table 11. The upper vibrator device can be pressed towards the lower device by the aid of pistons 16 and pneumatic cylinders 17. The secondary circuit S of a welding plant has one pole connected by a cable 7 to the lower sheet metal 2, and the other pole connected by a cable 4 to the upper sheet metal 1. The wires 9*a* are connected at their respective ends to the poles of the said secondary circuit. For the purpose of welding compressed air is introduced into the cylinders 17, and the alternating current for the magnets 14 is switched on. Vibration of the parts to be welded to each other facilitates penetration of the current through the coatings, and accelerates the welding of the parts by reducing the resistance of transition. When switching on the welding current, the wires 9*a* are heated, they fuse the adjacent coatings 1*b* and 2*a* and establish contact with the sheet metals 1 and 2, to which they are welded under the pressure of the cylinders 17. The two outer coatings 1*a* and 2*b* remain undamaged.

FIG. 7 shows a similar arrangement. Underneath an upper vibrator device 13 comprising a magnet plate 15 and a cooling plate 10 lies an upper sheet metal panel 1 with coatings 1*a*, 1*b*, and a lower panel 2 with coatings 2*a*, 2*b* rests on a lower vibrator device. On top of the coating 2*a* there lie a series of wires 9*a*, and under the coating 1*b* a series of wires 9*b*, which cross the wires 9*a*. Instead of the second series of wires a sheet metal 9*c* covering all the wires 9*a* may be provided, which on its face contacting the wires may be either blank, or if coated, is stripped on circular or stripe-shaped zones. The wires 9*a* are connected by a cable 4*a* to one pole, and the wires 9*b* or the sheet metal 9*c* by a cable 7*a* to the other pole of a secondary circuit S. Moreover, the upper sheet metal 1 is connected to the cable 4, and the sheet metal 2 to the cable 7, i.e. with a polarity opposite to that of the adjacent wires. When switching on the welding current, firstly the wires are fused, starting on the crossing points, then the coatings 1*b*, 2*a* along the wires, and finally the sheet metals 1,2 come into contact with, and under the pressure of the plate 15 are welded to each other. The outer coatings 1*a*, 2*b* remain undamaged.

Instead of the round cross section wires illustrated in FIGS. 4 to 7, profiled wires having sharp edges may be used.

For example, FIG. 8 shows a wire having an hourglass-shaped cross section, and FIG. 9 shows a wire having a cusped triangular cross section, FIGS. 8 and 9 being on a larger scale. Circular or stripe-shaped stripped areas may be provided on the welding spots or lines, and intermediate welding pieces in the shape of wires or lengths of wires may be inserted therein.

FIG. 10 shows an example for angularly turned-up sheet metals e.g. of partition walls. One margin of a sheet metal panel 1 with coatings 1*a*, 1*b* is folded over under an angle of 180°. Before the folding, stripped zones 1*d*, 1*d'* of circular or stripe shape have been provided in the coating 1*b* at the prospective welding zones. The angularly turned-up margin of a panel 2 having coatings 2*a*, 2*b* engages in the bend of panel 1. On the turned-up flange stripped zones 2*c* and 2*d*, respectively, are provided at the welding zones.

In the upper stripped zones 1*d*, 2*c* and in the lower stripped zones 2*d*, 1*d* welding pieces 20 in the form of discs, strips or wires are inserted, the thickness of which for establishing contact exceeds the sum of the thicknesses of two coatings. The bend of the sheet metal panel 1 rests through a cooling plate 10 on a table 11, while the upper surface of the panel 1 is covered by a further cooling plate 10, and can be pressed down by a presser plate 15, piston 16 and pressure cylinder. The panel 1 is connected by a cable 4 to one pole, and the panel 2 by a cable 7 containing a regulating resistor 8 to the other pole of the secondary circuit of a welding plant. When switching on the current, the sheet metals 1 and 2 are welded to the welding pieces 20. The outer coating 1*a* of the panel 1 remains undamaged.

A further embodiment of the method for maintaining an outer coating undamaged is illustrated in FIG. 11. A panel 1 with coatings 1*a*, 1*b* is to be welded to a panel 2 with coatings 2*a*, 2*b*. For this purpose the juxtapositioned coatings 1*b* and 2*a* have stripped zones 1*d*, 2*c*, into which a welding piece in the form of a wire is inserted. To the outer surfaces of the panels 1, 2 an upper capacitor plate 31*a* and a lower capacitor plate 31*b* are applied, the upper one being capable of being pressed down through an insulator 12 by a presser plate 15. The upper capacitor plate is connected to one pole of a direct current source, the lower one to the other pole thereof. Moreover the sheet metal 1 is connected by a cable 4 to one pole, and the sheet metal 2 by a cable 7 to the other pole of a source of welding current, the pole of the upper capacitor plate 31*a* being of the same polarity as the pole of sheet metal 1, and likewise that of the lower capacitor plate 31*b* being of that of the sheet metal 2. When the capacitor plates are charged and the welding current is switched on, the electric field of the capacitor plates forces the welding current from the outer layers inward towards the welding point, whereby the welding is accelerated, warming is reduced and kept away from the decorative outer coating. The decorative outer coating remains undamaged even with thin sheet metals and thin coatings.

The capacitor plates may serve at the same time as cooling plates. Their shape may be adapted to a curved row of welding spots or line, and they are capable of being pressed towards each other by pistons and pneumatic cylinders, see FIG. 6. Likewise the vibrator device shown there may be additionally provided.

The method according to the present invention may be carried out also with light metal alloy sheets having oxidized surfaces or with bonderized steel sheets the outer surfaces of which are to remain undamaged. At the welding zones oxide layers, which would require a temperature of 2000° C. for melting, and the bonderized layers are removed by mechanical stripping. Inserts of the same metal or of suitable special alloys are to be inserted into the cavities, which inserts are quickly welded to the blank welding zones while developing little heat.

In order to confine the warming of the panels to a small region, to increase the resistance of transition at the welding zone and to make do with short welding periods the contact areas on the welding zone are substantially reduced. According to a first example this can be done simultaneously with the stripping. As exaggeratedly shown in FIG. 12, an upper panel 1 with coatings 1*a*, 1*b* is provided on the outer surface with a small stripped zone 1*d*, and a lower panel 2 with coatings 2*a*, 2*b* is provided not only with a stripped zone but moreover with a recess 2*f* milled out of the sheet metal, which reduces the contact area at the welding zone to a very small welding spot 2*g*. An annular milling cutter cuts out an annular groove 2*f* and leaves a cylindrical welding pin 2*g* standing. The lower panel 2 is supported on a table 11 by a cooling plate 10, while the panel 1 is depressed by means of a piston 16 and pressure cylinder 17, through an upper cooling plate 10 having a cutout for an electrode 5. The electrode 5 having a small tungsten tip 5*b* is connected to one pole of the secondary circuit of a welding plant, preferably a capacitor welding plant, while the other pole thereof is connected to the sheet metal 2. When switching on the current, the small area of the tungsten tip 5*b* contacts the sheet metal 1. Under the pressure of the electrode 5 the sheet metal 1 comes into contact with the small welding pin 2*g* and is welded thereto. The outer coating 2*b* of

the panel 2 remains undamaged, and the outer coating 1*a* of the panel 1 is to be recoated on a small area only.

In accordance with a second example shown in FIG. 13 each of the panels 1 with coatings 1*a*, 1*b* and the panel 2 with coatings 2*a*, 2*b* is to be provided on the inner surface with a stripped zone 1*f*, 2*f*, respectively, with the formation of a welding pin 1*g*, 2*g*, respectively, and a welding piece 20 is inserted between the welding pins, the thickness of which piece exceeds the sum of the thicknesses of the removed coatings. The lower panel 2 rests on a table 11 through a cooling plate 10, while the upper panel 1 is capable of being pressed down through an upper cooling plate by a piston 16 and pressure cylinder 17. The sheet metal 1 is connected by a cable 4 to one pole of the secondary circuit S of a welding plant, and the sheet metal 2 is connected by a cable 7 to the other pole thereof. When switching on the current, the same can flow only through the small contact areas of the welding pins 1*g*, 2*g*, which are heated quickly and are welded to each other under the pressure of the cylinder 17 while developing little heat. The outer coatings 1*a*, 2*b* thus remain undamaged.

In accordance with a third example illustrated in FIG. 14 the upper panel 1 with coatings 1*a*, 1*b* is provided on top with a trough-shaped milled recess 1*f* corresponding to the shape of the electrode, and on the under side with a stripped zone 1*d*, and the panel 2 is provided with a conical milled recess 2*f* leaving a welding point 2*g* standing. Between the sheet metals an intermediate welding piece 20 is inserted, which has on top a pin 20*a* and/or an annular edge for reduction of the contact area. The lower panel 2 rests on a table 11 through a cooling plate 10. An electrode 5 connected by a cable 4 to one pole of a secondary circuit S is pressed down into the milled recess 1*f* of the upper panel, while the other pole thereof is connected to the sheet metal 2 by a cable 7. When switching on the current, the same can flow through small contact areas only, which are quickly heated and welded to each other. The coating 2*b* of the lower panel remains thus undamaged.

In accordance with a fourth example illustrated in FIG. 15 a panel 1 with coatings 2*a*, 2*b* are each provided on their inner surfaces only with a milled recess of rectangular cross section, 1*f*, 2*f*, respectively, and an intermediate welding piece 20 of spherical or wire shape is inserted into the recesses, the diameter of which intermediate piece exceeds the depth of the two milled recesses put together, and has only a point or line contact with the bottoms of the milled recesses. The panel 2 rests on a table 11 through a cooling plate 10, while the panel 1 is capable of being pressed down through an upper cooling plate 10 by means of a piston 16 and pressure cylinder 17. The sheet metal 1 is connected by a cable 4 to one pole of a secondary circuit, and the sheet metal 2 is connected by a cable 7 to the other pole thereof. When switching on the current, the same can flow only through the contact points or lines which are heated quickly and are welded to each other. The outer coatings 1*a* and 2*b* thus remain undamaged.

In accordance with a fifth example illustrated in FIG. 16, a panel 1 having coatings 1*a*, 1*b* and a panel 2 having coatings 2*a*, 2*b* are provided on their inner surfaces with stripe-shaped stripped zones 1*d*, 2*c*, respectively, and within these stripped zones with small milled recesses of triangular cross section 1*f*, 2*f*, respectively; into these milled recesses a welding piece 20 in the form of a wire is inserted, the diameter of which exceeds the depths of the said recesses put together. The panel 2 rests at its left-hand side end through a cooling plate 10 and an insulator 12 on the lower electrode of a welding plant, while the upper panel 1 overlaps with its right hand side end the lower panel 2 and is capable of being pressed down through an upper cooling plate 10 and an insulator 12 by the upper electrode 5 of a welding plant. The panels 1, 2 are held in position by upper and lower pairs of pistons 16 and pressure cylinders 17, respectively. The electrodes 5, 6 are connected by a cable 4 and 7, respectively to current supply device 24 contacting the outer cut edges 1*s*, 2*s* respectively, of the sheet metals. These devices comprise flexible silver-plated copper strips 24*a* attached to an elongated plate 24*c* through resilient insulating strips 24*b*, e.g. of rubber, and can be clamped by holders 24*d*, e.g. resilient clips, on the margins of the panels 1, 2 respectively. The plates 24*c* are capable of being pressed by pistons 16 and pressure cylinders 17 against the edges of the panels 1,2, respectively. The length of the device depends on the current intensity to be transmitted. When switching on the current, the same flows through the cables 4, 7 into the sheet metals 1, 2 respectively, and through their contact lines with the welding piece, which are quickly heated and welded. The outer coatings 1*a*, 2*b* thus remain undamaged.

According to a modification, the coating 1*a*, at the dimple 1*l* and/or the coating 2*a* of the welding zone underneath may be previously removed.

A further example of welding with little development of heat in the lower decorative panel is illustrated in FIG. 17. An upper holder panel 1 with coatings 1*a*, 1*b* has on top a milled recess 1*f* reducing the thickness of the sheet metal. In the middle of the milled recess a downwardly pointed dimple 1*l* is provided which is produced by the tip of an electrode or by a punch in a separate operation. A lower panel 2 with coatings 2*a*, 2*b* rests on a cooling plate 10 having a recess 10*c* underneath the welding spot. Coolant supply-and-drain pipes 10*a* and 10*b*, respectively, issue into said recess, whereby even a slight warming of the outer coating 2*b* is prevented which might cause a slightly lustrous spot thereon. An electrode 5 having a bore 5*e* engages in the milled recess 1*f*, in which bore a spring-loaded electrode pin 5*m* is mounted, having a tip 5*n* for the dimple 1*l*. The electrode 5 and electrode pin 5*m* are connected by a cable 4 to the one pole of the secondary circuit S of a welding plant, the other pole of which is connected by a cable 7*a* through a regulating resistor 8 to the sheet metal 1 and by a cable 7 through a further regulating resistor 8 to the sheet metal 2. When switching on the current, the same flows via the electrode 5 and the sheet metal 1, whereby the latter is warmed at the thinned region at the milled recess; the coating 1*b* and subsequently the coating 2*a* melt. The dimple 1*l* comes into contact with the sheet metal 2; current flows then also through the sheet metal 2 and welds the sheet metal 2 to the sheet metal 1 under the pressure of the electrode 5. The tip 5*n* of the spring-loaded electrode pin 5*m* is thus pushed into the electrode 5 so that a weld blob is formed with little warming of the decorative panel. The outer coating 2*b* thus remains undamaged.

Further reduction of the heating of the coated panels is possible by making the welding pieces of a material, the melting point of which is below the melting point of the sheet metals to be connected. For steel sheet the usual hard and soft solders, and for aluminum sheet, aluminum alloys are in consideration which have a low melting point.

In accordance with FIG. 18 an upper panel 1 1 with coatings 1*a*, 1*b* is provided with a stripped zone 1*c* on top and a stripped zone 1*d* on its underside, and a lower panel 2 with coatings 2*a*, 2*b* is provided with a stripped zone 2*c* on top, these stripped zones having the shape or circles or strips. In the cavity formed by the inner stripped zones there is inserted an intermediate piece 21 in the form of a disc or strip and of a material the melting point of which is lower than that of the sheet metals 1,2. The lower panel 2 rests through a cooling plate 10, e.g. of copper, on an electrode 6. An upper electrode 5 engages in the stripped zone 1*c* of the upper panel. The lower sheet metal is connected by a cable 7 to the lower electrode 6. When switching on the current, the intermediate piece 21 melts and connects itself to the sheet metals, whereafter the current is switched off before the melting point of the sheet metals is reached. The outer coating 2*b* of the lower panel thus remains undamaged.

In accordance with FIG. 19 the warming of the sheet metals is reduced and the resistance of transition at the contact areas is increased. For this purpose the panel 1 with coatings 1*a*, 1*b* and the panel 2 with coatings 2*a*, 2*b* are provided at their inner surfaces will milled recesses, 1*f*, 2*f*, respectively, leaving small welding pins 1*g*, 2*g*, respectively, standing in their centers. The milled recesses are annular for spot welding, and in the

shape of grooves for seam welding. Between the welding pins intermediate pieces **21** are inserted, the melting point of which lies below that of the sheet metals and to which flux is added. The lower panel **2** rests on a table **11** through a cooling plate **10**. The upper panel **1** is capable of being pressed down through a cooling plate **10** by a piston **16** and pressure cylinder **17**. The upper sheet metal **1** is connected by a cable **4** to one pole of a secondary circuit S, and the panel **2** is connected by a cable **7** to the other pole thereof. When switching on the current, the same flows through the sheet metal **1** and the small welding pins **1***g*, **2***g* into the sheet metal **2**, whereby the intermediate piece melts quickly and connection is established by the pressure of the piston, before the sheet metals reach their melting point. The outer coatings **1***a*, **2***b* thus remain undamaged.

Further reduction of the duration of the welding period and hence of the warming of the sheet metal panels is attainable by the use of a capacitor pulse welding plant. For the generation of small electric arcs between the juxtapositioned stripped sheet metal surfaces the latter must have a predetermined small spacing or only very small contact spots or points with each other.

The cavity formed by the stripping and having a height of fractions of a millimeter slows the formation of small electric arcs. In the embodiment illustrated in FIG. **20** an upper panel **1** with coatings **1***a*, **1***b* is provided on top and on the underside with stripped zones **1***c*, **1***d*, respectively, and a lower panel **2** having coatings **2***a*, **2***b* is provided on top with a stripped zone **2***c*, so that the blank sheet metal surfaces **1***p* and **2***p* are juxtapositioned with a narrow gap. The lower panel rests on a table **11**, through a cooling plate **10**, while the upper panel is subject to the pressure of an electrode **5**. This electrode is connected by a cable **4** to one pole of a capacitor pulse welding plant K, the other pole of which is connected by a cable **7** to the sheet metal **2** and by a cable **7***a* through a regulating resistor **8** to the sheet metal **1** for additional warming. When switching on a current of sufficient voltage, electric arcs are formed between the blank surfaces **1***p*, **2***p* of the sheet metals, whereby these surfaces are superficially fused without thermal effect in depth. In the meantime the upper sheet metal surface **1***p* has been pressed against the lower sheet metal surface **2***p* to which it is welded in the final phase. These operations occur in periods of the duration of milliseconds. The outer coating **2***b* of the panel **2** thus remains undamaged.

The welding current pulse requires a sufficient initial voltage in order to initiate the formation of an electric arc and to sustain the latter. For metering the optimum welding energy required, the capacitor battery has a capacity variable by suitable switching (energy selector).

In the case of a capacitor pulse welding machine with transformed capacitor discharge, the secondary circuit of the pulse transformer, between the poles of which the welding zone is connected, is to be constructed with sufficient voltage for initiating and sustaining the electric arcs.

As capacitor welding machines for the resistance-arc welding method those are also suitable in which the capacitor output is not transformed, and which comprise long cables of the welding appliance and a very bulky welding circuit. Since with such discharge current pulses the total welding period lasts only substantially one millisecond, the depth of penetration of the heat is very small. Accordingly the obverse decorative coating of the workpiece is not affected if the thickness of the sheet metal is from 0.5 mm. upward. The working life of the electrodes is then practically almost unlimited. Welding is independent of the thickness of the sheet metal.

The welding parameters, i.e. the voltage as well as welding period may be set permanently. Depending on the actual conditions and on the sort of sheet metal panels to be welded to each other, the current intensity has to be varied. This is done by connecting or disconnecting capacitor units of the capacitor battery and of the welding energy selectors. The electric arc welding within the cavities according to the present invention likewise requires certain definite minimum magnitudes of energy for the welding and for the sufficient superficial melting of the juxtapositioned blank surfaces and for the melting of any inserted welding pieces.

Since the energy transformation is concentrated in the space of the electric welding arc, the loss of energy due to thermal conduction is low as compared with resistance welding. Welding is accordingly effected with a substantially lower requirement in energy as in a corresponding case of resistance welding. Consequently the decorative coating remains undamaged provided the welding parameters, the inserted pieces, or the like are correctly dimensioned.

Between the minimum magnitude of energy required for welding and the maximum magnitude permissible without damaging the decorative coating there are close tolerances.

Likewise, the pressure of the electrodes or of a presser means, which does not carry a current, are of importance for the welding, when the capacitor welding current is supplied to the welding spot, e.g. through a cut edge or elsewhere through a stripped area of the sheet metal to be welded. The resistance of transition between the two sheet metals to be welded to one another must not then be reduced so far that a current flows by contact rather than as an electric welding arc. Also the shape of the effective electrode surface or presser means may be of importance.

It is necessary to make the stripper welding zones juxtapositioned to each other in the cavity approach one another with a progressively diminishing spacing by pressure, e.g. by spring bias, until sufficient superficial melting by the electric arcs is achieved; this progressive approach is corresponding to the progress of the superficial melting. Substantially on termination of the welding current after a predetermined welding period, when attaining a fused surface condition of the welding areas, the latter are then united by being pressed on each other. The time lag required for this purpose may be produced in various ways. By means of inserts, such as wire lengths crossing each other or of fine wire mesh, this delay may be extended up to the complete fusion of such inserts, in synchronism with the moment of optimum superficial melting of the blank sheet metal surfaces by the electric arcs. This is done while applying an appropriate pressure through electrodes or presser means by means of compressed air and additional spring-mounting of the electrodes.

Formation of electric arcs is promoted by the provision of ribs **57** on the stripped blank sheet metal surfaces **1***p*, 2p. In FIG. **21** circular ribs are shown for spot-welding, and in FIG. **24** longitudinal ribs on the sheet metal surface **1***p* are shown for seam welding, said ribs being produced by profiled milling cutters when stripping off the coatings. For comparatively large spacings between the sheet metal surfaces **1***p*, **2***p*, intermediate welding pieces **58** may be inserted for establishing the correct spacing, which pieces may have the shape of discs as in FIG. **22** or of strips as in FIG. **23**, and have ribs **58***a* on the front and ribs **58***b* on the back.

For sheet metal panels having comparatively thick coatings the gaps between the blank sheet metal surfaces to be welded to each other are to be reduced or bridged by means of pointed embossings. In FIG. **25** an upper panel **1** with the coatings **1***a*, **1***b* is provided on its underside with a stripped zone **1***d*, and a lower panel **2** with the coatings **2***a*, **2***b* is provided on top with a stripped zone **2***c*. The lower panel rests on a cooling plate **10**. Above the upper panel a pointed punch **46** is arranged at the welding zone, which punch may be impressed into the panel **1** by a resilient presser means, e.g. a spring or by the piston **16** of a pressure cylinder so that a pointed dimple **1***h* is embossed in the panel **1** and contact is established between the blank sheet metal surfaces **1***p*, **2***p*. The upper sheet metal **1** is connected by a cable **4** to one pole of a capacitor pulse welding plant K, and the lower sheet metal **2** is connected by a cable **7** to the other pole thereof. When switching on the current, electric arcs are formed. After superficial melting of the surfaces **1***p*, **2***p* the same are welded to each other under the pressure of the punch **46**. The outer coatings **1***a*, **2***a* thus remain undamaged.

For spot welding the cross section of the punch **46** is circular, for seam welding strip shaped.

In FIG. **26** contact is established by means of intermediate welding pieces provided with points. An upper panel **1** with coatings **1***a*, **1***b* is provided with a stripped zone **1***c* on top and on its underside with a stripped zone **1***d*, and a lower panel **2** with coatings **2***a* **2***b* is provided with a stripped zone **2***c* on top. Between the blank sheet metal surfaces **1***p*, **2***p* an intermediate welding piece **45** is inserted, which e.g. in FIG. **27** consists in a disc **45** having points **45***a*, **45***b* alternately embossed upwardly and downwardly. The panel **2** rests on a cooling plate **10**, while the panel **1** can be pressed down by an electrode **5**. This electrode is connected by a cable **4** to one pole of a capacitor pulse welding plant K, the other pole of which is connected by a cable **7** to the sheet metal **2** and by a cable **7***a* through a regulating resistor **8** to the sheet metal **1**. The sheet metal **1** is spaced from the sheet metal **2**. When switching on the current electric arcs are formed between the sheet metal surfaces **1***p*, **2***p* which are then welded to the intermediate piece by the pressure of the electrode. The outer coating **2***b* remains undamaged.

A further kind of contact formation, by the use of a welding pin, is shown in FIG. **28**. An upper panel **1** with coatings **1***a*, **1***b* has on top a stripped zone **1***c*, on its underside a stripped zone **1***d*, and in the middle of the latter a bore **1***i*. A lower panel **2** with the coatings **2***a*, **2***b* is provided on top with a stripped zone **2***c*. In the bore **1***c* a pointed welding pin **52** is inserted. Its diameter of about 1 mm. corresponds to the diameter of the hole, and its upper end projects beyond the panel **1** towards the electrode **5**. One pole of a capacitor pulse welding plant K is connected by a cable **4** to the electrode **5**, and by a cable **4***c* through a regulating resistor **8** to the sheet metal **1**, while its other pole is connected by a cable **7** to the sheet metal **2** which rests on a cooling plate **10**. When switching on the current by the contact of the pointed welding pin **52** with the opposite blank surface **2***p* electric arcs are ignited between the blank sheet metal surfaces **1***p*, **2***p* in the cavity formed by the stripping; the blank sheet metal surfaces are brought to welding temperature and are welded to the fused welding pin **52** and to each other under the pressure of the electrode. The outer coating **2***b* of the panel **2** thus remains undamaged.

A modification with an enlarged welding zone is illustrated in FIG. **29**. An upper panel **1** with the coatings **1***a*, **1***b* is provided on top with a stripped zone **1***c*, on its underside with a larger milled zone **1***f* and in the middle of the stripped zones with a bore **1***i*. A lower panel **2** with the coatings **2***a*, **2***b* has a large stripped zone **2***c* on top, and rests on a cooling plate **10**. The electrode **5** has a blind bore **5***e*, in which there are inserted a spring **5***f*, a pusher pin **5***c* and a cylindrical welding pin **52**, the underside of which has a cavity producing an annular edge **52***b*. One pole of a capacitor pulse welding plant K is connected by a cable **4** to the electrode **5**, and by a cable **4***c* through a regulating resistor **8** to the sheet metal **1**, while its other pole is connected by a cable **7** to the sheet metal **2**. When switching on the current, electric arcs are ignited by the annular edge of the welding pin **52** between the blank sheet metal surfaces **1***p*, **2***p* connected to opposite poles; the surfaces thereof are heated to welding temperature while the welding pin is fused from below, the melt being forced by the pressure of the spring **5***f* and of the pusher pin **5***c* into the cavity and being welded there to the two blank sheet metal surfaces. The outer coating **2***b* thus remains undamaged.

A further example in accordance with FIG. **30** illustrates the welding of coated sheet metals of low electric resistance such as aluminum, brass or copper. Such sheets are usually coated on their outer surface only, since the blank inner surfaces are not corroded. An upper panel **1** having an outer coating **1***a* is to be welded to a lower panel **2** having an outer coating **2***b*. For this purpose an insulating insert **92** of paper or synthetic material having cutouts **92***a* is placed between the blank inner surfaces of the two panels. Lengths of wire **93** of high electric resistance, e.g. of steel, which have a diameter of about 0.7 mm. and a length of 1 to 5 mm. are inserted into these cutouts. The lower panel rests on a table **11** through a cooling plate **10** with coolant pipes **10***a*. On top of the panel **1** a cooling plate **10** and on top of the latter a presser plate **15** are placed, which can be pressed down by pistons **16** and pressure cylinders **17**. The sheet metal **1** is connected to a source of a welding current, and the panel **2** is earthed. When switching on the current, electric arcs are ignited within the cutouts of the insulating insert by the short lengths of wire having high electrical resistance, and these wires are welded to the blank surfaces under the pressure of said cylinders. The outer layers **1***a*, **2***b* thus remain undamaged. In this manner it is possible to connect coated aluminum sheet panels by invisible internal welding.

Instead of an insulating insert having cutouts and of inserted intermediate welding pieces, insulating strips with wires may be used for more economical working of the method: In FIG. **31** an insulating strip **121** has holes **122**. A wire **123** provided with flats **123***a* outside the welding zones and stuck on the insulating strip serves as the intermediate welding piece so that the undeformed portions **123***b* of the wire are juxtapositioned with the said holes and to ignite electric arcs there. In this way the insertion of individual intermediate welding pieces is dispensed with.

The internal welding of sheet metal panels coated on both surfaces can also be carried out with the use of welding—or presser punch—appliances. For better illustration the following examples are shown on a greatly enlarged scale. In the first example of FIG. **32** an upper panel **1** with the coatings **1***a*, **1***b* has a milled recess **1***f* on its underside, leaving a pin **1***g* standing in the middle of the recess, and a lower panel **2** has on top a stripped area **2***c* of equal size as said recess. The lower panel rests on a table **11** through a cooling plate **10** with coolant pipes **10***a*. Above the upper panel a presser punch **72** of a welding appliance **71** is arranged which punch is guided perpendicular to the surface of the panel by an insulating tube **73** resting with a tripod **74** on the panel **1**. The presser punch has a central bore **72***a*, into which coolant pipes **72***b* and a compression spring **72***c* are inserted from above. The presser punch is kept under the bias of said spring at regulable spacing of substantially 3 mm. above the panel **1**. This panel **1** is connected to a source of welding current, while the panel **2** is earthed at E. For the welding a discharge current is conducted into the sheet metal **1** to be welded, which at that moment has no contact with the decorative panel **2**. By the impact from outside of the presser punch, which does not carry current, on the welding zone, the pin **1***g* of the sheet metal **1** is made to approach the blank area **2***p* whereby arc welding and fusion of the contact pin *g* are initiated. By appropriately dimensioned pressure of the spring the sheet metal **1** is brought in area contact of its superficially fused underside with the likewise superficially fused welding zone of the sheet metal **2** and is thereby connected to it by welding. The outer coatings thus remain undamaged and the outer decorative coating **2***b* of the panel **2** remains also plane, while the holder panel **1** has a depression in its outer surface **1***a*.

Instead of cylindrical pins **1***g* line-shaped webs of substantially the same height and thickness as the pins may be provided for seam welds made, e.g. by means of capacitor discharge currents forming electric arcs, said webs being left standing when milling out recesses on the stripped juxtapositioned surfaces by means of side milling cutters.

A further example with the use of an intermediate welding piece is shown in FIGS. **33**, **34**. A lower panel **2** with coatings **2***a*, **2***b* has on top a stripped zone **2***c* with a blank metal area **2***p*, and rests on a table **11** through a cooling plate **10** having bores **10***a* for a liquid coolant. Above the stripped zone **2***c* the electrode **5** of a welding appliance is guided in an insulating tube **73** perpendicular to the surface of the panel, said tube being supported by a tripod **74**. The electrode **5** has a central bore **5***e* for a compression spring **5***f* and a holder means **5***g* for an intermediate welding piece **75** to be inserted into the foot of the electrode. The holder means illustrated comprises a suction air pipe **5***h* which issues in the electrode foot. When

using magnetic intermediate welding pieces 75 an electromagnet may be inserted instead of the air suction pipe. The intermediate welding piece has a diameter somewhat smaller than the thickness of the stripped zone 2*c* and a height of substantially twice the thickness of the sheet metal. On its under surface the intermediate welding piece has a small pin 75*g* which prior to welding is kept at a regulable spacing from the blank sheet metal surface 2*p* and is preloaded by the spring 5*f*. The intermediate welding piece is connected through the electrode 5 to the source of welding current, and the sheet metal 2 is earthed at E. When switching on the welding current, the electrode previously held by a solenoid coil is released, jerks the intermediate welding piece against the blank sheet metal surface 2*p* and is welded to the same.

In a further operation a panel 1 with the coatings 1*a*, 1*b* and a milled recess 1*f* on its underside, wherein a welding pin 1*g* is left standing, is brought on top of the welding piece previously welded to the sheet metal 2, and is held at a small distance from that sheet metal 2 by a welding device 71. For this purpose the presser punch 72, which does not carry current, comprises a holder means 72*g* e.g. with a suction air pipe 72*h*, and is guided in an insulating tube 73 mounted on a tripod 74. The sheet metal 1 is connected to the source of welding current, and the intermediate welding piece 75 is connected through the sheet metal 2 to Earth E. When switching on the welding current, the presser punch is released and jerks the sheet metal 1 with its welding pin 1*g* against the intermediate welding piece, and welds it to the same.

A modification for simpler treatment of a welding pin is shown in FIG. 35. An upper panel 1 with the coatings 1*a*, 1*b* has on top a stripped zone 1*c*, on the underside a stripped zone 1*d* and in the middle thereof a bore 1*i*. A lower panel 2 with the coatings 2*a*, 2*b* is provided with a stripped zone 2*c* on top, and rests on a table 11 through a cooling plate 10 with coolant pipes 10*a*. A welding device 71 is put on top of the panel 1, which device comprises an electrode 5, an insulating guide tube 73 and a tripod 74. The electrode is subject to the bias of a spring 5*f* and is provided on its underside with a holder means 5*g* for a welding pin 76. The holder means consists in FIG. 35 e.g. of an air suction pipe 5*h*. The welding pin has a flange 76*a* on top, and fits into the bore 1*i* of the sheet metal 1. Its length corresponds at least to the thickness of the sheet metal plus the thickness of the coatings 1*b* and 2*a*. One pole of a capacitor pulse welding plant K is connected by a cable 7 to the sheet metal 2. When switching on the welding current, the electrode 5 is released and jerks the welding pin 76 against the blank sheet metal zone 2*p*, ignites the electric arcs between the blank sheet metal areas 1*p* and 2*p*, and welds the same to each other. The outer coating of the panel 2 thus remains undamaged.

The pin may have been arranged on top of the sheet metal with an airgap, and the electrode may have been preloaded, so that said pin originally does not contact the decorative panel and comes into contact with it only by the resilient jerking forward of the electrode, when switching on the capacitor current, thus effecting the formation of the electric arcs.

The welding pin 76 having the flange 76*a* may be constructed preferably in such a manner that a flange-shaped enlargement is provided on top of the pin 76; the bore 1*i* is kept larger corresponding to that flange-shaped enlargement the height of which corresponds to the thickness of the sheet metal panel 1 and fills this bore 1*i* completely.

On this flange a further, even larger flange is provided, which after the termination of the welding operation, i.e. after the fusion of the welding pin 76, bears on the upper panel 1 in the manner of a rivet head, and presses said upper panel on the decorative lower panel 2. Welding thus takes place, instead of between the two panels 1 and 2, between the flange portion of the welding pin 76 and the lower panel 2.

Sheet metals of equal or different composition, e.g. steel with brass or copper, steel with aluminum or brass with copper may be connected, etc. and likewise sheet metals of widely different thicknesses. A requirement consists in that owing to appropriate dimensioning of the contact pins or the like, in accordance with the composition of the metal, the resistance of transition between the sheet metals is so high that the welding current is forced substantially to jump the air gap originally determined by the welding pin in the form of an electric arc and thus superficially to melt the milled surfaces.

Further relief of the outer coatings may be attained by displacement of the flow of current by the aid of capacitor plates. In the embodiment of FIG. 36 an upper panel 1 with the coatings 1*a*, 1*b* has on its underside a milled recess 1*f* with a welding pin 1*g* left standing therein, and a lower panel 2 with the coatings 2*a*, 2*b* has a stripped zone 2*c* on top, panel 1 serving as a holder panel, and panel 2 as a lining. The panel 2 is connected, e.g. by an adhesive, to a thin decorative panel 3 with coatings 3*a*, 3*b*. At least one capacitor foil 31*c* is inserted between the panels 1 and 2 and above the panel 1 as well as underneath the panel 3 a capacitor plate 31*a*, 31*b*, respectively, is arranged. The lower capacitor plate 31*b* rests on a table 11. On top of the upper capacitor plate 31*a* a welding device 71 is placed, which comprises a presser punch 72 guided in an insulating tube 73 mounted on a tripod 74. A spring 72*c* engages in a bore 72*a* of the presser punch. The presser punch can pass through a bore 31*d* of the upper capacitor plate 31*a* and bear on the upper panel 1. In order to bring the welding pin 1*g* into the correct distance from the blank sheet metal surface 2*p*, the sheet metal 1 is provided at the welding zone with a downward depression 1*k*. The sheet metal 1 is connected to a capacitor pulse welding plant and the sheet metal 2 is earthed. The capacitor plates are connected to one pole of a voltage source and the capacitor foil 31*c* interposed in the middle between them to the other pole thereof. Firstly the voltage source for the capacitor plates is to be switched on, whereby electric fields are built up from the outer capacitor plates towards the capacitor foil lying in the middle between them. When switching on the welding current, the same is displaced from the outsides of the panels 1 and 2 towards their insides, and is directed, reinforced, on to the blank areas 1*p*, 2*p*. At the same time the presser punch 72 is released, the same jerks from outside against the sheet metal 1, having the welding pin 1*g* on the underside, effects the igniting of the electric arcs, and welds the blank sheet metal surfaces 1*p*, 2*p* to one another. The outer coatings of the panels 1 and 2, and in any case the outer coating 3*b* of the panel 3 thus remain undamaged.

Shortening of the welding period and/or reduction of the energy required for the welding may be attained also by prewarming the holder panel. In the embodiment of FIG. 37 an upper holder panel 1 with coatings 1*a*, 1*b* has on top a stripped zone 1*c*, and on its underside a stripped zone 1*d*, and a decorative panel 2 with coatings 2*a*, 2*b* lying underneath has on top a stripped zone 2*c*. This panel rests on a table 11 through a cooling plate 10. On the panel 1 a welding device 71 is placed, which comprises an electrode 5 guided vertically slidably in an insulating tube 73 mounted on a tripod 74. The electrode is biased by a spring 5*f* engaging in a blind bore 5*e* thereof. One pole of a secondary circuit S of a prewarming plant is connected by a cable 7*a* through a regulating resistor 8 to the sheet metal 1, and if desired by a cable 7*b*, likewise through a regulating resistor 8, to the sheet metal 2, the other pole of it being connected to the electrode 5 by a cable 4. Moreover, one pole of a capacitor pulse welding plant K is connected by a cable 4*K* to the electrode 5, and the other pole thereof is connected to the sheet metal 2 by a cable 7*k*. A switch 111 is pivotable about a pivot 111*a* into a left-hand side end position for switching on the prewarming plant, and into a right-hand side end position for switching on the welding plant. When switching on the prewarming plant, the current flows through the electrode 5 loosely resting on the sheet metal 1 into the latter, and from there back through the cable 7*a*. The switch 111 is reversed by a time control so as to switch on the welding current. Thereby the spring 5*f* is released, the blank sheet metal surfaces 1*p*, 2*p* are made to approach each other, the electric arcs are ignited, and welding is performed

under the pressure of said spring. The prewarming of the panel 1 facilitates the downward deformation of its sheet metal. The outer coating 2*b* of the panel 2 thus remains undamaged.

For increasing the welding pressure of manually operated appliances, the welding device may be built into a vacuum bell. At the same time the vacuum reduces the resistance of transition and increases the lifetime of the electrode. In FIG. 38 an upper panel 1 with coatings 1*a*, 1*b* has a stripped zone 1*c* on top and a stripped zone 1*d* on its under side, and a lower panel 2 with the coatings 2*a*, 2*b* has on top a stripped zone 2*c*. 141*a* transparent vacuum bell 141 is placed with a high resilient seal 141*a* on to the upper panel, and is connected through a valve 145 to a source of vacuum. In the interior of the vacuum bell there are arranged an upper flange 141*b* and a lower flange 141*c*, each with air passage bores 148, which flanges hold an electrode guide 147. The upper portion 147*a* of said guide serves at the same time as an abutment for a compression spring 5*f* which biases the electrode 5 through an adjustment nut 5*i*. An upper extension of 141*d* encloses the vacuum bell, a switch 150 and the current supply and control cables 149*a*, 149*b*. For the welding operation the electrode and vacuum bell are to be placed over the welding zone, if desired with the aid of a template, and the bell is evacuated. Thereby the seal 141*a* is compressed, and the electrode 5 is pressed on to the stripped zone of the panel 1. When switching on the welding current, electric arcs are ignited between the blank sheet metal surfaces 1*p*,2*p*, and the same are welded to one another by the pressure of the electrode. The outer coating 2*b* of the panel 2 thus remains undamaged.

Instead of pressing the welding electrodes or presser punch, which does not carry current, on to the panel by the vacuum bell, electromagnets may be provided, which when energized adhere to the sheet metal to be welded and load the spring of the electrode.

Alternatively the welding appliance may be held by electromagnets on the sheet metal panel. These electromagnets may form the legs of a tripod. The electrode or the presser punch may be pressed on to the welding zone by compressed air or by another electromagnet instead of by a spring.

Such vacuum bells are suitable also for the housing of milling devices, drilling devices, presser devices, punching devices, frame arrangements and the like in any local arrangement desired on the coated surfaces.

The igniting of the electrical arcs may be alternatively affected by temporarily lifting off the upper panel by the aid of an automatic mechanism as used in pin welding appliances. For this purpose firstly a lifter pin is welded on top of the upper sheet metal panel. In FIG. 39 an upper sheet metal panel 1 with coatings 1*a*, 1*b* is provided on top with a stripped zone 1*c* and on the underside with a longer stripped zone 1*d*, and with a downwardly directed depression 1*k* on the welding zone the height of which depression slightly exceeds twice the thickness of a coating. Within the stripped area a lifter pin 131 which has notches 131*a* is welded to the sheet metal 1. The welding zone of the prepared panel 1 is placed on the stripped zone 2*c* of a second panel 2 having coatings 2*a*, 2*b*, which rests on a cooling plate 10 having a recess 10*c* and coolant supply and drain pipes 10*a* and 10*b*, respectively. Between the sheet metals 1,2 a ring 132 of a high melting point material is placed around the welding area for damming up the melt. For melting, a bolt welding appliance (not shown) similar to FIG. 35 is to be put on, and the lifter pin is to be clamped therein. When switching on the current, the panel 1 is raised by the automatic lifting mechanism e.g. by an electromagnet, whereby the electric arcs are ignited; by switching off the current in the next moment the panel 1 is released, the blank sheet metal areas 1*p*, 2*p* are pressed against and welded to each other. Subsequently the lifter pin is broken off at its notches.

When using coated sheet metal panels for outdoor use e.g. for the lining of the facades of buildings or for vehicles, the welding zone has to be protected from corrosion. For this purpose the sheet metal panels may be provided with adhesive around the welding zone, or may be cemented to each other by the interposition of rings, self-adhesive on both surfaces, or of perforated margin strips. The most economic way is the use of an interposed foil, self-adhesive on both surfaces, and provided with a protective paper for the stripping of the coating. After the stripping, the protective paper is pulled off, the second panel is superimposed with its prepared welding zone, and welding is carried out.

In the example of FIG. 40 a self-adhesive foil 165 is stuck on a lower panel 2 having coatings 2*a*, 2*b*, which foil has a protective paper 165*a* on top. The stripping of the upper coating 2*a* is carried out by means of a milling machine 161 comprising a chuck casing 161*a*, p57p161*b*, a chuck 161*b*, a compression spring 161*c* and spring-biased ball detent 161*d*, which keeps the inserted milling cutter 162 in position, which cutter has a flattened end 162*a* engaging in the chuck 161*b*. Around the lower portion of the chuck 161*b* a tube 164 having an annular cutting edge is arranged slidably and coupled to said chuck for rotation by means of a transverse pin, and is axially biased by a compression spring 163. When pressing down the milling machine 161, the layers 165*a*, 165 and 2*a* are firstly severed by the annular cutting edge of the tube 164 and then stripped by the milling cutter 162, the protective paper 165*a* preventing the adhesive layer from sticking to the milling cutter 162. The stripped zone 2*c* thus formed has a blank metal surface 2*p*. Subsequently an upper sheet metal panel 1 is superimposed having coatings 1*a*, 1*b* and a welding zone prepared e.g. for arc welding, which zone may consist in a welding pin 1*g* left standing in a milled recess 1*f*. After an indirect connection of both sheet metal panels to the secondary circuit of a welding plant and switching on the current, electric arcs are ignited by the aid of the presser punch 72 and of the welding pin 1*g*, and the blank areas 1*p*, 2*p* of the sheet metal panels are welded to each other. The outer coatings 1*a*, 2*b* thus remain undamaged.

Pins, points, straight or circular webs having sharp edges and the like may be produced, instead of by milling, by pressing, stamping, embossing, punching or the like.

The deformation of the welding areas thus prepared may be effected by the pressure of an electrode or of presser punches, which do not carry current, either immediately while welding or previously, before or after the formation of the pins, points, webs or the like.

Particularly when welding panels consisting of different sheet metals to each other these metals are preferably to be alloyed with other metals in such a manner that an optimum results of physical properties, particularly of strength. The same applies when using inserts.

Electrical currents of any kind, particularly the discharge currents of capacitors may be used e.g. those generated by capacitor pulse machines.

I claim:

1. A method for the connection of sheet metal panels coated on at least one surface with an insulating layer by the electrical fusion of a metal, said sheet metal panels having peripheral edges being uncoated throughout a portion of its edge surface, at least one of said insulating layers being an outer insulating layer, wherein the improvement comprises the steps of removing a portion of said outer insulating layer forming an exposed zone, supplying an electric current through a welding electrode placed essentially adjacent an area of said portion of said outer insulating layer for the fusion of metal essentially parallel to the surface of the sheet metal from a point on said edge surface and providing a return path through said electrode, and keeping the temperature of said outer insulating layer of at least one of said panels below the melting point of said layer.

2. A method as claimed in claim 1, comprising the step of subjecting the zones, at which said panels are to be connected to each other, to vibration.

3. A method as claimed in claim 1, comprising the step of cooling the coating of the surface of at least one of said panels which does not contact another of said panels.

4. A method as claimed in claim 1, comprising the step of melting the metal by electrical resistance welding.

5. A method as claimed in claim 1 wherein an insulating layer is interposed between the contacting surfaces of the metal sheets and comprising the steps of stripping zones at opposite surfaces of sheet metal panels of said insulating coating, temporarily superficially melting said zones by electric arc discharges, and pressing said superficially melted zones against each other for metallic connection thereof.

6. A method as claimed in claim 1, comprising the step of melting the metal by the current of a capacitor pulse discharge.

7. A method according to claim 1, comprising the step of reducing the contact zone and thereby increasing the transfer resistance of the electrical current from one of said panels (1, 2) to the other.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,614,375 Dated October 19, 1971

Inventor(s) OTTO ALFRED BECKER

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 15: "s" should read -- r --;
column 17, line 11: "141 a" should read -- A --;
column 18, line 12: "p57pl61b" should be cancelled.

Signed and sealed this 5th day of December 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents