

SPECIFICATION

Terminal Attached Electrode Foil and Device and Method for Producing the Terminal Attached Electrode Foil

Background of the Invention

Field of the Invention:

The present invention relates to a terminal attached electrode foil and a device and a method for producing the terminal attached electrode foil which comprises a lead attached terminal having a tab and an electrode metal foil, the tab being superposed on a hole formed at the electrode foil and fixedly connected to the electrode foil by a method for moving down a piercing needle from the upper side of the tab to pierce through the tab and the hole of the electrode foil to form the fins of the tab at the under side of the electrode foil, the fins and the tab being pressed against the electrode foil.

Description of the Related Art:

According to the prior art, as shown in Fig. 21, the electrolytic condenser has a lead attached terminal fixed thereto. The electrolytic condenser includes a positive etching aluminum foil of purity about 99.9%, 60 to 100 μm thickness, the positive electrode foil having an oxidized film formed at the surface thereof, a negative etching aluminum electrode foil of 40 to 60 μm thickness and an electrolytic paper, the positive electrode foil, the negative electrode foil and the electrolytic paper being superposed one after another and wound up into a cylinder.

In Figs. 21 through 25, the lead attached terminal 2 is generally produced by welding a tab 2a of aluminum to a lead member 2a, pressing the tab 2a into a flat plate and trimming the periphery of the flat tab into an optional shape. The lead

attached terminal 2 is fixedly connected to the aluminum foil 1 by way of a piercing process. Precisely, the tab 2b of the lead attached terminal 2 is superposed on the aluminum foil 1 placed on a work table as shown in Fig. 25(a) and is fixedly held by a holder 4 as shown in Fig. 25(b) and a piercing needle 5 of a point portion which is square in horizontal section is moved down to pierce through the tab 2b and the aluminum foil 1 as shown in Fig. 25(c) so as to form the fins 1a and 2c of the aluminum foil 1 and the tab 2b respectively at the under side of the aluminum foil 1 and then the fins 1a and 2c are fixed to the lower side of metal portion of the aluminum foil 1 as are pressed in the directions as indicated by arrows R and S as shown in Figs. 22 and 23.

In Figs. 22 through 24, according to the conventional method of piercing process, the fins 1a of the aluminum foil 1 and the fins 2c of the tab 2b are formed under the aluminum foil 1 in a double structure that the fins 2c of the tab 2b are formed at the outside of the fins 1a of the aluminum foil 1. Here, it must be pointed out that the aluminum foil 1 and tab 2b are required to come in mechanically fixed connect with each other with the electrical conductive resistance being remarkably reduced and with the variations of conductive resistance being reduced to minimum, which are important elements directly influencing the quality of the electrolytic condenser, especially for an extremely small electrolytic condenser of extremely weak electric current.

In order to reduce the electric conductive resistance of the aluminum foil 1 and tab 2b, it is required that the aluminum foil 1 and the tab 2b are in direct contact with each other. However, according to the conventional piercing method, the fins 1a of aluminum foil 1 are formed while the surface of formation film remains as it is and the fins 2c of the tab 2b are formed as embracing the fins 1a of the aluminum foil 1 as shown in Fig. 23. The tab 2b is, therefore, in contact with the aluminum foil 1 with the formation film intervening between the tab 2b and the aluminum foil 1. As the result, the electric

conductive resistance will be 1.9 m Ω to 2.2 m Ω , the values being not sufficient for reduction of the electric conductive resistance.

On the other hand, the formation film of the aluminum foil 1 may be partly broken by formation of the fins 2c of tab 2b in the piercing process, and the film broken part or parts may come in direct contact with the metal portion of the aluminum foil 1 for better inclination of resistance reduction. However, according to the conventional piercing method, it is almost impossible to control to obtain a desirable contact area between the fins and the metal portion of the aluminum foil 1. As the result, the variations will not be avoided in electric conductive resistance.

Further, the demand of an extremely small electrolytic condenser has been increased in the recent years, wherein an electrode foil of 1 mm width is employed. In this case, the electrode foil may be easily broken, but so much reduction of electric conductive resistance and of variation thereof is required. Further according to the conventional piercing method, a two-point piercing process is required to obtain mechanical strength. It is, however, impossible to make a two-point piercing process at the small electrode foil of 1 mm width. It is, therefore, unavoidable to take a one-point piercing process to obtain a sufficient conductive area. Since a sufficient conductive area can not be obtained by way of the conventional one-point piercing method as mentioned above, it has been impossible to satisfy the demand of an extremely small electrolytic condenser of extremely small width and of 4 mm height or less.

Further, since the aluminum foil 1 is forcibly broken at the time of piercing process, a crack may be produced at the aluminum foil 1 and may cause the aluminum foil 1 to be torn off.

Objects of the Invention:

The invention has been provided to eliminate the defects

and disadvantages of the prior art. It is, therefore, a primary object of the invention to produce an extremely small electrolytic condenser, wherein a tab of a lead attached terminal is superposed on a hole formed at an electrode foil which has a formation film treated at the surface and a piercing needle is moved down from the upper side of the tab to pierce through the tab and the hole of the electrode foil to form the fins of tab at the under side of the electrode foil without formation of the fins of the electrode foil for the purpose of fixedly connect the metal portion of electrode foil and the lead attached terminal in direct contact with each other.

It is another object of the invention to reduce the electric conductive resistance of the electrode foil and the tab and simultaneously reduce the variations of the electric conductive resistance with a sufficient conductive area obtained by means of one-point piercing process at an electrode foil of extremely small width, for example, of 1 mm.

It is another object of the invention to produce a smallest electrolytic condenser of 5 mm height or less, precisely of 3.25 mm height with a base plate included, which is smallest in the world.

It is another object of the invention to produce an extremely small electrolytic condenser, wherein a tab of a lead attached terminal is superposed on a square hole formed at an electrode foil which has a formation film treated at the surface thereof, the square hole having four corners oriented in the longitudinal and lateral directions of the electrode foil respectively and a piercing needle which is square in horizontal section is moved down from the upper side of the tab to pierce through the tab and the square hole of the electrode foil with the corners of the piercing needle being in agreement with the corners of the square hole respectively, thereby to form the fins of tab at the under side of the electrode foil without formation of the fins of the electrode foil for the purpose of fixedly connect the metal portion of electrode foil and the lead attached terminal in direct contact with each other by way of a pressing process

without generation of damage at the electrode foil.

It is another object of the invention to produce an extremely small electrolytic condenser of extremely weak electric current by means of the one-point piercing process as mentioned above.

It is another object of the invention to produce a terminal attached electrode foil of reduced electric resistance by use of a device, the device comprising a press mold including a die having a die hole and arranged on one side of the electrode foil and a punch arranged on the opposite side of the electrode foil and movable into and out of the die hole to form a hole at the electrode foil, a mechanism for supplying a lead attached terminal to the electrode foil such that a tab of the lead attached terminal may be superposed on the hole of the electrode foil and a piercing needle for piercing through the tab and the hole from the upper side of the tab.

Summary of the Invention:

According to a first aspect of the present invention, there is provided a method for producing a terminal attached electrode foil comprising the steps of: forming a hole at an electrode foil which has a formation film treated at the surface thereof; superposing a tab of a lead attached terminal on said hole of the electrode foil; operating a piercing needle to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other, wherein said hole formed at said electrode foil prevents fins of said electrode foil from being formed at the time of said piercing step.

According to a second aspect of the present invention, there is provided a method for producing a terminal attached electrode foil comprising the steps of: pulling out an electrode foil from a reel having said electrode foil wound therearound, said electrode foil having a formation film treated at the surface thereof; forming a square hole at said

electrode foil, said square hole having four corners oriented in the longitudinal and lateral directions of said electrode foil respectively; superposing a tab of a lead attached terminal on said square hole of the electrode foil; operating a piercing needle to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other, wherein said piercing needle is square in horizontal section having four corners which are put into agreement with the four corners of said square hole of said electrode foil at the time of said piercing step and wherein said electrode and said tab of the lead attached terminal are fixed to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof.

According to a third aspect of the present invention, there is provided a terminal attached electrode foil comprising an electrode foil which has a formation film treated at the surface thereof and has a hole formed thereat; a lead attached terminal having a tab superposed on said hole of the electrode foil and fixedly connected to the electrode foil; wherein said electrode foil and said lead attached terminal are fixedly connected by means of a piercing needle operated to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof.

According to a fourth aspect of the present invention, there is provided a terminal attached electrode foil comprising an electrode foil which has a formation film treated at the surface thereof and is wound around a reel to be pulled out therefrom, said electrode foil having a square

hole formed thereat, said square hole having four corners oriented in the longitudinal and lateral directions of said electrode foil respectively; a lead attached terminal having a tab superposed on said square hole of the electrode foil and fixedly connected to the electrode foil; wherein said electrode foil and said lead attached terminal are fixedly connected by means of a piercing needle having a square shape of four corners in horizontal section, said piercing needle being operated to pierce through said tab and said square hole from a vertically upper side of said tab in the condition that the four corners of said piercing needle are put into agreement with the four corners of said electrode foil respectively, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof.

According to a fifth aspect of the present invention, there is provided an electrolytic condenser comprising an electrode foil which has a formation film treated at the surface thereof and has a hole formed thereat; a lead attached terminal having a tab superposed on said hole of the electrode foil and fixedly connected to the electrode foil; wherein said electrode foil and said lead attached terminal are fixedly connected by means of a piercing needle operated to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof, thereby to form a terminal attached electrode foil which is to be used on the positive and negative sides of electrolytic condenser respectively.

According to a sixth aspect of the present invention, there is provided a device for producing a terminal attached electrode foil comprising a press means including a die having

a die hole formed thereat and located on one side of an electrode foil which has a formation film treated at the surface thereof and is wound around a reel to be pulled out therefrom and a punch located on the opposite side of said electrode foil, said punch being moved into said die hole of said die to form a hole at said electrode foil in cooperation with said die; a means for supplying a lead attached terminal onto said electrode foil in the condition that a tab of said lead attached terminal is superposed on said hole of said electrode foil in agreement therewith; a piercing means including a piercing needle operated to move piercing through said tab and said hole of said electrode foil, said piercing needle being moved from a vertically upper side of said tab to form fins of said tab on the opposite side of said electrode foil so as to fixedly connect said electrode foil and said lead attached terminal to each other.

Brief Description of the Drawings:

Figs. 1 through 20 relate to the embodiments of the invention, wherein,

Fig. 1 is a perspective view of a terminal attached electrode foil of the invention.

Fig. 2 is an exploded perspective view of the terminal attached electrode foil, wherein (a) is a perspective view of a lead attached terminal and (b) is a perspective view of an electrode foil wound around a reel.

Fig. 3 is a front elevational view of a device for producing the terminal attached electrode foil of the invention.

Fig. 4 is a front elevational view of the device for producing the terminal attached electrode foil, shown in an initial condition of operation.

Fig. 5 is a front elevational view of the device for producing the terminal attached electrode foil, wherein a press mold is operated to form a square hole at the electrode foil.

Fig. 6 is a front elevational view of the device for producing the terminal attached electrode foil, wherein a die and a punch are moved away from the electrode foil after the square hole is formed at the electrode foil.

Fig. 7 is a front elevational view of the device for producing the terminal attached electrode foil, wherein a foil holder is moved down to fixedly hold the electrode foil while the lead attached terminal is supplied.

Fig. 8 is a front elevational view of the device for producing the terminal attached electrode foil, wherein a piercing needle is moved down to carry out a piercing process.

Figs. 9 through 18 relate to the processes for attaching the lead attached terminal to the electrode foil, wherein

Fig. 9 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein the

electrode foil is supplied to between the die and the punch.

Fig. 10 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein the die is moved down to clamp the electrode foil in cooperation with a work table.

Fig. 11 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein the punch is moved up into a die hole of the die to form the square hole at the electrode foil.

Fig. 12 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein (a) shows the die and the punch moving away from the electrode foil after the square hole is formed at the electrode foil and (b) is a plan elevational view of the electrode foil having the square hole formed thereat.

Fig. 13 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein the lead attached terminal having a tab is supplied to the electrode foil while the tab is placed in agreement with the square hole of the electrode foil.

Fig. 14 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein the die is moved down again to clamp the tab and the electrode foil in cooperation with the work table.

Fig. 15 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for producing the terminal attached electrode foil, wherein the piercing needle is moved down to pierce the tab to form the fins of tab at the lower side of the electrode foil.

Fig. 16 is an enlarged front elevational view, shown partly in vertical section, of the essential parts of the device for

producing the terminal attached electrode foil, wherein the piercing needle and the die are moved up after the piercing process.

Fig. 17 is an enlarged front elevational view, shown in vertical section, of the tab and the electrode foil, wherein the fins of tab are formed at the lower side of the electrode foil.

Fig. 18 is an enlarged front elevational view, shown in vertical section, of the tab and the electrode foil, wherein the fins of tab are pressed against the lower side of the electrode foil and the tab is fixedly connected to the electrode foil.

Fig. 19 is an enlarged plan elevational view of the terminal attached electrode foil.

Fig. 20 is an enlarged perspective view of the terminal attached electrode foil.

Figs. 21 through 25 relate to a prior art, wherein

Fig. 21 is a perspective view showing a piercing needle moving down to pierce through a tab of a lead attached terminal and through an electrode foil on which the tab is placed.

Fig. 22 is an enlarged front elevational view shown in vertical section of the tab and the electrode foil, wherein the fins of tab and electrode foil are formed at the lower side of the electrode foil by the piercing process, the fins of electrode foil being larger than the fins of tab.

Fig. 23 is an enlarged front elevational view shown in vertical section of the tab and the electrode foil, wherein the fins of tab and electrode foil are pressed against the lower side of the electrode foil to fixedly connect the lead attached terminal to the electrode foil, the fins of tab being in contact with the electrode foil through the larger fins of electrode foil.

Fig. 24 is an enlarged plan elevational view of the terminal attached electrode foil showing the fins of electrode foil extending beyond the extension area of the fins of tab.

Fig. 25 relates to the processes for fixedly connect the lead attached terminal to the electrode foil, wherein

(a) is an enlarged front elevational view of the essential parts of the invention shown in vertical section, wherein the tab and the electrode foil are supplied to the predetermined positions respectively.

(b) is an enlarged front elevational view of the essential parts of the invention shown partly in vertical section, wherein the die is moved down to clamp the tab and the electrode foil in cooperation with a work table while the piercing needle is moved down.

(c) is an enlarged front elevational view of the essential parts of the invention shown partly in vertical section, wherein the piercing needle is moved down to pierce the tab and the electrode foil to form the fins of the tab and electrode foil at the lower side of the electrode foil.

Detailed Description of the Preferred Embodiments:

The invention will be described in detail in reference to the embodiments as shown in the attached drawings. In Figs. 1, 2 and 3, a device 10 is used to produce an electrode foil having a terminal. The device 10 is operated to pierce a tab 14b of a terminal 14 having a lead, the tab 14b being placed on an electrode foil 13 which is etching treated and has a formation film treated at the surface thereof, to form fins of the tab 14 at the rear side of the electrode foil 13, thereby to fix the electrode foil 13 and the terminal 14 to each other. For attaining such an object, the device is provided with a press mold 11, a mechanism (not shown) for supplying the terminals, each of which having a lead and a needle 12 for piercing the tab 14b of the terminal 14 and the electrode foil 13 as shown in Figs. 3 through 8.

The press mold 11 is provided to form, for example, a square hole 13a at the electrode foil 13, the square hole 13a having four corners 13b being oriented in the longitudinal and lateral directions of the electrode foil 13 as particularly shown in Fig. 12(b). As shown in Fig. 3, the press mold 11 is composed of a die 18 and a punch 19, the die 18 being positioned above

the electrode foil 13 which is drawn out from a reel 17 and supplied as guided by guide rollers 16 and the punch 19 being positioned below the electrode foil 13.

The die 18 is fixed to a die holder which is in engagement with a base 27 and may be vertically movable in the directions indicated by arrows B and E as shown in Figs. 5 and 6 respectively. As shown in Fig. 3, a cam follower 22 is arranged through rod ends 21 in connection with the die holder 20. The cam follower 22 may be pressed down by a cam device (not shown) to move the die holder 20 in the directions indicated by arrows B and E, such that the die 18 may press the electrode foil 13 against a work table 23 of the electrode foil producing device 10. The die 18 is formed with a square die hole 18a for forming the square hole 13a at the electrode foil 13.

The punch 19 includes a pin having a free end of a same shape in section with the square die hole 18a so as to punch out the square hole 13a in cooperation with the square die hole 18a and is positioned as opposite to the square die hole 18a. The punch 19 is fixed to a punch holder 24 and may be slidably move through a punch guide 25 in vertical directions as indicated by arrows C and F as shown in Figs 5 and 6 respectively. The punch 19 may be moved into the square die hole 18a to punch out the square hole 13a at the electrode foil 13, the square hole 13a having four corners 13b being oriented in the longitudinal and lateral directions of the electrode foil 13.

A mechanism (not shown) for supplying the lead attached terminals is provided to supply the lead attached terminal 14, as shown in Figs. 19 and 20, in such a manner as to place the tab 14b of the terminal 14 on the electrode foil 13 in conformity with the square hole 13a of electrode foil 13, the lead attached terminal 14 including a lead member 14a having the tab 14b of aluminum welded thereto. The terminal supplying mechanism is of a generally known mechanism which is composed of a first device (not shown) for transporting the lead attached terminals 14 in alignment with one another in a predetermined direction and a second device (not shown) for receiving the lead attached

terminals 14 from the first transporting device and for transporting the lead attached terminals 14 while the terminals 14 are placed in agreement with the square holes 13a of the electrode foil 13.

As shown in Fig. 3, above the punch guide 25, a foil presser 28 is arranged as is fixed to a foil presser holder 29 which is in engagement with the base 27 so as to be vertically movable. A cam follower 30 is arranged at the top of the foil presser holder 29. The cam follower 30 may be moved in the direction indicated by arrow H by a cam device as shown in Fig. 7, thereby to hold the electrode foil 13 in cooperation with the punch guide 25.

The piercing needle 12 is provided to give a piercing processing to the tab 14b of the lead attached terminal 14 so as to fix the terminal 14 to the electrode foil 13. Further in reference to Fig. 14, the piercing needle 12 is a needle or pin having a distal end 12a which is of a four-cornered gimlet and is fixedly held by a needle holder 31 so as to be vertically moved through and out of the square die hole 18a of the die 18. The needle holder 31 is in engagement with the base 27 so as to be vertically moved in the direction indicated by arrow J in Fig. 8 by way of a cam follower 32 arranged on the top of the needle holder 31, the cam follower 32 being operated by a cam device (not shown). Thus the piercing needle 12 is moved down in the direction indicated by arrow L to give a piercing process to the tab 14b of the lead attached terminal 14.

A terminal attached electrode foil 15 produced by use of the device 10 for producing the terminal attached electrode foil comprises the electrode foil 13 and the lead attached terminal 14 which are formed in one body as shown in Figs. 19 and 20, the lead attached terminal 14 including the tab 14b superposed on the upper side of the electrode foil 13 in such a manner that the tab 14b comes into agreement with the square hole 13a formed at the electrode foil 13, the tab 14a being pierced through by means of the piercing needle 12 which is moved down to pierce through the tab 14a and through the square

hole 13a as shown in Fig. 5 to form fins 14c of the tab 14b at the lower side of the electrode foil 13, the fins 14c being pressed against the lower side of the electrode foil 13.

A method for producing the terminal attached electrode foil 15 substantially comprises the steps of: forming a hole 13a at the electrode foil 13 which has a formation film treated at the surface thereof; superposing the tab 14b of the lead attached terminal 14 on the hole 13a of the electrode foil 13; piercing through the tab 14b and through the hole 13a from the upper side of the tab 14b by means of the piercing needle to form the fins 14c of the tab 14b at the lower side of the electrode foil 13 so as to fix the tab 14b of the lead attached terminal 14 to the electrode foil 13, wherein fins will not be produced from the electrode foil 13 due to presence of the hole 13a at the electrode foil 13.

Another aspect of the method for producing the terminal attached electrode foil 15 substantially comprises the steps of: pulling out the electrode foil 13 from a reel 17, the electrode foil 13 having a formation film treated at the surface thereof and wound around the reel 17; forming a square hole 13a at the electrode foil 13, the square hole 13a having four corners 13b oriented in the longitudinal and lateral directions of the electrode foil 13 respectively; superposing the tab 14b of the lead attached terminal 14 on the square hole 13a of the electrode foil 13; piercing through the tab 14b and through the square hole 13a from the upper side of the tab 14b by means of the piercing needle to form the fins 14c of the tab 14b at the lower side of the electrode foil 13 so as to fix the tab 14b of the lead attached terminal 14 to the electrode foil 13 by pressing the fins 14c against the lower side of the electrode foil 13, the piercing needle 12 being square in horizontal section and having four corners, the piercing needle 12 piercing the tab 14b and the square hole 13a while the four corners of the piercing needle 12 are in agreement with the four corners 13b of the square hole 13a of the electrode foil 13 respectively.

The invention comprises the elements as mentioned above.

The steps or processes for fixedly connecting the tab 14b of the lead attached terminal 14 to the electrode foil 13 will be described in detail in reference to Figs. 4 through 16. Now in Figs. 4 and 9, the electrode foil 13, which has a formation film treated at the surface thereof, is pulled out from the reel 17 as is guided by guide rollers 16 and is arranged between the die 18 and the punch guide 25.

In Figs. 5, 10 and 15, the cam follower 22 is pressed down by a cam device (not shown) in the direction indicated by arrow A, thereby to move down the die holder 20 in the direction as indicated by arrow B. The die 18 held by the die holder 20 is, therefore, moved down to clamp the electrode foil 13 with the lower punch guide 25, the electrode foil 13 being, for example, 1 mm wide. Subsequently the punch holder 24 is moved up in the direction as indicated by arrow C, thereby to move up the punch 19 into the square die hole 18a of the die 18 to form the square hole 13 at the electrode foil 13.

In Figs. 6 and 12, as the die holder 20 is moved in the direction as indicated by arrow D, thereby to move up the die 18 while the punch 19 is moved down in the direction as indicated by arrow E, the electrode foil 13 will have the square hole 13a formed thereat, the square hole 13a having the four corners oriented in the longitudinal and lateral directions of the electrode foil 13 respectively. In this case, the square hole 13a has extremely small fins 13c formed as upstanding at the periphery thereof while the end surface of the square hole 13a has the material of aluminum exposed thereat. The residues (not shown) which may be produced at the time of punching out the square hole 13 will remain in the square die hole 18a of the die 18. The residues will, however, be pushed out of the square die hole 18a by the piercing needle 12 as the die 18 is moved up in the direction as indicated by arrow F.

In Figs. 7 and 13, the cam follower 31 is pressed down by the cam device (not shown) to be moved down in the direction as indicated by arrow H, thereby to move down the foil presser 28 and to hold the electrode foil 13 in position. Subsequently

the lead attached terminal 14 is transported in the direction as indicated by arrow G by a terminal transporting mechanism (not shown) in such a manner that the tab 14b may come into agreement with the square hole 13a of the electrode foil 13.

Subsequently in reference to Figs. 8, 14 and 15, the cam follower 21 is moved in the direction as indicated by arrow I while the cam follower 32 is pressed down in the direction as indicated by arrow J, thereby to move down the die 18 in the direction as indicated by arrow K so that the die 18 may press the tab 14b of the lead attached terminal 14 against the square hole 13a of the electrode foil 13. Subsequently the piercing needle 12 is moved down in the direction as indicated by arrow L such that the point of the needle square corners may pierce through the tab 14b and through the square hole 13a of the electrode foil 13 and such that the fins 14c of the tab 14b may be formed below the lower side of the electrode foil 13 as shown in Fig. 15. Subsequently as shown in Fig. 16, the piercing needle 12 and the die 18 are moved up in the direction as indicated by arrows M and N respectively.

In Fig. 17, since the square hole 13a is formed beforehand at the electrode foil 13, the fins will not be produced from the electrode foil 13 at the time of piercing process by means of the piercing needle 12. Further, since the aluminum material of the electrode foil 13 is exposed at the inner periphery of the square hole 13c and is directly in contact with the fins 14c of the tab 14b, the electric conduction resistance is extremely little between the electrode foil 13 and the tab 14b. Further as shown in Fig. 18, the tab 14b is connected to the electrode foil 13 with the pressure applied thereto in the opposite directions as indicated by arrows O and P, the electrode foil 13 being clamped between the tab 14b and the fins 14c of the tab 14b. In this case, the electric conduction resistance is further reduced. Thus, the terminal attached electrode foil 15 may be produced in the condition that the electrode foil 13 and the tab 14b are mechanically connected to each other with increased force by way of one-point piercing process as

shown in Figs. 19 and 20.

Example 1

20 pieces of terminal attached electrode foils were made up, wherein the aluminum electrode foil was of 1.08 mm, 80 μm thick and type 80 LJ (44FV) and the tab of lead attached terminal was of 0.18 mm thick, the square hole of the electrode foil was formed by use of a punch of 0.43 mm square, one-point piercing process was carried out by use of a piercing needle of 0.43 mm ϕ diameter and the tab and the fins thereof were pressed so the diagonal lines might be about 0.79 mm long. Those pieces of terminal attached electrode foils were measured as to the electric conductive resistance between the electrode foil and the lead attached terminal. The measured results were 1.37 m Ω as an average value, 1.49 m Ω as a maximum value and 1.28 m Ω as a minimum value.

Example 2

17 pieces of terminal attached electrode foils were made up, wherein the aluminum electrode foil was of 1.08 mm, 80 μm thick and type 80 LJ (12.5 FV) and the tab of lead attached terminal was of 0.18 mm thick, the square hole of the electrode foil was formed by use of a punch of 0.43 mm square, one-point piercing process was carried out by use of a piercing needle of 0.43 mm ϕ diameter and the tab and the fins thereof were pressed so the diagonal lines might be about 0.82 mm long. Those pieces of terminal attached electrode foils were measured as to the electric conductive resistance between the electrode foil and the lead attached terminal. The measured results were 1.19 m Ω as an average value, 1.32 m Ω as a maximum value and 1.14 m Ω as a minimum value.

Example 3

20 pieces of terminal attached electrode foils were made up, wherein the aluminum electrode foil was of 1.08 mm, 100 μm thick and type A06S and the tab of lead attached terminal

was of 0.18 mm thick, the square hole of the electrode foil was formed by use of a punch of 0.43 mm square, one-point piercing process was carried out by use of a piercing needle of 0.43 mm ϕ diameter and the tab and the fins thereof were pressed so the diagonal lines might be about 0.86 mm long. Those pieces of terminal attached electrode foils were measured as to the electric conductive resistance between the electrode foil and the lead attached terminal. The measured results were 1.14 m Ω as an average value, 1.38 m Ω as a maximum value and 0.99 m Ω as a minimum value.

Example 4

The Table 1 shows a comparison between the connecting resistance in the connecting method by way of piercing and pressing processes of the invention and the connecting resistance in the conventional connecting method, wherein 3 types of electrode foils were used for one-point connection, namely, an electrode foil of high magnification etching aluminum of formation voltage 8 V, an electrode foil of high magnification etching aluminum of formation voltage 50 V and an electrode foil of high magnification etching aluminum of formation voltage 68 V.

Table 1

Initial connecting resistance n = 20 (Unit m Ω)						
	Formation voltage 8V		Formation voltage 50V		Formation voltage 68V	
	Inven.	Conven.	Inven.	Conven.	Inven.	Conven.
Max	1.25	2.19	1.40	2.19	1.16	1.99
Min	1.07	1.72	1.23	1.62	1.09	1.51
x	1.12	1.95	1.31	1.95	1.13	1.69
R	0.18	0.47	0.17	0.57	0.07	0.48

The table 2 shows the results obtained with measurement of the connecting resistance of the products of the invention

and of those of the conventional method, the measurement having been made after the elapse of 48 hours after the products of the invention and of the conventional method were immersed in the bath of 60 °C liquid of 10 % of adipic acid ammonium and were applied with voltages equivalent to the formation voltages. The difference is remarkable as shown.

Table 2

Connecting resistance after Test n = 20 (Unit mΩ)						
	Formation voltage 8V		Formation voltage 50V		Formation voltage 68V	
	Inven.	Conven.	Inven.	Conven.	Inven.	Conven.
Max	2.125	10.95	2.38	11.17	1.97	9.95
Min	1.819	8.60	2.09	8.26	1.85	7.55
x	1.904	9.75	2.27	9.95	1.92	8.45
R	0.306	2.35	0.29	2.91	0.12	2.40

Example 5

The Tables 3 and 4 show the results, wherein the electrode foil of high magnification etching aluminum of formation voltage 8 V like was used just like Example 1 to produce electrolytic condensers of 6 V and 10 μ F and the condensers were continuously applied with the rated voltage 6 V for 1000 hours in the temperature of 105 °C. The products of the invention were stabilized in property after the elapse of time, but the products of the conventional method were unstable, open and remarkably deteriorated in property

Table 3

No.	Invention					
	Before Test			After Test		
	Cap[μ F]	Tan δ	LC[μ A]	Cap[μ F]	Tan δ	LC[μ A]
1	10.80	0.103	0.32	10.33	0.100	0.17
2	11.02	0.102	0.40	10.41	0.100	0.22
3	11.09	0.105	0.31	10.51	0.101	0.21
4	10.78	0.101	0.28	10.15	0.100	0.19
5	11.15	0.104	0.34	10.53	0.102	0.20
6	11.06	0.103	0.28	10.39	0.100	0.19
7	10.82	0.103	0.31	10.32	0.099	0.18
8	11.10	0.103	0.28	10.41	0.101	0.18
9	11.09	0.103	0.44	10.32	0.104	0.22
10	11.07	0.104	0.37	10.29	0.104	0.24
AV	10.998	0.1031	0.333	10.336	0.1011	0.200

Table 4

No.	Conventional					
	Before Test			After Test		
	Cap[μ F]	Tan δ	LC[μ A]	Cap[μ F]	Tan δ	LC[μ A]
1	10.37	0.103	0.46	10.01	0.106	0.16
2	10.41	0.127	0.48	Unstable	—	—
3	11.42	0.138	0.32	Open	—	—
4	10.57	0.103	0.43	9.96	0.102	0.13
5	10.47	0.103	0.38	Unstable	—	—
6	10.51	0.125	0.41	Open	—	—
7	10.44	0.103	0.41	9.99	0.127	0.19
8	10.41	0.103	0.36	Unstable	—	—
9	10.30	0.103	0.34	9.97	0.113	0.12
10	10.43	0.130	0.40	Open	—	—
AV	10.433	0.114	0.399	—	—	—

As shown in Tables 1 and 2, the initial connecting resistances of the conventional products are approximately twice as high

as those of the products of the invention. As to the products of the invention, the variation of values after a forcibly deteriorating test in a formation liquid is stabilized as is about 1.7 times or less. Whereas as to the conventional products, the variation is about 5 times.

As to the life test in a high temperature as shown in Table 3, the products of the invention show a good result without showing almost no change in property. Whereas the conventional products show a remarkably inferior result in property including open and unstable conditions.

As is described above, according to the invention, the product may be produced very efficiently and effectively with a practically very reliable property. Actually as shown in the measured results, the electric conductive resistance is very low, that is, 1.5 m Ω as a maximum value obtained in one-point piercing process, the value proving that the processing method of the invention is very effective compared with the electric conductive resistance 2.2 m Ω obtained by the conventional processing method. Further according to the processing method of the invention, the lead attached terminal may be fixed to the electrode foil of about 1 mm width without reduction of electric property. Thus an electrolytic condenser, which is smallest in the world, may be produced, the electrolytic condenser being 3.5 mm high including a base plate.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit of the invention, and all such modifications are intended to be included within the scope of the following claims.

Description of the Reference Numerals and Signs:

- 10 : Device for producing a terminal attached electrode foil
- 11 : Press mold
- 12 : Piercing needle
- 13 : Electrode foil
- 13a: Square hole
- 13b: Corners
- 13c: Fins of electrode foil
- 14 : Lead attached terminal
- 14b: Tab
- 14c: Fins of tab
- 15 : Terminal attached electrode foil
- 17 : Reel
- 18 : Die
- 18a: Die hole
- 19 : Punch

CLAIMS

1. A method for producing a terminal attached electrode foil comprising the steps of: forming a hole at an electrode foil which has a formation film treated at the surface thereof; superposing a tab of a lead attached terminal on said hole of the electrode foil; operating a piercing needle to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other, wherein said hole formed at said electrode foil prevents fins of said electrode foil from being formed at the time of said piercing step.

2. A method for producing a terminal attached electrode foil comprising the steps of: pulling out an electrode foil from a reel having said electrode foil wound therearound, said electrode foil having a formation film treated at the surface thereof; forming a square hole at said electrode foil, said square hole having four corners oriented in the longitudinal and lateral directions of said electrode foil respectively; superposing a tab of a lead attached terminal on said square hole of the electrode foil; operating a piercing needle to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other, wherein said piercing needle is square in horizontal section having four corners which are put into agreement with the four corners of said square hole of said electrode foil at the time of said piercing step and wherein said electrode and said tab of the lead attached terminal are fixed to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof.

3. A terminal attached electrode foil comprising an electrode foil which has a formation film treated at the surface thereof and has a hole formed thereat; a lead attached terminal having a tab superposed on said hole of the electrode foil and fixedly connected to the electrode foil; wherein said electrode foil and said lead attached terminal are fixedly connected by means of a piercing needle operated to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof.

4. A terminal attached electrode foil comprising an electrode foil which has a formation film treated at the surface thereof and is wound around a reel to be pulled out therefrom, said electrode foil having a square hole formed thereat, said square hole having four corners oriented in the longitudinal and lateral directions of said electrode foil respectively; a lead attached terminal having a tab superposed on said square hole of the electrode foil and fixedly connected to the electrode foil; wherein said electrode foil and said lead attached terminal are fixedly connected by means of a piercing needle having a square shape of four corners in horizontal section, said piercing needle being operated to pierce through said tab and said square hole from a vertically upper side of said tab in the condition that the four corners of said piercing needle are put into agreement with the four corners of said electrode foil respectively, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof.

5. An electrolytic condenser comprising an electrode foil which has a formation film treated at the surface thereof and has a hole formed thereat; a lead attached terminal having a tab superposed on said hole of the electrode foil and fixedly connected to the electrode foil; wherein said electrode foil and said lead attached terminal are fixedly connected by means of a piercing needle operated to pierce through said tab and said hole from a vertically upper side of said tab, thereby to form fins of said tab at a lower side of said electrode foil to fixedly connect said electrode foil and said tab of the lead attached terminal to each other by a pressure applied to said superposed tab and electrode foil from the vertically opposite directions thereof, thereby to form a terminal attached electrode foil which is to be used on the positive and negative sides of electrolytic condenser respectively.

6. A device for producing a terminal attached electrode foil comprising a press means including a die having a die hole formed thereat and located on one side of an electrode foil which has a formation film treated at the surface thereof and is wound around a reel to be pulled out therefrom and a punch located on the opposite side of said electrode foil, said punch being moved into said die hole of said die to form a hole at said electrode foil in cooperation with said die; a means for supplying a lead attached terminal onto said electrode foil in the condition that a tab of said lead attached terminal is superposed on said hole of said electrode foil in agreement therewith; a piercing means including a piercing needle operated to move piercing through said tab and said hole of said electrode foil, said piercing needle being moved from a vertically upper side of said tab to form fins of said tab on the opposite side of said electrode foil so as to fixedly connect said electrode foil and said lead attached terminal to each other.

Terminal Attached Electrode Foil and Device and Method for
Producing the Terminal Attached Electrode Foil

Abstract

A terminal attached electrode foil of electrically excellent conductive property may be produced by way of one point piercing process, wherein an electrode metal foil is fixedly connected to a tab of a lead attached terminal in contact with each other with an effect for reducing the electric conductive resistance in the electrode foil of about 1 mm width. More precisely, the tab 14b of the lead attached terminal 14 is superposed on a hole 13a formed at the electrode foil 13, and then a piercing needle 12 is moved down from the upper side of the tab 14b to pierce through the tab and the hole of the electrode foil for the purpose of forming the fins 13c of the tab 14b at the under side of the electrode foil 13, the fins 13c of the tab 14b being subsequently processed to be directly in contact with the lower side of the electrode foil.

Fig. 1