July 26, 1960 C. L. WELLINGTON 2,946,727

METHOD FOR MAKING ELECTROLYTIC CONDENSERS

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FIG. 1

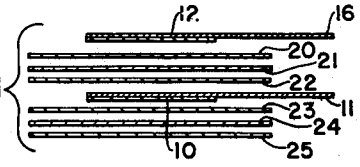


FIG. 2

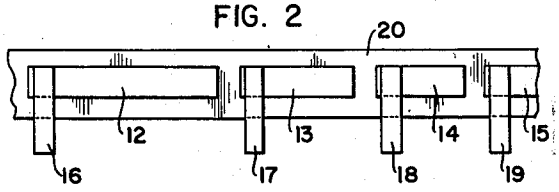


FIG. 3

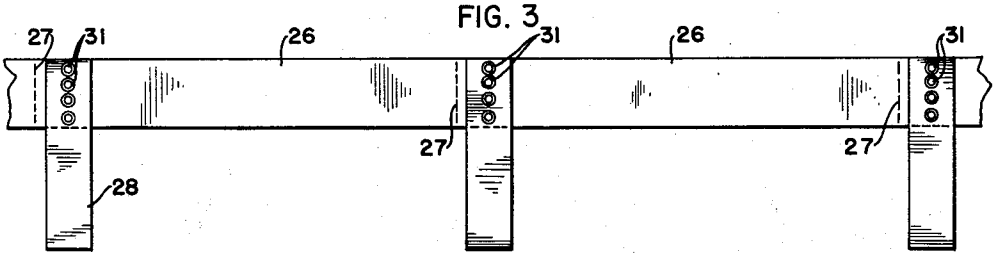


FIG. 4

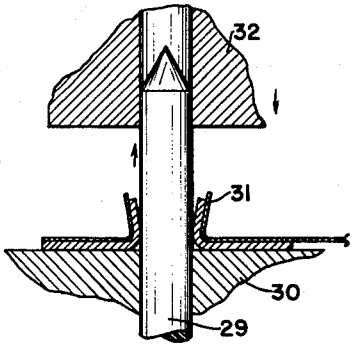


FIG. 5

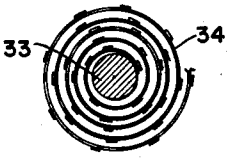
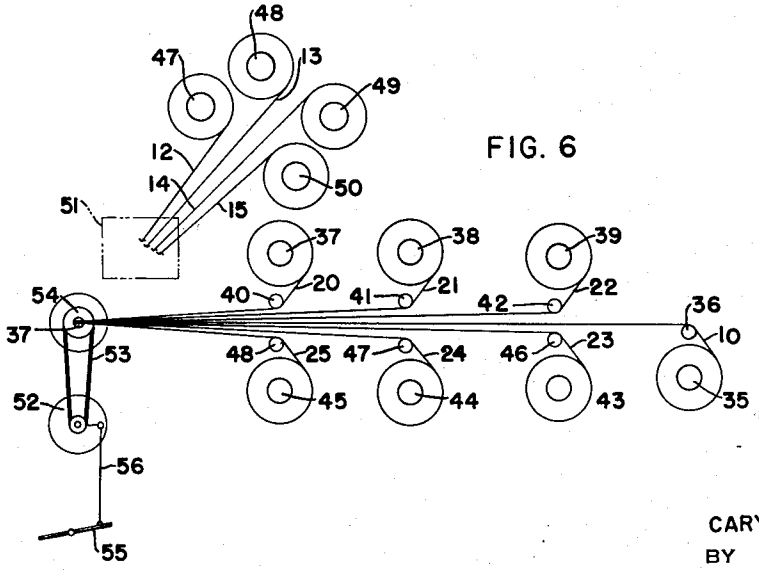


FIG. 6



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FIG. 7

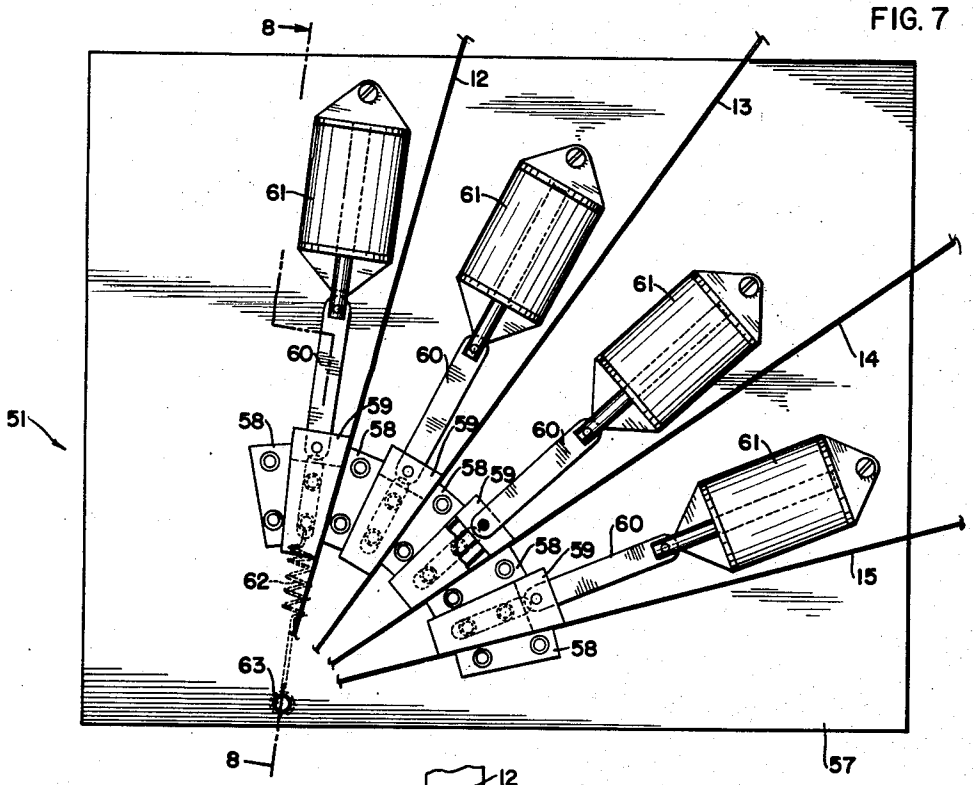
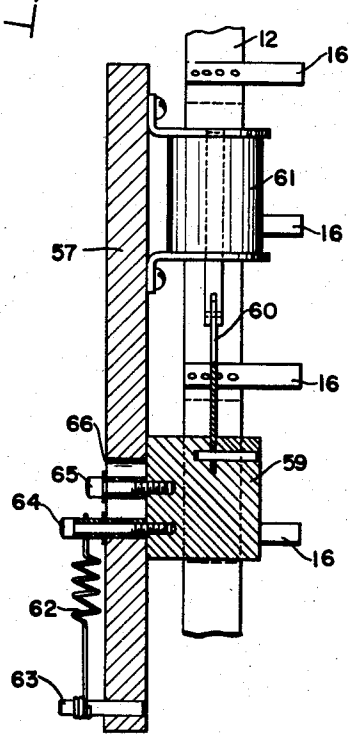


FIG. 8



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FIG. 9.

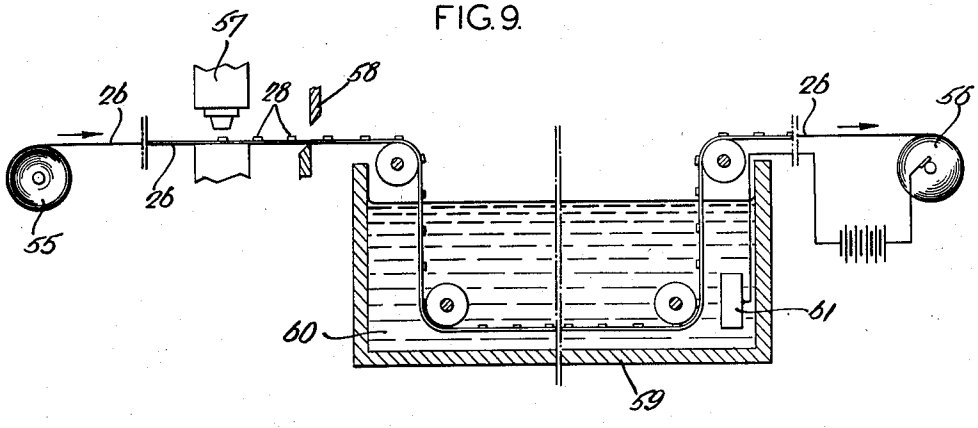


FIG. 10.

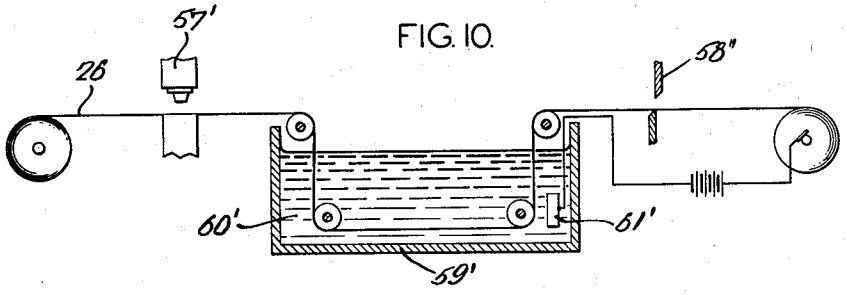
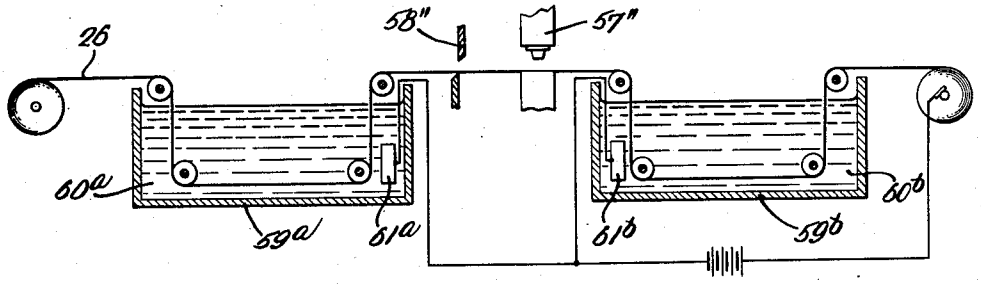


FIG. 11.



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METHOD FOR MAKING ELECTROLYTIC CONDENSERS

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2 Claims. (Cl. 204—28)

This invention relates to an improved method of manufacturing anodes for electrolytic condensers and of assembling the anodes in the condensers. The method is particularly advantageous in condensers having a plurality of anodes and includes a method of assembling the anodes into the condenser. This invention also relates to the apparatus employed in practicing the method of the invention and to the product of the method, an electrolytic condenser.

Electrolytic condensers are usually made using a strip of metal foil as the cathode and at least one strip of metal foil as an anode, each with a terminal tab attachment, rolled into a spiral package with strips of absorbent insulation separating the anode from the cathode or other anode electrodes. The spiral package is then impregnated and inserted into a container, and the container is sealed with the terminal tabs either themselves penetrating the container walls or connected to conductors which penetrate the container walls.

There would be conduction between the electrodes through the electrolye of the condenser, when potential is applied between its anode and cathode terminals, were the anode or anodes not "formed." In some instances it is desirable to form all electrodes. Forming produces a high quality, high dielectric strength oxide coating on the anode material. The process of forming the anode is usually accomplished prior to the assembly of the condenser by introducing the anode foil material into a bath consisting of a boric acid solution or other electrolyte, using the foil as one of two electrodes and applying a voltage between the electrodes.

Heretofore, it has been common to form the anode material in sheets to facilitate handling and then cut the sheets into strips of desired length for the anode. Thereafter, tabs which may or may not have been separately formed have been affixed to the strips in order to provide terminals for the particular electrode, and the attachment of a tab to a strip has been usually accomplished by some mechanical crimping means. All through these processes and until the condenser is completed, the strips have had to be handled extensively and this handling has resulted in bending, rubbing and other effects which damage the oxide coating. As a consequence of the processing and handling after forming, raw edges and bruised and broken oxide covered areas have exposed bare metal to the electrolyte in the assembled condenser. It has been possible to partially replace the oxide lost by these effects by passing low currents for long periods through newly completed electrolytic condensers in order to "age" them. The oxide coating formed by aging, however, is far inferior electrically and less durable mechanically than the oxide coating produced by forming, and, hence, condensers produced in this way frequently have had a far shorter life than a condenser with an ideal anode completely covered with formed oxide would have because of failure of those oxide portions produced by aging.

The present invention is directed to a method of forming whereby practically the whole of the anode is formed just prior to its assembly into a condenser so that damage to the formed oxide coating prior to the completion of the condenser is minimized and so that the amount of oxide required to be formed by aging is extremely small. The method of the present invention forms anodes for a second time just prior to the time when they are ready for use in the condenser and makes it possible to store the formed anodes still attached together by small bridges of foil between perforations in the ribbon wound onto a mandrel. In handling and placing them in their electrode positions in the condenser only a small amount of damage compared to that which is usual in the prior art methods of handling will occur.

The condenser of the present invention has one or more anode electrodes each of which is prepared from an oxide coated ribbon of metallic foil initially formed as sheet or ribbon. The ribbon is divided into a plurality of consecutive portions by transverse perforations which leave only a few narrow bridges of foil between the perforations, said bridges being just wide enough to hold adjacent portions together under conditions of manufacture encountered. Each portion of the ribbon provides an anode which has a transverse metallic tab which extends beyond its edge affixed to it before or after making the perforations, but prior to its separation from other anode portions. A second forming may differ somewhat from the first which usually takes place in a short time at relatively high current density. The second forming usually takes place after the anodes are completed and while they remain in a ribbon, either before or after perforations are made between adjacent anode perforations. In the first forming electrical contact is made with the bare metal through rollers over which the ribbon passes. In the second forming, however, the oxide coating prevents good electrical contact with the rollers, but in accordance with the invention one end of the ribbon is conductively attached to a conductive mandrel or reel and remains attached throughout the forming operation. As the ribbon of anodes is passed through the second forming bath, the raw metal and bruised areas of the whole roll are formed using a current density which of necessity is somewhat lower than in the first forming but as high as possible in view of the formed and/or perforated condition of the ribbon.

The apparatus for assembly of condensers having a plurality of anodes in accordance with the present invention may employ one or a number of rolls of the anode ribbons previously described which rolls are positioned convenient to the winding arbor so that individual anodes may be detached from the rolls when needed. If a plurality of rolls are employed, anodes are detached from them in a predetermined sequence. Each roll contains a ribbon formed to give its anodes a particular capacitance and voltage rating per unit length at a selected electrode spacing. Each condenser contains a plurality of these anodes all insulated from each other, as well as from the cathode, and each having a different voltage and capacitance rating from the others and these anodes are wound consecutively one after another opposite the cathodes into a spiral package. The present invention also provides apparatus whereby when a plurality of rolls of anode ribbon are employed, the different anodes may be taken only in the proper sequence one at a time so that each condenser wound using the apparatus is provided with the proper anode electrodes arranged in the order specified.

For a better understanding of the present invention, reference is made to the following drawings in which:

Fig. 1 illustrates in section the various tapes or ribbons employed in making an electrolytic condenser of the present invention;

Fig. 2 is a plan view from above showing a condenser

spiral package unrolled to show the different anodes in position;

Fig. 3 is a plan view from above of a ribbon of anodes in accordance with the present invention;

Fig. 4 is an enlarged schematic view showing one method of attaching terminal tabs to the condenser electrodes;

Fig. 5 is a diagrammatic view representing the way in which a ribbon of anodes is attached to a mandrel for its second forming which is performed in accordance with the present invention;

Fig. 6 is a diagrammatic view showing the apparatus for assembly of condensers of the present invention;

Fig. 7 is a side-elevational view of the portion of the apparatus of Fig. 6 which holds the various anode ribbons in place;

Fig. 8 is a view of the structure of Fig. 7 along line 8—8 of that drawing.

Fig. 9 is a schematic diagram of one method of processing electrodes in accordance with the present invention;

Fig. 10 shows another method of processing electrodes; and

Fig. 11 shows schematically another method of processing electrodes.

Referring to Fig. 1, it is common practice in the art to make electrolytic condensers by winding strips of metallic foil and strips of an absorbent insulator together onto an arbor such that the foil strips are separated from one another by the absorbent strips. The foil strip **10** is a continuous metallic strip of material such as aluminum and has affixed to it a tab **11** which provides a cathode terminal for the device. The anode **12** shown in Fig. 1 is preferably only one of several anodes as may be seen in Fig. 2. Anodes **12**, **13**, **14**, and **15** each have a terminal tab, **16**, **17**, **18**, and **19**, respectively, extending transversely of its anode strip and beyond the edge of the anode strip, and each of these terminal tabs is fixed in a similar position, preferably adjacent to one end of the anode portion. Between adjacent anode and the cathode surfaces are arranged a plurality of absorbent insulator strips **20**, **21**, **22** which may be composed of different materials having different combinations of desirable properties, such as electrical resistance, electrolyte absorption, wet strength, etc. A similar group of strips **23**, **24**, and **25** below the cathode **10** provide insulation between the other surfaces of the anode and cathode as they are rolled together on the winding arbor to form a cylindrical package.

In accordance with the present invention, a plurality of like anodes are made from a single aluminum ribbon. This ribbon **26** is preferably initially formed as ribbon in a boric acid bath in accordance with well known practices to provide an oxide coating over all its surfaces. After forming, the ribbon is perforated at **27** at equal intervals leaving between perforations narrow bridges of material sufficient to hold portions of the ribbon separated by the perforations together under light tension. Tabs **28** of aluminum foil are next attached in such a way as to make good electrical contact with the ribbon, transverse to each portion to extend beyond an edge of the portion. The tab terminals **28** are advantageously affixed to each portion of the ribbon using a plurality of pointed punch members **29** (see Fig. 4) which are arranged in a row to move upward through a base member **30**, to penetrate the ribbon **26** and a tab **28** placed in proper position on top of the ribbon to punch a hole and form a ring flange **31** which is crimped in place by a downwardly moving anvil **32**. Thereafter, the ribbon shown in Fig. 3 has one end conductively attached to a mandrel **33** onto which it may be wound into a spiral package **34** as shown in Fig. 5. The ribbon conductively attached to the mandrel may be passed through its forming bath as it is wound onto the mandrel and/or it may be unwound from the mandrel to pass through the bath. In the bath a voltage is applied between the ribbon through the mandrel and a cathode in the bath, but the current must be limited to an amount sufficiently small to avoid burning part the bridges between adjacent portions of the ribbon. The current which flows through the ribbon will cause oxides of a quality superior to those formed during aging to be formed at all raw edges such as those at the perforations and at the flanges **31**. In order to avoid limiting the current the perforations **27** may be made after the second forming, but it will be appreciated that subsequent perforation of the tape will produce additional raw edges which must be formed by aging, thereby acquiring an inferior oxide coating in that particular area.

It is possible to change the sequence of various steps of the method of the present invention. For example, it is possible to form sheets of foil before cutting them into ribbons. And as mentioned, it is possible to attach the tab to the ribbon before forming so that only the perforating is left to be accomplished before or after the second forming operation.

The assembly of the condenser of the present invention follows relatively standard procedures. The ribbon of foil **10** for the cathode on a reel **35** is fed over a guide **36** toward an arbor **37** which is split and accepts the different materials being wound between its parts. The absorbent insulator tapes **20**, **21**, and **22** are each supported on reels **37**, **38**, and **39** and pass over guides **40**, **41**, and **42**, respectively. Similarly, absorbent insulator tapes **23**, **24**, and **25** are supported reels **43**, **44**, and **45** and pass over guides **46**, **47**, and **48**, respectively. These absorbent tapes in the completed condenser have the function of retaining the electrolyte and mechanically separating the electrodes from one another. All of these tapes are directed toward the arbor **37** as shown in Fig. 6. The various anode tapes **12**, **13**, **14**, and **15** are mounted on reels **47**, **48**, **49**, and **50**, respectively, and are arranged above the tapes as they come to the arbor so that they may be selected one at a time and placed by hand atop tape **20** in the course of the winding process. Advantageously, the tapes all pass through the holding device **51** which not only permits the tape portions to be separated from one another along their perforations, but advantageously is of such arrangement that the tapes are selected in the order in which they are to be wound in a manner which will hereafter be described. The arbor is driven by a motor **52** which may be belt connected by belt connector **53** to a drive **54**. A foot pedal **55** connected by linkage **56** to a clutch and braking mechanism permits the arbor to be started or stopped by the pressure of the operator's foot.

In the use of the device of Fig. 6 tapes are taken from the tapes **12**, **13**, **14**, and **15** in the order shown in Fig. 2 and placed between the portions of the split arbor atop insulator tape **20** in time for the leading edge of the particular anode to be started into the package roll. The arbor is caused to rotate by manipulation of foot pedal **55** to connect motor **52** to the drive. Tapes are successively selected from reels **47**, **48**, **49**, and **50** and portions are torn from each of the tapes **12**, **13**, **14**, and **15**, in that order. Each anode tape portion is wound into the package as the arbor turns, a space being left between adjacent anodes, and the arbor may be stopped to assure the proper positioning by hand of each anode. Device **51** assures that the handling of the formed anode tapes will produce a minimum of damage so that the amount of oxide replacement required by the latter aging process will become minimized. When the cylindrical package is completed, the arbor is withdrawn and the package is impregnated with electrolyte which is held by the absorbent insulator material and then the package is inserted into a tubular housing which is next closed at both ends with the terminal tapes either protruding through the enclosure or being connected to appropriate conductors which extend through the enclosure.

The holding device **51** is shown in Figs. 7 and 8. The device is supported on a support plate **57** which also sup-

ports a plurality of radially arranged wedge shaped blocks 58 fixed to the plate by bolts or other appropriate means. Between the wedge shaped blocks are movable wedge members 59 which are attached by linkage connections 60 to solenoids 61. Each of the blocks 59 is spring-connected by a spring 62 to a common post 63. The block is supported by means such as bolts 64, 65 in a slot 66 passing through plate 57 so that it may move radially up and down. The bolt 64 extends further behind the plate than does bolt 65 so that the spring 62 may be attached to it. Accordingly, it may be seen that ordinarily the spring 62 holds its block 59 in place against the fixed blocks 58. In this condition, a tape such as the anode tapes 12, 13, 14, and 15 passing between a movable block 59 and a fixed block 58 will be held in place by the wedging action. Each block 59 is released by energizing of its solenoids 61, and this is advantageously done in such a way that one tape after another is freed in a predetermined order such as 12, 13, 14, 15; 12, 13, etc., so that only the proper tape for the needed anode may be had for adding to the condenser package. Appropriate interlocking devices for assuring that the solenoids will work successively in the desired sequence will occur to one skilled in the art. For example, it is possible to employ two switches in series with each solenoid and the energy source so that one switch will be closed by the action of the previous solenoid and opened by the release of its own solenoid and the other switch will be manually operated and spring loaded to automatically open upon release of pressure.

It will be observed that the number of elements employed in the device 51 will depend upon the number of anodes to be used in a particular condenser. Likewise, the nature of the device may be varied considerably as, for example, by putting the wedges between two plates 57 instead of mounting them on only one. The advantage of using wedges on only one plate accrues from the ease of access to the strips whereas mounting the wedges between two plates may give the device added stability.

Figs. 9, 10 and 11 illustrate various modifications of the process according to the present invention.

Fig. 9 illustrates the preferred process whereby ribbon 26 is provided with tabs 28 and then perforations 27 before being formed, or reformed. As can be seen in Fig. 9, the ribbon comes from a ribbon supply 55 and is drawn therefrom to a takeup 56. In the course of its path between these two termini it passes tabbing means 57 at which tabs 28 are affixed. Thereafter it passes perforating knives 58 which perforate the ribbon between tabs. Finally, it is directed by suitable rollers through tank 59 filled with a conducting electrolyte 60 which electrolyte contains an electrode 61, which is specifically a cathode. This electrode may be connected to the takeup reel or one of the conducting rollers through a suitable battery or voltage source to impress the necessary forming current through the electrolyte to form the electrodes in a conventional way.

The process of Fig. 9 may be modified by omitting either the tabbing or the perforating of the ribbon 26 and may be varied by using either formed or unformed ribbon 26.

Fig. 10 diagrammatically illustrates a modified arrangement whereby tape is first tabbed by tabbing means 57', then fed through electrolyte 60' in bath 59' and finally perforated by a perforating knife 58'.

Fig. 11 illustrates that the order of perforating by perforating means 58'' and tabbing by tabbing means 57'' may be reversed and that either, or both, of these means may follow or precede electrolytic forming in bath 60*a* or 60*b* in tanks 59*a* or 59*b* in the presence of electrodes 61*a* and 61*b*. In any of these situations the process has in common the use of a continuous tape, and preferably formed tape or tape which is formed at some point while it is still continuous.

Many other modifications of the types described will occur to those skilled in the art and all such modifications are intended to be within the scope and spirit of the present invention.

I claim:

1. In the electrolytic condenser art, the method of attaching metal tabs at intervals to a metal ribbon, perforating the metal ribbon at intervals generally transverse to the ribbon and no more than once between any adjacent pair of metal tabs, and before severing into individual electrodes passing the ribbon through an oxide-forming bath and placing a voltage between the foil and an electrode in the bath to cause current to flow in the ribbon, whereby an oxide coating is formed on all exposed surfaces of said tabs and of said ribbon.

2. A ribbon of metallic foil divided into a plurality of electrode portions by transverse perforations, each portion having at least one transverse metallic tab affixed to the ribbon, the said at least one transverse metallic tab, the edges of the perforations, and the exposed surfaces of said ribbon being formed to provide an oxide coating thereon.

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