

May 5, 1953

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2,637,686

PROCESS OF PRODUCING DRAWN ARTICLES

Filed April 2, 1949

2 SHEETS—SHEET 1

Fig. 1.

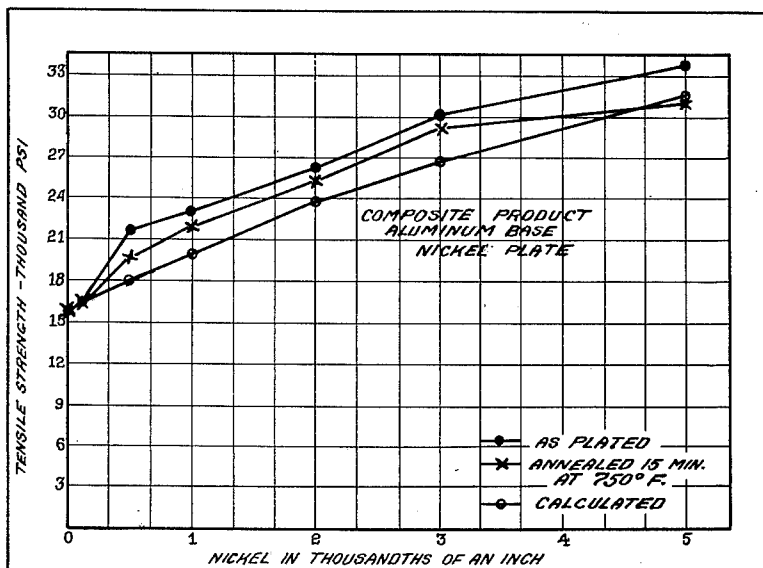
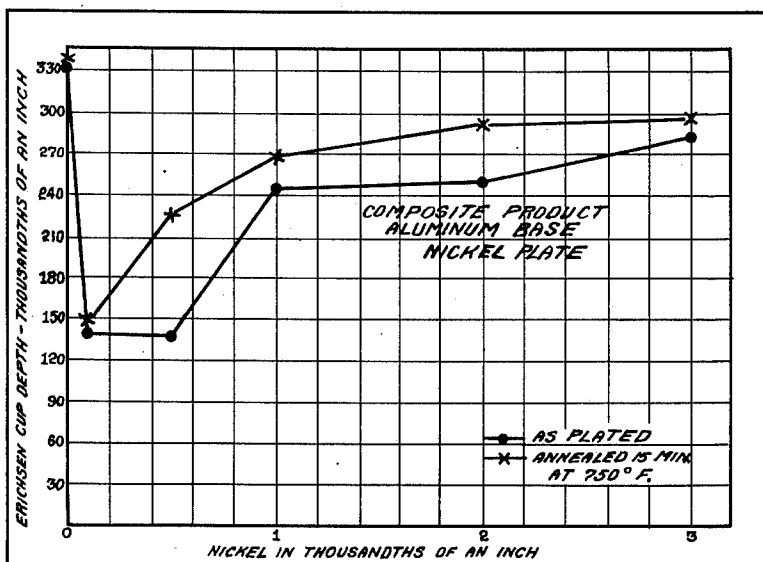


Fig. 2.



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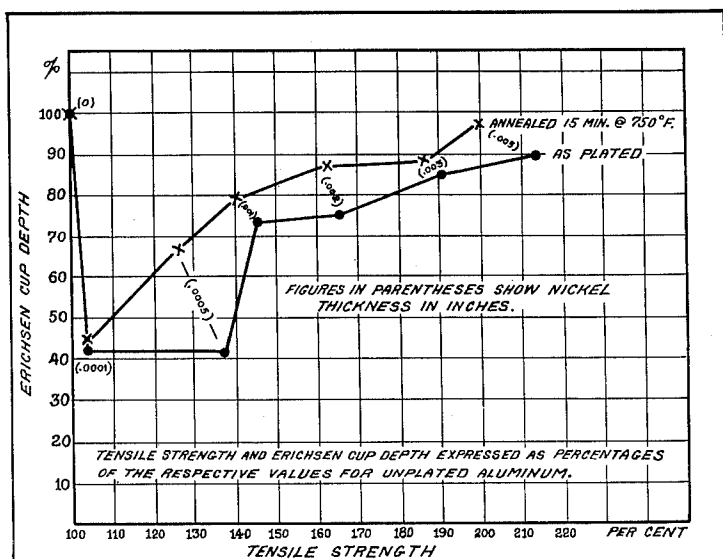
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2 SHEETS—SHEET 2

Fig. 3.



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PROCESS OF PRODUCING DRAWN ARTICLES

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2 Claims. (Cl. 204—33)

1 The present invention relates to composite metal products and it relates, more particularly, to severely drawn composite metal articles such as cooking utensils.

Cooking utensils such as skillets, Dutch ovens, chicken fryers, griddles, kettles, boilers, roasters, pressure cookers and the like have heretofore been made from a variety of materials such as cast iron, copper, aluminum, stainless steel and various combinations of some of these materials. Prior experience with the plating of nickel or other metals on a ductile base metal, such as aluminum, has been that the plating has caused a lowering of ductility so that the ability to shape by cold drawing or stamping has been seriously and detrimentally reduced. It has been appreciated in the art that such characteristics as good heat conductivity, lightness in weight, good resistance to denting and other deformation, pleasing appearance and resistance to undesirable corrosive attacks by foodstuffs are all desirable in cooking utensils. It has also been recognized that all of these desirable characteristics were not present in utensils of the prior art.

While utensils have been made both from the several solid metals and alloys mentioned as well as combinations of these in the form of laminations, no practical method has heretofore been found of producing a laminated metal using alternating layers of rolled and electrodeposited metals which is sufficiently strong and ductile to stand the severe deep drawing operation necessary to the manufacture of cooking utensils. Former experience with the plating of nickel or other metals on a ductile base metal, such as aluminum, has been that the plating has caused a lowering of ductility so that the ability to shape by cold rolling and stamping has been seriously and detrimentally reduced.

I have discovered that a cooking utensil or other article possessing all of the aforesaid desirable characteristics is obtained when such an article or utensil is cold drawn or pressed from a laminated structure comprising a foundation layer of aluminum and an overlying layer firmly bonded to the foundation layer and consisting of electrodeposited nickel of sufficient thickness to substantially equal or at least closely approach the strength of the foundation layer, with or without an additional layer of chromium electrodeposited on said nickel layer and firmly bonded thereto.

It is an object of the present invention to provide a laminated structure adaptable for severe cold drawing operations and comprising a founda-

2 tion layer of aluminum and one or more composite surface layers of corrosion-resisting metals such as nickel and chromium, which are free from constituents such as copper or iron which might contaminate foods.

Another object of the present invention is to provide a cooking utensil having good heat conductivity in a direction parallel to the surface thereof and having a bright and easily cleaned cooking surface.

A further object of the present invention is the production of cooking utensils in which the cooking surface is highly resistant to the corrosive action of food products.

15 It is also within the contemplation of the present invention to provide an economical, durable, cooking utensil which is light in weight, which is easy to handle and which is also resistant to deformation, denting and the like.

20 It is another object of the invention to provide a severely drawn composite metal article, such as a cooking utensil, formed from a laminated structure comprising a foundation layer of aluminum and an overlying layer firmly bonded to the foundation layer and consisting of electrodeposited nickel of sufficient thickness to substantially equal the strength of the foundation layer with or without an additional layer of chromium electrodeposited on the nickel layer.

25 The foregoing and other objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

30 Fig. 1 is a graphical representation showing the effect of the nickel plate thickness on the tensile strength of the composite structure comprising an aluminum base and a nickel plate;

35 Fig. 2 is a graphical representation of the effect on the Erichsen cup depth of the thickness of an electrodeposited nickel layer on an aluminum foundation layer in a composite product; and

40 Fig. 3 represents graphically the relationship between Erichsen cup depth and tensile strength of composite products made of 350 aluminum with various thicknesses of nickel plate.

45 Generally speaking, the invention contemplates the provision of a cold drawn, laminated structure, such as a cooking utensil, which is constituted of a foundation layer of aluminum and a surface layer or layers of nickel or nickel and chromium. The surface layer or layers are preferably electrodeposited on the foundation layer and are firmly bonded thereto. The nickel layer is preferably more than .002 inch thick and is

preferably about one-tenth or more of the thickness of the aluminum foundation layer.

In its broad aspect, the invention contemplates the production of a composite product or laminated structure suitable for cold drawing and comprising a foundation layer of aluminum or other heat-conductive metal, a layer of nickel electrodeposited on said heat-conductive layer and firmly bonded thereto and having a thickness of about one-tenth the thickness of said foundation layer, and a layer of chromium electrodeposited on said nickel layer and firmly bonded thereto and having a thickness of about one-tenth the thickness of the nickel layer. Both plane surfaces of the foundation layer may be provided with the nickel and chromium layers and the chromium layer may be deposited before or after the drawing of the foundation metal-nickel structure.

I have found that composite sheets comprising a foundation sheet of aluminum having firmly bonded to the surface or surfaces thereof a layer or plate of electrodeposited nickel of sufficient thickness to possess about the same tensile strength and ductility as the foundation layer and having sufficient adhesion to the aluminum sheet that it is not separated therefrom when the composite structure is subjected to deep drawing operations, are particularly adapted for use in the manufacture of cooking utensils.

In obtaining the results designated by the charts illustrated in Figs. 1 and 2, the nickel layer or plate was electrodeposited on an aluminum foundation layer or sheet of about .020 inch thickness after first preparing the surface of the aluminum layer in the manner described in detail hereinafter. The effect of the nickel plate thickness on the tensile strength is plotted in Fig. 1 for the composite structure or product as plated, as annealed and as calculated. It is seen that the tensile strength of the composite product increases gradually with the nickel thickness. At a thickness of about .003 inch nickel plate, the tensile strength of the original aluminum sheet is nearly doubled. In other words, the strength of the nickel layer or plate is about equal to that of the aluminum sheet. It is to be noted in this graph that the highest values are obtained for the composite sheet in the "as-plated" condition although the results for the "as-plated" and annealed composite products generally parallel the calculated strengths.

On referring to Fig. 2, it will be noted that the Erichsen cup depth values decrease somewhat precipitously to a minimum in the initial stages of electrodeposition of the nickel plate, and then reverse to an abrupt upward turn and increase when the deposit attains a thickness of about .0005 inch. The increase in depth value finally attains a level nearly as high as the original sheet when the thickness exceeds about .003 inch. This occurs at approximately the point where the tensile strength of deposited nickel plate equals that of the aluminum base. The chart also shows that somewhat higher but generally parallel results are obtained when the composite aluminum-nickel structure or product is annealed for about 15 minutes at about 750° F. The abrupt upward turn occurs at a somewhat lesser thickness for the nickel layer in the annealed composite structure. It is to be particularly noted from the graphs shown in Fig. 2 that the increases in Erichsen cup depth values are obtained to the same degree in the composite structure "as-plated" as are obtained in the composite struc-

ture as annealed, although values are slightly higher in the annealed structure.

Fig. 3 further illustrates the relationship between Erichsen cup depth and tensile strength of composite products made of an aluminum sheet and a nickel plate by plotting the values of depth and strength in terms of percentages in the same graph. The tensile strength and the Erichsen cup depth values are expressed as percentages of the respective values for unplated aluminum and it is seen that when the tensile strength reaches about 200% the ductility has returned nearly to its original value or 100%.

In a preferred embodiment, the laminated structure consists of a central layer of rolled sheet aluminum of about .020" to about .040" thickness, an electrodeposited layer of nickel of about .003" to about .004" thickness firmly bonded to both of the plane surfaces of the foundation aluminum layer, and a surface layer of electrodeposited chromium of about .0002" to about .0003" thickness firmly bonded to the nickel surfaces. Alternatively, the nickel-chromium layers may be applied to only one surface of the aluminum foundation layer, thus providing a laminated aluminum-nickel-chromium structure having one exposed surface of chromium and the other exposed surface of aluminum.

It is an essential feature of the present invention, however, that the laminated structure shall be made up of at least one layer of electrodeposited nickel firmly bonded to the surface of a heat-conductive foundation layer, preferably aluminum, and that this layer (or layers) of nickel shall be of sufficient thickness to approximate the strength of the aluminum foundation layer.

The general method of procedure for producing a suitable laminated structure is as follows:

The aluminum foundation layer is thoroughly cleaned, the method of cleaning depending on the type of dirt to be removed. Thus cleaning may be done by any of the well known methods such as vapor-degreasing, alkali cleaner or acid cleaner, for example, nitric acid. After cleaning, the aluminum sheet is thoroughly rinsed in water and is then dipped in a caustic soda solution for etching. A 5% caustic soda solution at about 150° F. in which the aluminum sheet is etched for about ten seconds has been found to give very satisfactory results. After etching, the aluminum sheet is again thoroughly rinsed in water and is dipped in concentrated nitric acid at room temperature for about ten seconds for additional cleaning action. The aluminum sheet is then anodically treated for about 10 to 15 minutes in 35% to 50% phosphoric acid at about 70° F.-90° F. under continuous agitation to build up an oxide film on the surface of the sheet of a nature to improve adhesion of the plating metal. A voltage of about 10 to about 23 volts is used and an amperage of about 12 amperes per square foot. The aluminum sheet is again thoroughly rinsed in water and is provided with a layer of electrodeposited nickel on each of its plane surfaces. The plating bath used may be any conventional bath which will deposit a firmly adhering layer of nickel on the prepared aluminum foundation layer, for example, a chloride bath of a Watts bath. The current densities used, however, are critical. The starting current density must be about 10 amperes per square foot and this current density is preferably maintained for about 30 seconds. The current density is then gradually increased until it reaches about 60 amperes per

square foot after about one minute. Plating is continued at this latter rate until the electrodeposited nickel layer attains a thickness of about three to four thousandths of an inch (.003" to .004"). The nickel-plated, aluminum sheet is then rinsed in water and dried and is then polished and buffed. The buffed sheet is then provided with an electrodeposited layer of chromium on the nickel surfaces. The chromium plate may be electrodeposited by any well known method which is preferably continued until the chromium layer attains a thickness of about .0002". The multi-layer, aluminum-nickel-chromium sheet is then annealed at about 750° F. to 800° F. for about 15 minutes to 2 hours, depending on the original temper of the aluminum foundation sheet.

When blanks of suitable contour and dimensions are cut, stamped, or otherwise obtained from composite laminated sheets or products prepared in the manner described heretofore, such blanks may be subjected to cold drawing operations such as those commonly used in preparing cooking utensils without separation occurring between the aluminum foundation layer and the electrodeposited nickel layer or between the electrodeposited nickel and chromium layers.

The results shown in Figs. 1 and 2 are shown in tabulated form in Tables 1 and 2 in comparison with results of breaking load tests on 1 inch wide strips of the laminated sheet, the aluminum layer and the nickel layer. The data shown in Table 1 were obtained from annealed laminated strips while data shown in Table 2 were obtained on laminated strips as plated and without subse-

quent annealing. It will be noted from these figures that the breaking load for the nickel layers, both in the annealed and the un-annealed condition, closely approaches the breaking load required for the aluminum foundation layer when the nickel layer attains a thickness of .002 inch and exceeds the load required for the aluminum foundation layer when the thickness is .003 inch. Consequently, the breaking load required for the laminated sheet is approximately double the load required for the aluminum foundation layer alone when the plated nickel layer on the composite sheet is .002 inch in thickness and is more than double the breaking load required for the aluminum foundation layer when the plated nickel layer is .003 inch thick. It is also to be particularly noted that the ultimate strength of the laminated sheet, the breaking load required and the Erichsen cup depths continue to increase proportionately as the thickness of the nickel layer is increased. Thus, although the invention in its preferred embodiment contemplates the drawing of a composite sheet having a foundation layer of aluminum and an electrodeposited layer of nickel on the foundation layer with each of said layers being of approximately the thickness thereof desired in the final product, it will be apparent that a laminated sheet in which the aluminum foundation layer and the electrodeposited nickel layer are each of thicknesses considerably greater than those desired in the finished article may be used, the laminated sheet being first rolled to the desired thickness before the drawing operations.

TABLE 1

Ultimate strength of laminated sheet compared with actual breaking load on 1" wide strip of laminated sheet aluminum layer and nickel layer

[Laminations compared with Erichsen ductility of laminated sheets. Aluminum thickness .025", 3S0, annealed after plating.]

Thickness of Ni Layer in 1/1000 inch	Ult. Strength Laminated Sheet, Lbs. per sq. in.	Actual Breaking Load on 1" wide strip			Erichsen Cup Depth, Inches
		Lam. Sheet, Lbs.	Al Layer, Lbs.	Ni Layer, Lbs.	
0.0 thousandths.....	15,700	314	314	0.0	.34
0.1 thousandths.....	16,300	320	314	.15	.15
0.5 thousandths.....	19,800	416	314	.102	.225
1.0 thousandths.....	22,000	454	314	.170	.27
2.0 thousandths.....	25,400	610	314	.286	.29
3.0 thousandths.....	29,200	759	314	.445	.30
5.0 thousandths.....	31,200	936	314	.622	.33
10.0 thousandths.....	38,800	1,149	314	.835	.37

TABLE 2

Ultimate strength of laminated sheet compared with actual breaking load on 1" wide strip of laminated sheet aluminum layer and nickel layer

[Laminations versus Erichsen ductility of laminated sheets. Aluminum thickness .025", 3S0, no annealing.]

Thickness of Ni Layer in 1/1000 inch	Ult. Strength Laminated Sheet, Lbs. per sq. in.	Actual Breaking Load on 1" wide strip			Erichsen Cup Depth, Inches
		Lam. Sheet, Lbs.	Al Layer, Lbs.	Ni Layer, Lbs.	
0.0 thousandths.....	15,800	316	316	0	.33
0.1 thousandths.....	16,400	332	316	.16	.14
0.5 thousandths.....	21,700	456	316	.140	.14
1.0 thousandths.....	22,000	503	316	.190	.24
2.0 thousandths.....	26,200	629	316	.313	.25
3.0 thousandths.....	30,100	784	316	.463	.28
5.0 thousandths.....	33,700	1,022	316	.706	.30
10.0 thousandths.....	38,800	1,552	316	1,236	.34

As a more specific illustration of the present invention, reference is made to the following examples:

EXAMPLE I

A conventional side handle sauce pan was made by the following procedure using the novel composite or laminated product described herein.

Sheets of aluminum alloy, known as 3-S, 42" long, 29" wide and .020" thick were cleaned in a vapor degreaser and rinsed in water. The cleaned sheets were etched in a 5% caustic soda solution at 150° F. for about 10 seconds and were again rinsed in water. The etched sheets were then dipped in concentrated nitric acid, followed by rinsing in water. The sheets were then treated as an anode in a 40 Twaddell phosphoric acid solution at a temperature of 80° F. for 12 minutes and at a current density of 12 amperes per square foot. The sheets were again rinsed in water and were treated as a cathode in a low pH Watts type nickel plating bath at 10 amperes per square foot for 30 seconds, the ampereage then being gradually increased to 50 amperes per square foot during the succeeding 30 seconds and the nickel plating was continued at 50 amperes per square foot until the thickness of the nickel plate on each side of the aluminum alloy sheet was about .003". The sheets were then rinsed and dried and were buffed to a high finish. The buffed plates were then immersed as cathodes in a chromium plating bath of approximately the following compositions:

250 grams per liter chromic acid
2.5 grams per liter sulphate radical

The current density used for the chromium plating in the aforesaid bath was about 108 amperes per square foot and was maintained for about 45 minutes or until a plate of chromium about .0002" thick was deposited. The plated sheet, after rinsing and drying, was heat treated in an electric furnace at about 750° F. for 30 minutes and was cooled in the atmosphere. Six circles were cut from the heat-treated sheet and these circles were cold drawn in a single operation to hollow vessels about 7" in diameter and 4 1/4" deep. The vessels were trimmed to a smooth edge which was turned to a roll edge bead. The wrinkles were then spun out on a spinning disc, the vessel was washed and polished to a satin finish, and a stainless steel handle was secured to each vessel with stainless steel rivets.

EXAMPLE II

In this example the aluminum alloy sheets of the same composition and dimensions as in Example I were subjected to cleaning and nickel plating procedures identical to that of Example I, but all polishing, heat treating, and chromium plating as described in Example I were omitted. The sheets after being nickel plated were dried and four discs or circles 13 1/2 inches in diameter and 4 1/4 inches deep. The drawn shapes were then trimmed, the edges beaded, the wrinkles spun out and they were then polished and buffed to a high mirror finish. They were then cleaned and chromium plated under the conditions described in Example I, using an electrodeposited layer of chromium .0002 inch thick, and a stainless steel handle attached as in Example I.

It will be apparent to those skilled in the art that the general procedures as given in Examples I and II could be followed using discs of the

aluminum alloy as the starting material thus eliminating the production of plated scrap. Many other variations in the foregoing procedure may be made without departing from the spirit of the present invention. Sheets may be produced at a heavier gauge and thereafter rolled to the desired thickness. Polishing and buffing may be omitted until after the drawing is completed. All heat treating may be omitted until after the first draw and then included before final drawing and the annealing may be done either before or after plating with chromium. Also, the chromium plate may be applied after drawing and polishing.

While the present invention is defined with reference to the relation between the tensile strength of the different layers as an important controlling factor in obtaining the desired results it will be understood that the important improvements obtained are not necessarily the result of the tensile strength alone but are obtained in combination with other inherent properties of the metals employed including that of properly related degree of ductility. Also while it is believed that the improved results of the present invention are related largely to the combination of tensile strength and ductility of the specific metals employed there are perhaps other and unrecognized properties inherent in the specific metals and relative thicknesses as employed which contribute advantageously to the successful deep drawing operations.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that variations and modifications may be resorted to, as one skilled in the art will readily understand. Thus the invention contemplates the use of other metals of high heat conductivity for the foundation metal or other metals of high corrosion resistance for the exposed surfaces of the multi-layer article.

I claim:

1. A process for producing severely drawn articles of composite metal having high heat conductivity and non-corrosive properties which process consists of cleaning and etching a foundation layer sheet of a metal selected from the group consisting of aluminum and high aluminum alloys and having a thickness of from about .020 inch to about .040 inch, dipping said etched sheet in a concentrated nitric acid followed by rinsing in water, anodically treating said dipped sheet in a 35%-50% phosphoric acid solution at a temperature of about 80° F. with a current density of about 12 amperes per square foot for a period of about ten to fifteen minutes, electrodepositing a layer of nickel on the plane surfaces of said foundation layer sheet and controlling the electrodeposition to produce a thickness of the nickel layer of from about .003 inch to about .004 inch and wherein the thickness of the nickel plating is 10% to 15% the thickness of the foundation layer whereby the tensile strength of the composite foundation metal-nickel sheet is approximately double that of the tensile strength of said foundation layer, electrodepositing a layer of chromium of about .0002 inch to about .0003 inch on the exposed surfaces of said nickel layer, heat treating the composite sheet at a temperature of about 750° F. to about 800° F. for from fifteen to thirty minutes and deep drawing articles from the sheet so produced.

2. A process for producing severely drawn articles of laminated metal sheet having high heat conductivity and non-corrosive properties which

process consists of cleaning and etching a foundation layer sheet of aluminum and having a thickness of from about .020 inch to about .040 inch, dipping said etched sheet in a concentrated nitric acid followed by rinsing in water, anodically treating said dipped sheet in a 35%-50% phosphoric acid solution at a temperature of about 70° F. to 80° F. under continuous agitation with a current density of about 12 amperes per square foot and voltage of from 10 to 23 volts for a period of about ten to fifteen minutes, electrodepositing a layer of nickel on the plane surfaces of said foundation layer sheet and controlling the electrodeposition to produce a thickness of the nickel layer from about .003 inch to about .004 inch by treating the foundation sheet as a cathode in a low pH Watts-type nickel plating bath at 10 amperes per square foot for about thirty seconds, increasing the amperage gradually to and continuing at 50 amperes per square foot until a thickness of nickel plating is obtained which is 10% to 15% the thickness of the foundation layer whereby the tensile strength of the composite foundation metal-nickel sheet is approximately double that of the tensile strength of said foundation layer, electrodepositing a layer of chromium of about .0002 inch to about .0003 inch on the exposed surfaces of said nickel layer, heat

treating the composite sheet at a temperature of about 750° F. to about 800° F. for from fifteen to thirty minutes and deep drawing articles from the sheet so produced.

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