This invention relates to a continuous method of strip annealing aluminum foil. Aluminum foil is commercially available in the form of rolls of continuous strips or sheets having a very thin gauge of about .002" and consisting of substantially pure aluminum. Such foil is used, among other things, as a spotting or lining material for container closures as well as for a variety of wrapping purposes.

By "a continuous method of strip annealing" is meant the continuous feeding of the aluminum foil, as for example, from a roll, to and through an annealing instrumentality and the rewinding of the annealed foil. This method is distinguished from, and marks a decided advance over, the generally accepted and, in fact, heretofore considered best, practice of "batch annealing".

Batch annealing is slow in that a coil of aluminum is heated in an oven for a period of 12 to 14 hours at about 600° F. or between 650° F. and 850° F. and then cooled for a similar period. Consequently, it is necessary to constantly keep a large supply on hand which is not economical, since in most cases the minimum quantity which must be kept available amounts to about a forty-eight hour supply. Furthermore, since the annealing operation is conducted with the aluminum foil in the form of a coil or roll, it is recognized that it is not possible to secure a uniform anneal nor impart constant characteristics throughout the strip or sheet of foil. Moreover, the batch annealing method has the equally important disadvantage that the oil film with which the foil is usually coated is not removed by the annealing operation. The commercial foil annealed by the batch method therefore still has an objectionable oil film which is difficult and expensive to remove and highly undesirable, as will be appreciated, where the foil is used as a spotting or lining material for container closures and is in contact with a food or chemical product and likewise to be avoided where the foil is employed as a wrapper.

It is an object of the present invention to produce a foil annealed so as to have uniform characteristics and properties, free of objectionable oil film, and to achieve such results by a method which is both rapid and efficient. While continuous methods of strip annealing have been employed, for example, as described in the United States Patent to Webster 1,971,666, so far as known, no satisfactory commercial method for strip annealing aluminum foil has been developed. This is probably due to the difficulties attendant upon the treatment of the relatively thin, weak foil on the one hand, and the necessity for a simple and adequate control on the other.

I have discovered that aluminum foil may be continuously and uniformly annealed with complete volatilization of the oil film and without product wrinkling or matting or tearing of the foil by (1) travelling the foil at a constant speed and under a constant tension, (2) controlling the heating temperature and the time period of heating, and (3) cooling the strip substantially immediately after the heat treatment by a positively controlled reduced temperature and for a relatively shorter time period than the heat treatment, followed by air cooling at normal temperature.

In practicing the method of the invention, and by way of example, a coil of aluminum foil having a thickness of about .002" more or less, and having the usual oil film upon its surface, is drawn continuously from a roll by means which also act as a tension device, and the strip is passed over and in contact with a heating surface. The temperature, the area of the heated contact surface, and the time period which is a resultant of the size of the contact area and the speed of the strip are controlled so that the strip is uniformly heated through. I have discovered that high temperatures above the melting point of aluminum, e.g., up to 1275° F. may be used because the foil has an oxide coating on both sides which raises its melting point, but at the same time, allows the heat to uniformly penetrate the aluminum foil throughout by conduction. Thus, the aluminum foil may be heat treated in the annealing operation to develop any required physical properties.

In cooling the aluminum foil, similar control factors are observed and with reference to the heat treatment, it is particularly important that the foil be continuously and immediately travelled from the heating to the cooling instrumentality and given a quick cooling by contact with a cooling surface having the required temperature. This quick cooling, however, is for a relatively shorter time period than the heating and is followed by cooling the foil at normal atmospheric temperature in the air and while it is being carried away from the cooling instrumentality and Rewound as a coil or roll. The proximity of the heating and cooling contact surfaces, the speed of the foil, and the cooling area presented to the strip material govern the quick cooling of the foil. The air cooling is controlled by the speed of the strip and the proximity of the rewinding means to the cooling instrumentality, but cooling of the annealed foil as a roll under atmospheric conditions, will take place until the foil reaches normal atmospheric temperature.

Preferably the heated surface contacts with one side of the continuously moving foil and the cooling surface is presented to the opposite side. The annealing is usually conducted in a chamber or insulated hood to preserve the best conditions, and an inert atmosphere such as nitrogen.
or a reducing atmosphere such as hydrogen, is treated at a proper speed by the motor or a separate prime mover to preserve the correct constant tension and obtain the desired quick cooling. This roll 16 is rotated at a speed to assure travel of the strip at a constant speed. The roll is supplied with a cooling medium such as water circulating in the jackets 20 and at a temperature for bringing about the required anneal. The rolls 16 and 18 are adjustably mounted to face each other to control the time period elapsing between the heat treatment and the quick positive cooling.

In the present instance, the diameter of the roll 18 is 2/3 that of the heating roll 16. The area of contact of the roll 18 with the strip is relatively much smaller than that provided in the heat treatment, so that the cooling period is reduced. This contact area, however, is regularized by means of guide rolls, as described above, or by adjusting the position of the rolls 16 and 18 to each other.

The diameters of the rolls 16 and 18 may vary as well as their respective areas presented to the strip to develop desired properties in the foil, but in all cases a relatively brief positive cooling is considered necessary.

The annealing, as will be appreciated, takes place during travel of the strip over and by contact with the several rolls and within the hood 14.

For example, a foil of .002 gauge is travelled at a speed of 22.5 feet per minute over the roll 16 having a surface temperature of about 900° F. and is delivered in satisfactory annealed condition, devoid of oil film from the roll 16 at a temperature of about 600° F.

It will be noted that the heated surface of the roll 16 presented to the foil is substantially one-half of the cylindrical surface of the roll, while the cooling area presented by roll 19 is somewhat less than one-half the cylindrical surface.

Also, the foil is heated on one side and its opposite surface presented to the cooling roll 19, and the foil is continuously passed in direct contact with and beneath a cooling roll 9 which is rotated at a constant speed.

The present apparatus may be associated with the means for forming the foil so that the rolls or rolls, as produced, may be immediately transferred to the annealing apparatus and annealed as a continuous operation.

I claim:

The method of continuously annealing a continuous band of aluminum foil comprising feeding the same under constant tension and at a constant speed first with one side of the band in direct contact with a heated rotating surface for a predetermined time period and then substantially immediately subjecting the other side of the band to direct contact with a rotating cooler surface for a substantially lesser time period and thereby appreciably reducing the foil temperature, conducting the heating in a non-oxidizing atmosphere, and rewinding the foil from said cooling surface while continuing the cooling at normal atmospheric temperature.

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