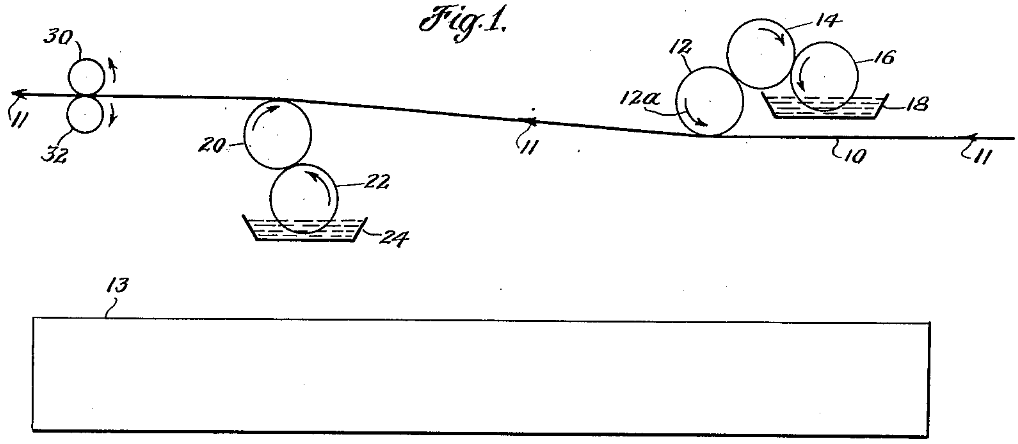
Nov. 2, 1965 | J. H. THIRSK | 3,215,564

METHOD OF APPLYING CHEMICAL CONVERSION COATINGS TO METAL SURFACES

Filed Jan. 11, 1963 | 2 Sheets-Sheet 1

Fig. 1.



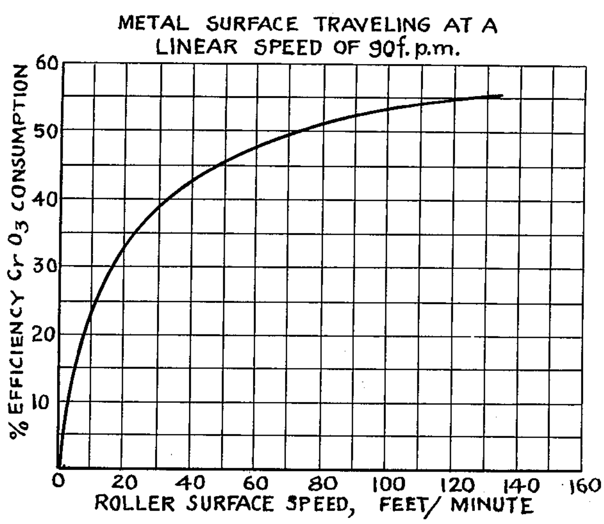


Fig. 2.

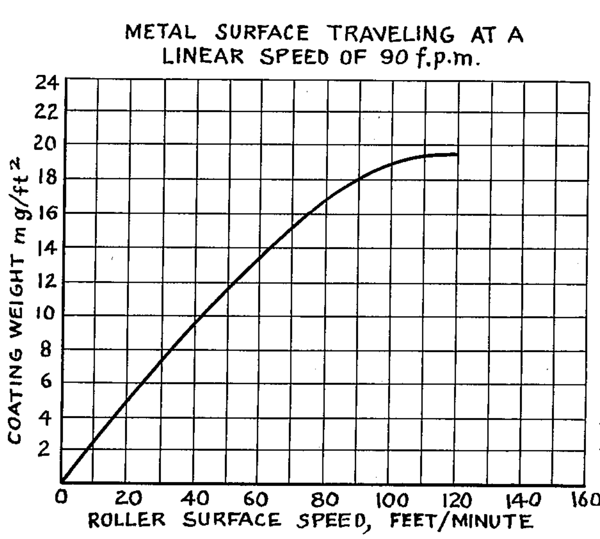


Fig. 3.

INVENTOR.

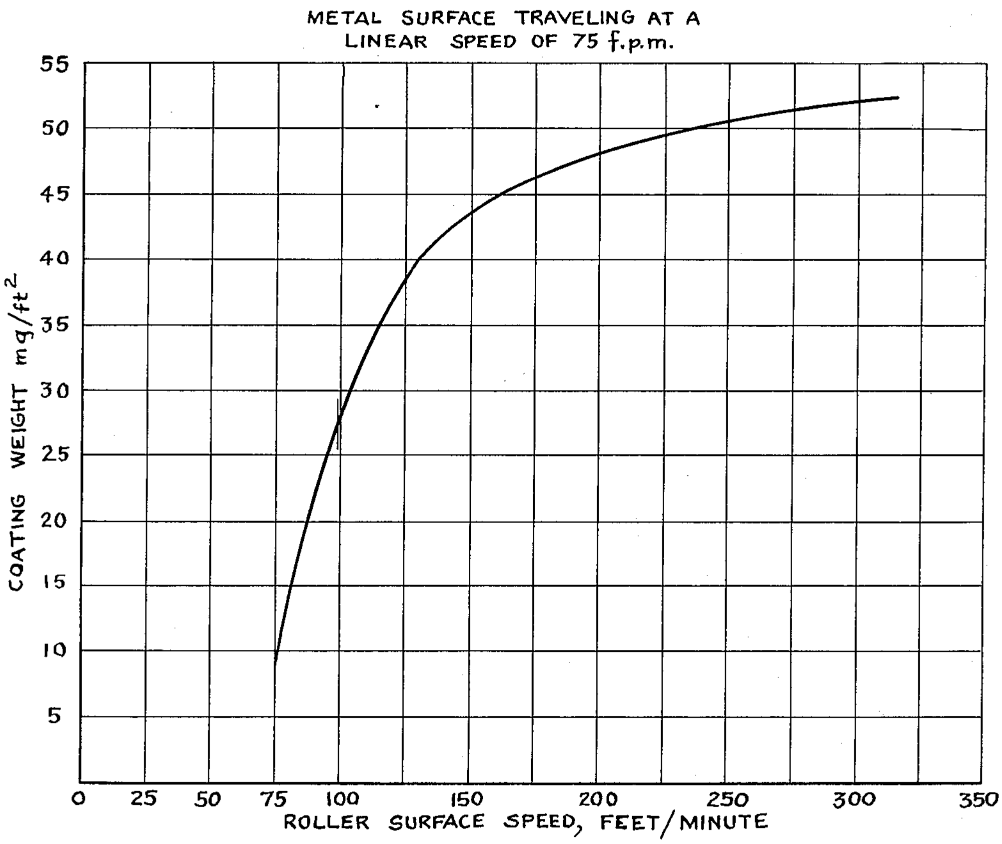
James H. Thirsk

BY

Synnestvedt & Lechner

ATTORNEYS

Fig. 4.



INVENTOR.
BY James H. Thirsk
Hynnestvedt & Lechner
ATTORNEYS

United States Patent Office

3,215,564
Patented Nov. 2, 1965

3,215,564

METHOD OF APPLYING CHEMICAL CONVERSION COATINGS TO METAL SURFACES

James H. Thirsk, Meadowbrook, Pa., assignor to Amchem Products, Inc., Ambler, Pa., a corporation of Delaware

Filed Jan. 11, 1963, Ser. No. 250,949
The portion of the term of the patent subsequent to July 23, 1980, has been disclaimed
2 Claims. (Cl. 148—6.14)

This application is a continuation-in-part of my earlier co-pending application Serial No. 130,398, filed August 9, 1961, which application was subsequently issued on July 23, 1963, as Patent No. 3,098,775.

This invention relates to the art of coating metal surfaces and more particularly to what is known as the roller coating technique of applying chemical conversion coating solutions to the surfaces of various metals. In this technique the rollers are employed to spread the solution over the surface of the metal under treatment with a view to securing uniform distribution thereof and otherwise improving the coating operation and the results which can be secured.

The roller coating technique is particularly applicable to the coating of metal in strip form although it is not necessarily limited in this way. Furthermore, as heretofore employed, it is the practice to have the rollers rotate in the direction which causes their surfaces to move in the same direction in which the surface of the metal under treatment is moving.

U.S. Patent 2,348,698 discloses a familiar application of the technique. As described in that patent a metallic surface is passed over a roller wetted with the desired coating solution with the surfaces of both the metal and the roller moving in the same direction. A somewhat later patent, namely U.S. Patent 2,373,432, discloses the idea of employing multiple pairs of rollers with at least one pair being rotated at a surface speed approximately twice that of the metal under treatment but in the same direction as that in which the metal stock is moving.

With the foregoing in mind the principal object of the present invention is to improve greatly this roller coating technique especially with respect to the rapidity of coating formation, the quality and uniformity of the results secured, and the efficiency of the coating operation. How this objective is attained will now be described with reference to the accompanying drawings, wherein

FIGURE 1 is a diagrammatic representation of my improved technique;

FIGURE 2 is a graph which illustrates the improvement in coating efficiency which is obtainable with my invention in the application of a chromate conversion coating solution to an aluminum surface;

FIGURE 3 is a graph which illustrates the improvement in coating weight which is obtainable with my invention when producing chromate conversion coatings on aluminum; and

FIGURE 4 is a graph similar to FIGURE 3 except that it was obtained from different operating conditions.

My invention is based upon the unexpected discovery that the rapidity with which conversion coatings can be applied to metal surfaces, the uniformity and quality of the finished work and the efficiency of the coating technique can all be markedly improved if the coating solution is applied to the surface to be treated by means of rollers which are rotated so that their surfaces move in a direction opposite to that in which the surface of the metal under treatment is moving. In this connection, it should be noted that the principal feature of my improved technique resides in the employment of opposed relative movement between the surfaces being treated and

the surfaces of the spreading rollers. This can be effected in any one of several ways as by moving the metal stock in one direction and positively driving the applying rollers so that their surfaces move in the opposite direction. It is also possible to move the rollers past the metal surface while at the same time positively rotating the rollers so that their surfaces are moving in the opposite direction.

My improved technique will be described in connection with the application of a chemically reactive chromate conversion coating solution to aluminum surfaces and especially to aluminum strip. For this reason, in the present disclosure the invention will be illustrated in its application to this specific field of usefulness. However, it should be understood that this is merely illustrative of the basic principles involved and should not be considered as limiting the broader aspects of the invention since it is applicable to the chemical conversion coating of metal surfaces generally, and especially to processes where the metal being coated is not immersed in the coating solution.

In FIGURE 1 of the drawings I have illustrated diagrammatically typical roller coating apparatus as modified to incorporate the features of my invention. In this drawing metal strip **10** is shown as being moved by suitable means (not illustrated) in the direction indicated by the arrows **11**. As it moves the strip is brought into intimate contact with a coating roller **12** supported in any conventional manner the details of which form no part of the present invention. This coating roller is positively driven in the direction indicated by the arrow **12*a*** which causes its surface to move in a direction opposite to that in which the surface of the strip is moving. In the present embodiment coating roller **12** is at all times in mesh or driving contact with a driving roller **14** which latter in turn is at all times in mesh or in contact with a driven solution feeding and spreading roller **16**. Roller **16** is at all times partially submerged in the chemical conversion coating solution reservoir **18** and this roller **16** may be driven in any suitable manner as by means of gearing and a motor (not shown).

In the embodiment shown one coating roller **12** is all that is illustrated, but a series of such rollers can be employed if desired. After contact with one or more of such solution feeding and spreading rollers **12** the metal strip, if desired, may be passed between a pair of squeegee rollers **30–32** for the purpose of removing any excess coating solution which can be collected, if desired, in a collecting pan **13**. From the squeegee rollers the strip may be passed through a water rinse followed by a drying stage, but these steps are not illustrated because they can be performed in any conventional manner. It is also possible to eliminate a water rinse and to dry the strip immediately after the coating has been formed. Drying may be effected in any conventional manner as by forced air, heat chambers or any other suitable means familiar to the art which will serve to dry effectively a chemically applied conversion coating preparatory to the application of paint or other siccative finish.

It may be desirable to coat both sides of the metal strip and in this event there can be provided a second oppositely driven coating roller **20** arranged to contact the undersurface of the metal as shown in the drawing. In the present embodiment such a coating roller **20** is arranged so that it will at all times be in mesh or driving contact with a solution feeding and spreading roller **22** which, in turn, is at all times partially submerged in solution reservoir **24**. It will be obvious, of course, that a plurality of oppositely driven solution feeding and spreading rollers may be employed in series and such details can be worked out as desired for any particular installation.

In the application of conversion coatings to metal surfaces, particularly in strip line operations, I have found that the speed of the metal strip as well as the size and reverse speed of the coating rollers all have an influence upon the coating weights obtained. For example, where small diameter coating rollers are used, the reverse speed with which such rollers can be operated is appreciably less than will produce the maximum reverse surface speed which can be usefully employed with my invention. This difference is attributable, at least in part, to the fact that coating solution is thrown from the surface of the rollers when they revolve at speeds which are too high in relation to their diameter. Thus, where it is impossible, due to such loss of coating solution by throw off, to obtain a desired reverse surface speed, using a certain size coating roller, and relative to a given strip line speed, it is only necessary to employ a coating roller of larger diameter to secure the desired surface speed. This relationship is shown in FIGURES 3 and 4 and will be explained in greater detail in the examples which follow hereinafter.

FIGURE 2 illustrates one relationship which has been found to exist between a constant linear speed of the surface under treatment and the speed of the reverse movement of the coating roller surface. This relationship is shown on the graph plotting the roller surface speed in feet/minute against the percent efficiency on CrO_3 consumption from a chromate conversion coating installation.

By way of specific example I will now describe one embodiment of my invention as it was employed in applying a chromate conversion coating to aluminum strip moving at a linear speed of travel of 90 feet/minute. The strip was composed of aluminum 3003 alloy and the chromate conversion coating solution employed was one which is commercially available and is described in United States Patent No. 2,796,370. The strip was fed through a pair of uniformly driven coating rollers (4.5 inches in diameter) the surfaces of which were positively driven in a direction opposite to that in which the surface of the strip was moving. The rollers were wet with a fresh solution such as described in the patent referred to and the analysis of which was as follows:

Ingredient:	Grams
$K_2Cr_2O_7$	6.4
HNO_3 (100%)	4
HF (100%)	2
Water, to make 1 liter.	

The rollers which were conventional neoprene rollers, having a 60 durometer hardness, were driven at various speeds in order to demonstrate the improved process of this invention, and following solution application the aluminum strip was passed between a pair of positively driven squeegee rollers in order to remove the excess coating solution therefrom, and the strip was subsequently dried by passing it over infrared lamps. The results from this test are summarized in the following table.

Table I

Run No.	Reverse Roller Speed, Feet/Minute	Coating Efficiency, Percent	Coating Weight, Mgs./Sq. Ft.
1	30	38.8	7.2
2	60	47.8	13.6
3	90	52.2	18.2
4	100	53.2	18.9
5	120	54.6	19.4

Following these runs coating rollers were utilized in the conventional manner, that is they were rotated so that their surfaces were moving in the same axial direction as the surface of the strip under treatment and at the same speed, namely 90 feet/minute. Under these conditions the coating efficiency was found to be 25% and the coating weight was found to be 12.3 milligrams per square foot. It will thus be seen that with the present invention it was possible to secure a coating efficiency improvement of more than 100% and a coating weight increase of about 50% as compared with prior practice where the roller surfaces move in the same direction as the surface of the strip under treatment and at the same speed. Coating efficiency, as reported in these tests, was determined on the basis of the hexavalent chromium content remaining in the solution after application to the metal under treatment divided by the original hexavalent chromium content of the fresh coating solution.

Turning now to the graph of FIGURE 3 it will be seen that this graph illustrates the increased coating weight which results from the use of reverse movement of the roller coating surface and the directly proportional relationship which exists between these variables under the conditions of these runs. For instance, it will be observed from the graph of FIGURE 3 that where reversed roller surface speed of 90 feet/minute was employed a coating weight of 18.2 mgs./sq. ft. resulted whereas, as noted above, use of a 90 feet/minute speed of both the coating roller surface and the aluminum strip when moving in the same direction as is the current art practice, resulted in a coating weight of only 12.3 mgs./sq. ft. Thus it will be observed from the comparison of the results obtained that increased roller surface speed not only increases the efficiency of the operation of the process but also results in heavier coating formation which in turn results in improved corrosion resistance of the treated aluminum surface.

A further series of runs using the same type of aluminum alloy strip and coating solution, as reported above, was made wherein a conventional neoprene coating roller, having a 60 durometer hardness and a diameter of 5.5 inches was employed, and where the aluminum strip was moved at a linear speed of 75 feet/minute. The strip was passed under the coating roller, positively driven in a direction opposite to that in which the surface of the strip was moving, and following solution application, the metal strip was passed between a pair of squeegee rollers in order to remove excess solution therefrom, and the strip was subsequently water rinsed and air dried. The results of this series of coating runs, which was effected within 12 seconds, are summarized in the following table:

Table II

Run No	Reverse Roller Speed, Feet/Minute	Percent Roller Speed Relative to Line Speed	Coating Weight, Mgs./Sq. Ft.
1	75	100	8.8
2	125	167	38.8
3	210	280	48.8
4	315	420	52.8

The results obtained from this series of runs were plotted graphically as illustrated in FIGURE 4, wherein the weight of the applied coatings in mgs./ft.^{2} was plotted against the roller surface speed in ft./minute. The slope of the curve of FIGURE 4 demonstrates that even where the coating roller surface is driven in an opposite direction, at a speed 420% faster than the linear speed of the metal surface under treatment, the coating weights continue to increase in a manner directly proportional to the reverse surface speed of the coating roller.

The vertical line drawn on the graph of FIGURE 4, at 99.7 feet/minute roller surface speed, represents the maximum roller surface speed reached in the first series of runs reported under Table I above that is, substantially 133⅓% of the linear strip speed

$$\left(\frac{120\ \text{ft./min.}}{90\ \text{ft./min.}}\simeq\frac{99.7\ \text{ft./min.}}{5.0\ 7\text{ft./min.}}\cong 133\ ⅓\%\right)$$

and shows that by varying conditions of linear strip speed, reverse coating roller surface speed and roller coater diameter, increased coating weights may be obtained far beyond the maximum point obtainable under other reverse roller coating conditions, that is, increased coating weights are obtained at relative roller speeds greater than 133⅓%.

In each of the sets of runs reported in Tables I and II, the maximum speed of revolution of the rollers was governed, under the conditions employed in each series of runs, by the tendency of the rollers to throw coating solution from the rapidly turning surfaces at the maximum speeds utilized. This tendency to lose coating solution in this manner is reflected in the slopes of the curves of FIGURES 3 and 4, which slopes tend to level out at the maximum speeds possible under the conditions of the respective runs. It is thus apparent that the maximum speeds at which the reverse coating rollers may be turned, relative to the linear speed of the metal being treated, is dependent upon the conditions of any given operation, and that by increasing the diameter of the coating roller while holding all other variables constant, increased coating weights may be obtained over virtually any desired range.

From the data given above it will be seen that the reverse speed of the surface of the roller in relation to the speed of the strip can vary widely although I have found that best results are obtained where the reverse speed of the roller surface is at least 33% of the surface speed of the strip. No absolute maximum for the roller surface speed in relation to the speed of the metal surface seems to be necessary and, as shown, I have found that the coating results steadily improve even to the point where the reverse surface speed of the roller is as great as 420% of the speed of the metal being coated. The only limiting factor seems to be in the size of the roller in that a roller of a given diameter should not be rotated at a speed sufficiently great to throw off and thus waste coating solution.

So far as the type of coating rollers which are employed in my improved process are concerned I prefer to select rollers which are made from elastomeric materials such as plastics, natural and synthetic rubbers having a surface hardness of 30 to 90 as determined by durometer readings. Durometer hardness is determined in accordance with ASTM D 676. I prefer to employ rollers having a hardness between the limits indicated because if the roller surfaces have a hardness of less than 30 or more than 90 durometer they do not yield completely satisfactory coating results. Indeed, a range of 40 to 60 durometer hardness has been found to provide optimum coating results.

The type of chromate conversion coating solution which can be employed with my invention is not critical and many different types of such solutions for use on aluminum surfaces are known to the art. By way of example, such solutions are described in U.S. Patents Nos. 2,438,877; 2,472,864; 2,678,291; 2,796,371; 2,814,577 and 2,909,455 in addition to No. 2,796,370 already referred to.

Inasmuch as the use of positively driven rollers for applying various types of films or coatings to surfaces of many diversified objects is a well known commercial prac-

tice, and since the improved process of the present invention utilizes the basic equipment involved in such practices, such auxiliary features as supporting means for the rollers as wel las for chains and belt drive means, and pressure adjusting means for the rollers have been omitted from the drawing in order to present the invention solely in terms of its improvement over the prior art.

In order to illustrate visually the surprising advantages flowing from the novel reverse roller coating technique of my invention, there are included herewith specimen aluminum panels which were coated in accordance with my novel process and in a conventional immersion process. Both aluminum coating solutions contained the same concentrations of coating ingredients, and both processes were operated at room temperature. The panel marked "4" reflects the uniformity of color and apperance which is obtained by the reverse roller coating technique in a period of only 12 seconds. The panel marked "1M" was obtained following a 60 second immersion in a bath which contained the same concentration of coating constituents as had been used in the reverse roller coating process, and which was operated at the same temperature.

Comparison of these panels clearly shows the excellent uniformity and appearance of the reverse roller coating technique, despite the fact that the coating cycle employed therein was only one-fifth as long as that utilized in the immersion process to obtain the "1M" panel. Thus the surprising rapidity of the reverse roller coating technique is apparent in its ability to produce coatings of outstanding uniformity and appearance in only a fraction of the time required by conventional coating techniques.

I claim:

1. In the art of forming a chemical conversion coating on a metal surface by treating the surface with a chemical conversion coating solution where the metal is not immersed in the solution, the method which comprises moving the surface in one direction past and in contact with a roller, the surface of which is being driven in the opposite direction, and simultaneously applying coating solution to the region of contact between the metal and the roller, the surface speed of the roller being greater than 133⅓% of the speed of said surface past the roller, and the speed at which the roller is driven, the diameter of said roller and the speed of said surface past the roller being so related to one another that the surface speed of the roller is less than that required to throw coating solution therefrom.

2. A method according to claim **1** in which the speed of said surface past the roller is about 75 feet per minute and the diameter of said roller is about 5.5 inches.

References Cited by the Examiner

UNITED STATES PATENTS

3,098,775 7/63 Thirsk ---------------- 148—6.2

JOSEPH B. SPENCER, *Primary Examiner.*

WILLIAM D. MARTIN, RICHARD D. NEVIUS, *Examiners.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,215,564

November 2, 1965

James H. Thirsk

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 69, for "5.0 7 ft./min." read -- 75.0 ft./min. --.

Signed and sealed this 5th day of July 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents