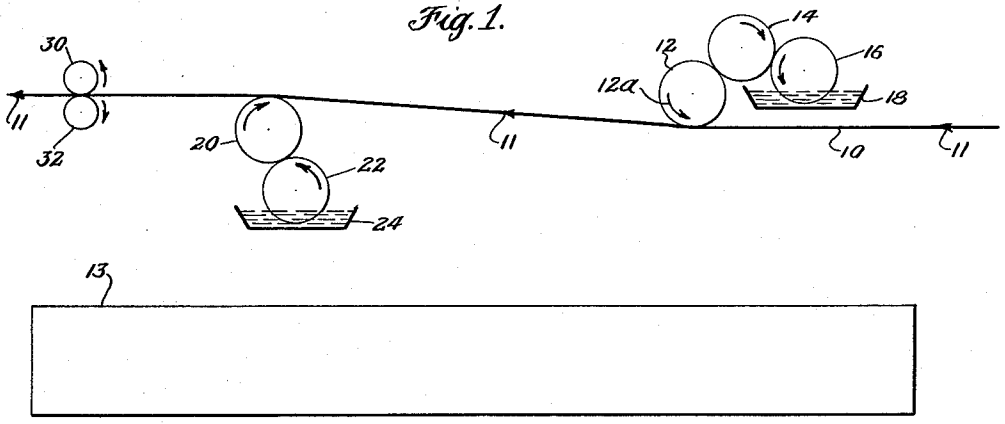
July 23, 1963 J. H. THIRSK 3,098,775

METHOD OF APPLYING A CHROMATE CONVERSION COATING TO THE SURFACE OF ALUMINUM

Filed Aug. 9, 1961

Fig. 1.



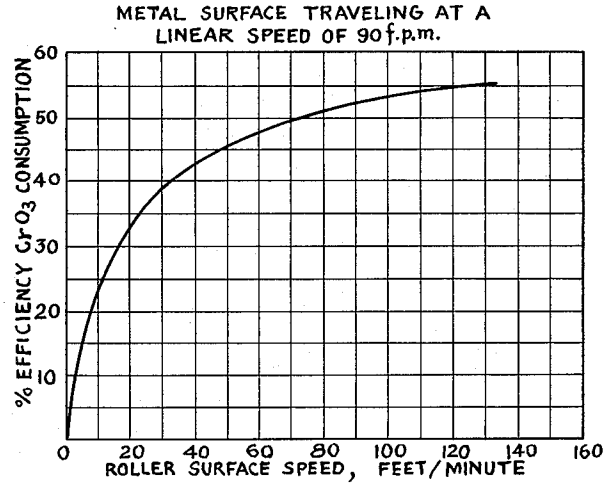


Fig. 2.

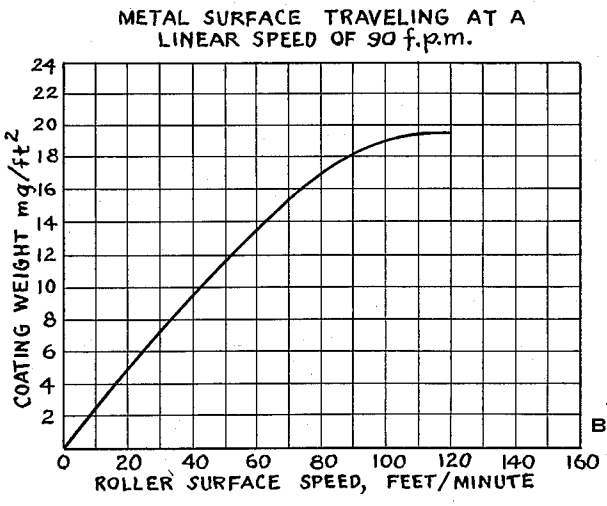


Fig. 3.

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METHOD OF APPLYING A CHROMATE CONVERSION COATING TO THE SURFACE OF ALUMINUM

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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 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 greatly improve this roller coating technique especially with respect to its efficiency, rapidity and the quality and uniformity of the results secured. 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; and

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.

My invention is based upon the unexpected discovery that the efficiency of the roller coating technique, the rapidity with which the conversion coating can be applied and the uniformity and quality of the finished work 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 has been developed in connection with the application of a chemically reactive chromate

conversion coating solution to aluminum surfaces and especially to aluminum strip. For this reason the present disclosure will be described and illustrated in its application to this specific embodiment. 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.

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 aluminum 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 chromate 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 aluminum 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 aluminum 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 a chromate conversion coating to aluminum strip I have found that there is a somewhat critical relationship which should be maintained between the reverse surface speed of the coating rollers and the opposed linear speed of the aluminum surface under treatment. For instance, I have found that at a constant linear speed of the surface under treatment, coating efficiency, within limits, is directly proportional to the speed of the reverse movement of the coating roller surface. This relationship is illustrated in FIGURE 2 which is a graph plotting the roller surface speed in feet per minute against the percent efficiency on $CrCO_3$ consumption. This will be discussed below in greater detail.

In addition to the improved coating efficiency obtain-

able as illustrated in FIGURE 2, I have discovered that with my reverse roller coating technique the weight of the finished chromate conversion coating is also directly proportional to the speed of the reverse movement of the coating roller surface at a constant linear speed of the surface being treated. This relationship is illustrated in FIGURE 3 where the weight of the applied coating in milligrams per square feet is plotted against the roller surface speed in feet per minute.

By way of specific example I will now describe my invention as it was employed in applying a chromate conversion coating to aluminum strip moving at a linear speed of travel of 90 ft. per 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 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.

Run No.	Reverse roller speed, feet per minute	Coating efficiency, percent	Coating weight, mgs. per 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 this the 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 ft. per 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.

These improvements in results are illustrated in the graphs of FIGURES 2 and 3, FIGURE 2 showing the direct relationship which was found to exist between roller surface motion in the direction opposite to that of the surface under treatment and the coating efficiency resulting therefrom under constant conditions. From the graph it will be seen that increases in the speed of the coating rollers appreciably increased the coating efficiency up to a maximum of about 120 feet per minute.

In operating the process of this invention in connection with the application of a chromate conversion coating on aluminum I have found it best and therefore prefer to maintain the speed of the reverse surface motion of the coating rollers at least as great as 50% of the

opposed linear speed of the aluminum under treatment. This seems to yield maximum coating efficiency. Incidentally, 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. For instance, it will be observed from the graph of FIGURE 3 that where reversed roller surface speed of 90 feet per minute was employed a coating weight of 18.2 mgs. per sq. ft. resulted whereas, as noted above, use of a 90 ft. per minute speed of both the coating roller surface and the aluminum strip when moving in the same direction resulted in a coating weight of only 12.3 mgs. per 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.

The type of coating rollers which are employed in my improved process is also an important factor if best results are to be secured. To this end 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 practice, 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 well as 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.

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 speed of movement of the roller surface lying between 33⅓% and 133⅓% of the speed of movement of the metal surface.

2. In the art of forming a chromate conversion coating on an aluminum surface by treating the surface with a chromate conversion coating 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 simultane-

ously applying coating solution to the region of contact between the metal and the roller, the surface speed of the roller being from 33⅓% to 133⅓% of the speed of the moving aluminum surface.

3. The method of claim 2 in which the coating solution is fed to the aluminum surface by the contacting roller.

4. The method of claim 2 wherein the roller has a durometer hardness of from 30 to 90.

5. The method of claim 2 wherein the surface speed of the roller is at least 50% of the speed of the moving aluminum.

6. The method of claim 2 wherein the coating roller is made from elastomeric material chosen from the class consisting of plastics and natural and synthetic rubbers.

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