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VACUUM COATING APPARATUS

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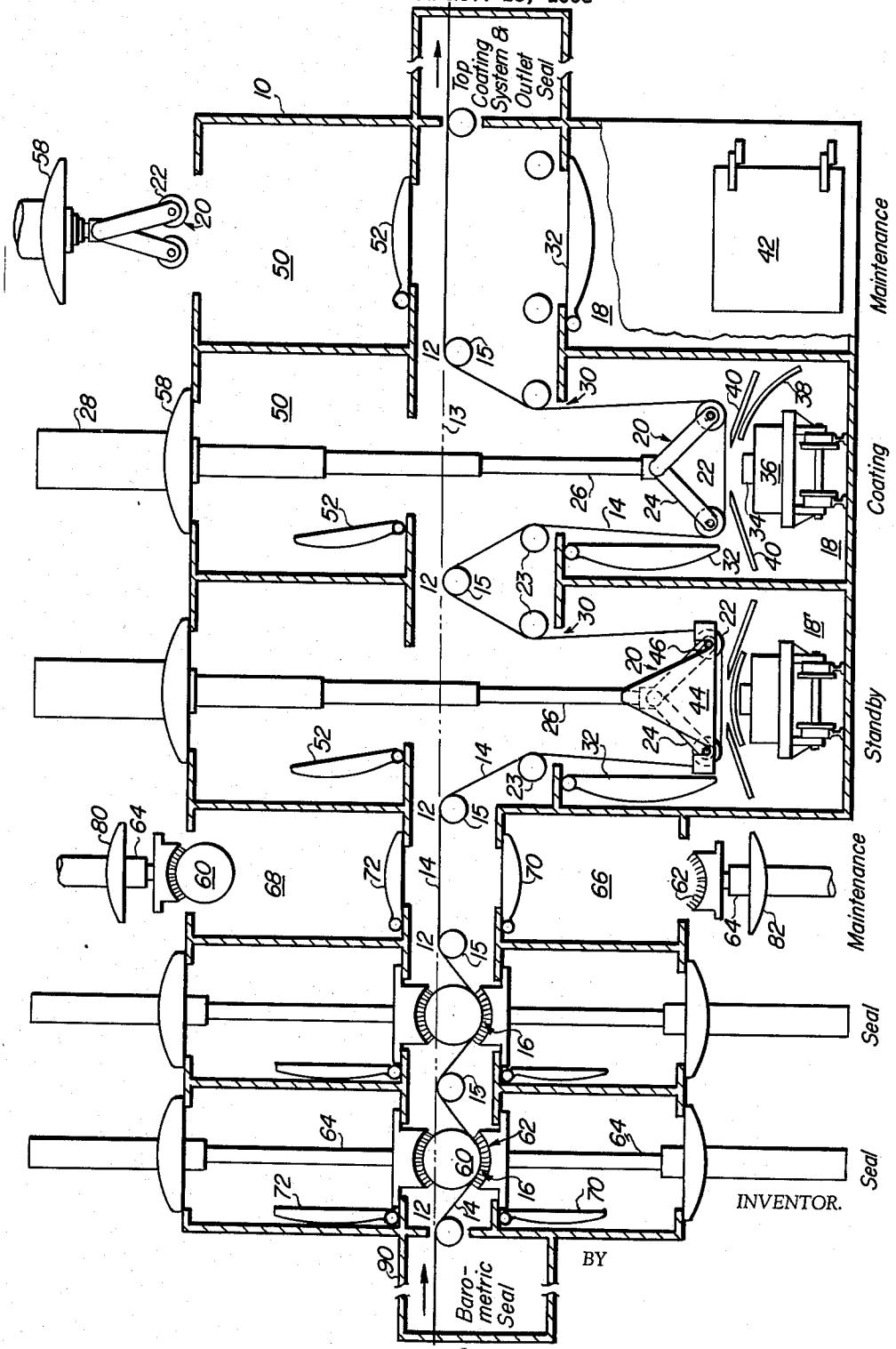

INVENTOR.

BY

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VACUUM COATING APPARATUS

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The present invention relates to coating and more particularly to coating of metallic and non-metallic substrates by high vacuum vapor deposition processes.

In the continuous coating of steel, paper and other substrates by the vacuum deposition of a thin, shiny layer of metal on the surface of the substrate, it is highly desirable that a coating machine operate continuously at high speed and be subject to easy maintenance with relatively unskilled labor.

For convenience of illustration, the present invention will be initially described in connection with its use in the aluminizing of black iron for the purpose of producing a "tin plate" substitute. This description is for illustrative purposes, it is not to be construed as limiting the scope of the invention.

In aluminizing steel, for example, it is highly desirable that the aluminum coating be applied under conditions of high vacuum, i.e. at a free air pressure on the order of less than 10 microns Hg abs. As this pressure is on the order of one 100 thousandths of an atmosphere, it is necessary that the steel strip be moved from the atmosphere to the coating chamber through seals permitting minimum passage of atmospheric air. It is also highly desirable that the seals have maximum ability to accommodate gross irregularities on the sheet such as welds, tears and the like without destroying the seal or permitting undue quantities of air and other vapors from passing through the seal. This seal provides extremely high impedance to the transfer of gases while having essentially no impedance to the transfer of the sheet and irregularities in the sheet. This is due to the wide clearance of the seal which is spanned by a great many flexible elements. One preferred embodiment of the brush seal is formed of a plurality of layers of fibers alternating with layers of plastic film. However, it is possible that such seal elements can be damaged by tears or can become contaminated by the deposition of rust, scale and the like in the seal.

It is also highly desirable in the aluminizing of steel that the machine be able to operate on an around-the-clock basis. This requires a source of a continuous supply of aluminum vapors. However, presently available sources of aluminum vapors do have a finite life and, as a general proposition, it is desirable to change sources of vapors every 6 to 8 hours. It is also possible that the aluminium vapor source may fail, due to some irregularity in the crucible material or other defect in the operation thereof which may be extremely difficult to predict in advance. It is also desirable that the portion of the apparatus exposed to the aluminum vapor source be capable of periodic cleaning, to prevent the deposition on the interior surfaces thereof of aluminum which can scale off and be carried by the sheet into the seals. Any scale or the like deposited in the seals can be very destructive to the steel sheet by scarring or scratching the sheet.

It is a principal object of the present invention to provide a continuous coating device which can be operated

continuously while permitting routine maintenance on various portions thereof.

Another object of the invention is to provide an apparatus of the above type which permits replacements or repair of various high vacuum seals without affecting the maintenance of a high vacuum in the interior portions of the apparatus.

Another object of the invention is to provide a coating apparatus of the above type which permits ready maintenance of the continuous aluminum vapor sources without interfering with the continuous operation of the machine.

Another object of the invention is to provide an apparatus which can be readily rethreaded with a substrate in the event of breakage of the substrate.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims. For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing which is a diagrammatic embodiment of one form of the invention.

In the present invention, there is provided a passage which defines a predetermined path of travel for the substrate. Along this predetermined path, there are provided a number of vacuum seals. A plurality of coating chambers are also provided along this path, and are preferably spaced from the path so that, in the normal travel of the substrate, it does not go through all of the coating stages. The apparatus preferably includes a means for deflecting the substrate out of its predetermined path and guiding the deflected substrate into, through, and back out of, a coating chamber. In a preferred embodiment of the invention, three or more coating chambers are preferably provided for coating one side of the substrate. In such an arrangement, one of the coating chambers will actually be serving as a coating chamber and will be depositing aluminum vapors and aluminum coating on the substrate moving through the coating chamber. Another coating chamber will preferably be serving as a standby and the aluminum source will be maintained at or near vaporization temperature. In this case, the substrate will preferably be guided into this standby coating chamber, but will be shielded from the coating vapors. A third coating chamber will be in maintenance.

Each coating chamber is preferably provided with a vacuum-tight door adjacent the opening between the coating chamber and the passage through which the substrate travels in its predetermined path. This door can be closed so as to completely isolate the coating chamber from the remainder of the apparatus. The thus isolated coating chamber can then be opened to atmosphere so that it may be cleaned and the source of aluminum vapors may be maintained such as by replacing crucibles, checking insulation and the like.

The vacuum sealing stations cooperate with both sides of the substrate to prevent passage of vapors therealong and each sealing station preferably comprises two cooperating portions which engage these opposite sides of the substrate. In a preferred embodiment of the invention, the apparatus is provided with more sealing stations than are necessary to obtain the desired pressure drop along the path of travel of the substrate. Thus, one or more of the seals may be made inoperative without interfering with the ability of the remainder of the seals to maintain the necessary high vacuum in the coating portion. Each sealing surface is preferably mounted so that it can be moved away from the sub-

strate into an adjacent chamber for maintenance. This adjacent chamber is provided with a door which can isolate the chamber from the passage through which the substrate moves. When this chamber has thus been isolated, it can be opened to the atmosphere and the seal can be removed for cleaning, replacement of elements, and the like.

Referring now to the drawing, there is illustrated a schematic, diagrammatic, fragmentary, sectional view of one preferred embodiment of the invention. As illustrated, the apparatus comprises a vacuum chamber generally indicated at **10** having a number of separate chambers separtaed by partitions. A plurality of vacuum pumps are required for maintaining a desired degree of vacuum in the system, but these have been omitted for the sake of clarity of illustration. Running through the center of the apparatus is a passage **12** along which the substrate **14** can travel in a predetermined path indicated by the dotted line **13**. A plurality of sealing stations, generally indicated at **16**, are provided adjacent the entrance of the coating device, while a plurality of coating stations **18** are positioned below the path **13** and so arranged that a deflecting means **20** can move the substrate **14** from the path **13** down into, and through, selected coating chambers **18**. As indicated, a plurality of rollers **15** are preferably provided along one side of the predetermined path **13** and serve to support the substrate during its travel through the machine. Other rollers **23** are provided, as indicated, for guiding the substrate during portions of time when it is deflected from its normal path.

As illustrated, one preferred embodiment, the deflecting means **20**, comprises a pair of rollers **22** carried by arms **24** shown schematically as being supported by a telescopic shaft **26** supported by an operating mechanism **28**. This arrangement permits the rollers **22** to be normally supported above the path **13** when these rollers are not serving their deflecting function. The rollers can then be moved downwardly, deflecting the substrate in the manner indicated through opening **30** serving as communication between one of the coating chambers **18** and the main passage **12**. The substrate **14** can thus be guided in close proximity to a source of aluminum vapors which is schematically indicated as a crucible **34** carried by a cart **36**. As illustrated in the lefthand chamber **18**, a cam **44** is preferably provided for spreading rollers **22** apart and rigidly supporting them in their lowermost position by engaging axles **46**.

A shield **38** is provided for preventing deposit of the aluminum vapors on the substrate during heat-up or when the coating chamber is being used as a standby. Another pair of baffles **40** are preferably included for adjusting the amount of substrate exposed to the coating source so as to control the thickness of the deposit of aluminum on the substrate. These baffles **40** also preferably prevent the deposition of aluminum on the ends of the rollers **22**.

Each coating chamber **18** may be isolated from the main passage **12** by means of door **32** which can be moved into position to seal opening **30** in a vacuum-tight fashion. Thereafter opening **42** provides access to the interior of coating chamber **18** for maintenance, cleaning and the like. Each deflecting means **20** is preferably arranged so that it can be withdrawn into a separate maintenance chamber **50** which is provided with a door **52** for isolating the chamber from the main passage **12**. Thereafter the vacuum-tight door **58** can be removed to provide access to the rollers **22** for maintenance.

Each of the seals **16** preferably comprises a roller **60** which cooperates with a brush seal schematically indicated at **62**, each of these two seal elements being carried by a moveable support **64**. The lower moveable support **64** permits dropping of the brush seal **62** into the chamber **66** which can be isolated by a door **70** from the main passage **12**. This permits removal of the brush seal **62** by means of door **82**. Similarly, roller **60** can be moved upwardly into a chamber **68** which can be isolated by means of door **72**, thereafter the roller **60** can be removed along with sealing door **80** to permit maintenance on the roller **60** and its associated sealing surfaces.

Adjacent the entrance end of the apparatus, there is shown a diagrammatic representation of a barometric seal **90**. On the exit side of the apparatus, there is provided a diagrammatic representation of a top coating system and an outlet seal. The top coating system can be identical to the bottom coating system illustrated.

One particular advantage of the apparatus illustrated in the drawing is the ease of rethreading the system if the substrate should break. This can be accomplished by merely lifting rollers **60** above the dotted line path **13** and by lifting the deflecting means **20** also above this path. This provides a substrate path along which the end of the steel sheet can be readily guided. In order to assist in this rethreading, additional guide rolls and guides can be readily provided, where necessary. For convenience of discussion all of such auxiliary equipment has been eliminated from the drawing. Many of the guide rolls can be driven or can be idler rolls, as is common practice in the steel strip handling art.

While one specific embodiment of the invention has been illustrated, it should be recognized that numerous modifications may be made without departing from the scope thereof. For example, may types of deflecting means can be employed other than that illustrated. Equally, the sheet can be deflected in a horizontal direction rather than in a vertical direction, as shown, and many different types of coating stations can be employed. Similarly, while rollers are preferred for forming the seal illustrated at **16**, this seal can be formed of two cooperating planar sealing surfaces.

When heating of the substrate or cooling thereof is desired from the standpoint of processing, heating and/or cooling means are preferably provided.

While the invention has been specifically described on the aluminizing of steel strip, it can equally be utilized for the coating of paper, plastics, textiles and other materials with aluminum, other metals and non-metals.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawing be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In apparatus for coating a substrate by vacuum deposition of a material onto a substrate wherein the substrate is moved past a source of coating vapors in a coating chamber maintained under a vacuum, the improvement which comprises a passage defining a predetermined path for travel of the substrate, a plurality of coating chambers spaced from said path, means for deflecting said substrate out of its predetermined path into one of said coating chambers, and a vacuum-tight door for sealing each said coating chamber from said passage.

2. In apparatus for coating a substrate by vacuum deposition of a material onto a substrate wherein the substrate is moved past a source of coating vapors in a coating chamber maintained under a vacuumn, the improvement which comprises a passage defining a predetermined path for travel of the substrate, a seal comprising two cooperating portions adapted to seal opposite sides of the substrate as it moves through the passage, a first moveable member supporting one of said portions, a second moveable member supporting the other of said portions, vacuum closures associated with each of said members through which said portions can be retracted from their

cooperating positions where said seal portions are isolated from the passage.

3. In apparatus for coating a substrate by vacuum deposition of a material onto a substrate wherein the substrate is moved past a source of coating vapors in a coating chamber maintained under a vacuum, the improvement which comprises a passage defining a predetermined path for travel of the substrate, a plurality of coating chambers spaced from said path, means for deflecting said substrate out of its predetermined path into one of said coating chambers, said deflecting means comprising roller means moveable from one side of said path through an opening to a coating chamber so as to deflect the substrate through said opening into said coating chamber and back out of said coating chamber to said predetermined path.

4. In apparatus for coating a substrate by vacuum deposition of a material onto a substrate wherein the substrate is moved past a source of coating vapors in a coating chamber maintained under vacuum, the improvement which comprises a passage defining a predetermined path for travel of the substrate, a plurality of coating chambers spaced from said path, means for deflecting said substrate out of its predetermined path into one of said coating chambers, said deflecting means comprising roller means moveable from one side of said path through an opening to a coating chamber so as to deflect the substrate through said opening into said coating chamber and back out of said coating chamber to said predetermined path, and a vacuum closure associated with said deflecting means through which said deflecting means may be withdrawn to a position where said deflecting means is isolated from said passage.

5. In apparatus for coating a substrate by vacuum deposition of a material onto a substrate wherein the substrate is moved past a source of coating vapors in a coating chamber maintained under a vacuum, the improvement which comprises a passage defining a predetermined path for travel of the substrate, a plurality of coating chambers spaced from said path, means for deflecting said substrate out of its predetermined path into one of said coating chambers, and a vacuum-tight door for sealing each said coating chamber from said passage, said deflecting means comprising a pair of rollers carried by a moveable member and said coating chamber including means for positioning said rollers in a predetermined location with respect to said source of coating vapors.

6. The apparatus of claim 5 wherein said coating chamber includes a second vacuum-tight door through which the source of coating vapors can be removed when said first vacuum tight door is closed.

7. The apparatus of claim 2 which includes means for guiding said substrate along the predetermined path when said sealing portions have been moved out of engagemen with the substrate.

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