

# PATENT SPECIFICATION

(11) 1 272 746

DRAWINGS ATTACHED



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- (21) Application No. 26890/68 (22) Filed 6 June 1968  
(61) Patent of Addition to No. 1 127 832 dated 14 June 1965  
(23) Complete Specification filed 31 July 1969  
(45) Complete Specification published 3 May 1972  
(51) International Classification C23C 1/14  
(52) Index at acceptance  
C7F 1G3 2A 2Z3 3C 3E 4K 5B3 G4 G5 G6 G7  
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## (54) IMPROVEMENTS RELATING TO THE COATING OF METALS

(71) We, NATIONAL STEEL CORPORATION, a Corporation organised under the laws of the State of Delaware, United States of America, of 2800, Grant Building, Pittsburgh, 19, Commonwealth of Pennsylvania, 15219, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to continuous strip hot-dip metal coating of metal sheet material.

British Patent Specification No. 10308/68 (Serial No. 1,127,832) describes a continuous metallic strip hot-dip metal coating process in which molten coating metal in excess of desired coating weight is applied to the continuous metallic strip by passing the strip longitudinally through a bath of molten coating metal having an upper surface which is exposed to a gaseous atmosphere and having a zone of controlled temperature maintained therein contiguous to the strip as the strip approaches said exposed upper surface and the continuous strip is passed in planar configuration from the zone of controlled temperature through a coating weight control zone located above the upper surface of the molten coating metal bath, in which coating weight control zone the molten coating metal applied to the strip in the bath remains molten and there is no mechanical contact with the coated strip, and in which a linearly extended narrow stream of hot gas is impinged against each of the opposite planar sides of the coated strip in the coating weight control zone across the full width of the strip in a line uniformly spaced from the upper surface of the bath and the rate of mass flow of the hot gas impinging against each side of the strip is the coating weight control zone is controlled to obtain a desired uniform weight of coating metal remaining on the strip leaving the coating weight control zone.

Specification No. 10308/68 (Serial No. 1,127,832) also describes continuous metallic strip hot-dip metal coating apparatus comprising a hot-dip bath for containing molten coating metal, guide rolls defining a travel path for longitudinal movement of the continuous metallic strip through a portion of the molten coating metal, then through a coating weight control zone located immediately above the molten coating metal, and then upwardly to a point where coating metal applied to the strip has solidified, the coating weight control zone extending upwardly from the molten coating metal through a portion of the travel path of the continuous metallic strip in which the weight of the molten coating metal applied to the strip in the bath can be controlled, a device disposed for heat exchange with molten coating metal in the bath for establishing a zone of controlled temperature coating metal in the bath contiguous to the travel path of the strip through the molten coating metal as the strip approaches the upper surface level of the bath, means for imparting a planar configuration to the strip during passage through the upper surface of the molten coating metal and through the coating weight control zone, such means including a rotatable guide roll submerged just below the coating metal surface level so as to cooperate with the metallic strip immediately prior to the passage of the strip through the upper surface of the molten coating metal, a nozzle arrangement positioned in the coating weight control zone and having two opposed linearly extended, narrow-width, gas outlets, each gas outlet having a length at least equal to the transverses edge to edge dimension of the metallic strip to be coated and each gas outlet being shaped to deliver a concentrated, narrow-width stream of hot gas and being disposed to direct said stream of gas against a respective side of the strip with hot gas impinging against the strip to prevent passage of molten coating metal in excess of desired coating weight and

to provide a substantially uniform coating weight on the continuous metallic strip, means for supplying hot gas under pressure to the nozzle arrangement and means for obtaining a desired coating weight remaining on the strip by controlling the flow of hot gas to the nozzle arrangement.

According to the present invention, the streams of hot gas are replaced by linearly extended narrow streams of unheated gas which are impinged against both sides of the coated strip and it is not essential that the controlled temperature zone be at the exit side of the bath.

In the apparatus of the present invention, the means for supplying hot gas under pressure to the nozzle arrangement are replaced by a gas compressor for supplying unheated gas under pressure and it is not essential that the controlled temperature zone be at the exit side of the bath.

Whereas, in the above mentioned patent specification, superheated steam under pressure is described as a preferred heated gaseous medium, the superheated steam preferably being at a temperature in the region of 840°F. when using the process and apparatus in a continuous strip hot dip galvanizing process, the preferred unheated gas for the process and apparatus of the present invention is compressed air which should be substantially dry relative to water and oil in order to obtain good quality product.

The invention is further described, by way of example, with reference to the drawings which accompany the provisional specification and in which:—

Fig. 1 is a schematic view of hot dip coating apparatus constructed in accordance with the present invention; and

Fig. 2 is a schematic front elevational view of the coating apparatus with some of the parts shown in section.

Referring to the drawings, steel strip is prepared for hot-dip coating by means of cleaning and/or annealing apparatus 12 and is delivered through a controlled atmosphere chute 14 into a coating bath 16 where molten coating metal in excess of the desired final coating weight adheres to the strip. Normally the temperature of the strip 18 as it enters the bath is several hundred degrees above atmospheric temperature and may be at a temperature higher than the temperature of the bath in order to add heat to the bath. The strip 18 may however be at a temperature lower than the temperature of the bath so that the bath adds additional heat to the strip. Due to this and due to changes in line speed, strip thickness and width, etc., the temperature of the major portion of the bath tends to fluctuate but a portion 20 of the coating bath is maintained at a substantially constant temperature by submerged temperature regulator tubes 21. The strip 18

after passage around a sink roll 22 passes upwardly through this controlled temperature portion 20 towards a top roll 23.

After exit from the coating bath the strip passes through a coating weight control zone where a gaseous barrier established by unheated air jets from nozzles 24 and 26 determines the final coating weight. The unheated air is made to impinge upon both sides of the strip uniformly across the full width of the strip in two opposed streams. Each stream emerges from a respective gas outlet 84 which extends the full width of the strip but which is comparatively narrow in the direction of strip travel, the gas outlet dimension in this direction preferably being between 5 and 15 thousandths of an inch.

Each nozzle 24 or 26 includes two die members 72 and 74 which are separated by shim stock 80 whose thickness determines the narrowness of the gas outlet. The die members 72 and 74 together define a manifold communicating with the gas outlet 84 throughout its length measured transversely of the strip. Several compressed air inlets 83 are connected to the die member 72 at points spaced apart along the length of the manifold with the direction of entry of air into the respective manifold substantially perpendicular to the direction of air discharged from the gas outlet 84.

The construction of the nozzles 24 and 26 is described more fully in Application No. 25065/65 (Serial No. 1,127,831). Each nozzle is provided with adjustment gearing (not shown) to enable the spacing between each nozzle and the adjacent surface of the strip to be continuously adjusted. The adjustment means are mounted on both longitudinal ends of the nozzles and are calibrated and adjustable from the same side of the equipment.

The nozzles 24 and 26 are positioned to impinge the air against the strip whilst the coating metal is molten and at a proper temperature. Thus the nozzles should be positioned quite close to the exposed surface of the coating bath but in such a way as not to induce turbulence at the surface of the coating bath, which might prevent a satisfactory smooth coating finally from being obtained. Thus the nozzles should not be inclined downwardly to too great an extent and the angle of impingement of unheated air against the strip should not be more than 15° and preferably not more than 10° above the perpendicular. Substantially perpendicular impingement is preferred. The term "substantially perpendicular" as used herein to denote the angle of impingement, includes impingement within the range of at the most 5° above and below the perpendicular with the limitation on the upwardly angled nozzle not being as critical as the downwardly inclined nozzle limitation. The

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nozzles may be so mounted that their inclination and their height above the exposed upper surface of the molten metal can be adjusted, for example, as described in Specification No. 1,071,572.

In order to obtain a desired planar configuration of the strip as it moves through the coating weight control zone a guide roll 28 engages the strip below but adjacent the bath surface at the controlled temperature portion 20 and applies a force to the strip which may co-operate with an upper guide roll 30 to control positioning of the strip. The guide roll 28 is preferably freely rotatable and both guide rolls 28 and 30 make contact with the strip as closely as possible to the coating weight control zone without interfering with the coating operation and the coating surface. Heat is removed from the strip after it leaves the coating weight control zone by air or wet steam which is ejected from a spout 32 to solidify the coating before contact with the guide roll 30. The wet steam discharged from the spout 32 may minimise spangle formation by rapidly solidifying the coating, as described in British Patent Specification No. 1,057,533.

The controlled temperature portion 20 of the bath is preferably cooled in the manner described in Patent Application No. 1,116,221. For this purpose, fluid coolant tubes 50, each preferably surrounded by a conduit 52 containing a heat conductive material 54, such as molten lead, for safety purposes, are submerged in the bath portion 20. Fluid flow in the tubes 50 is controlled by a valve 56 which may be adjusted responsively to temperature control apparatus 58 which receives signals from a temperature measuring device 60. Water is a preferred coolant.

Unheated atmospheric air is inducted through a filter 61 by a pump 62 and thereby compressed to a suitable pressure. Since the air to be impinged against the strip must be clean and substantially dry with respect to water and oil, the outlet air from the pump 62 is passed through cleaning apparatus, such as an oil trap 63, a filter 64 and a desiccator 65. Each nozzle 24 and 26 receives compressed air from the pump 62 through a valve 68 which serves to control the pressure of the air supplied to the respective nozzle 24 or 26. The valve 68 is adjusted responsively to the pressure in the nozzle 24 or 26 as measured by a control meter 66 so that this pressure is kept at a value selected at the meter 66.

To enable continuous automatic coating weight control to be effected, a non-contact coating thickness measurement device, such as a beta-ray back scattering gauge 67, is positioned on each side of the strip 18. The thickness measurements from the beta-ray gauges are delivered to coating weight con-

trol apparatus 69 and co-ordinated with the selected coating weight to automatically continuously adjust the pressure delivered to each coating weight control nozzle or to automatically continuously control the spacing between each nozzle and its respective side of the strip 18. Control signals are delivered over the dotted lines shown to a pressure control meter, such as the meter 66, for each surface of the strip and to motors (not shown) for actuation of the spacing adjustment gearing. Different coating weights on the opposite sides of the strip may be achieved by maintaining the pressure in one nozzle higher than that in the other and/or by maintaining one nozzle closer to the strip than the other.

It has been found that an air pressure of 25 p.s.i. in each of the nozzles 24 and 26 will enable results to be achieved which are comparable with those obtained by impingement with superheated steam, as described in Application No. 25065/65 (Serial No. 1,127,831). These results may be obtained with a nozzle gap of fifteen thousandths of an inch and satisfactory results may be obtainable with a pressure of 20 p.s.i. for this nozzle gap. With wider nozzle gaps still lower pressures may be used. However pressures higher than 25 p.s.i. may be used if desired and in fact pressures up to 200 p.s.i. may be satisfactory.

The oil trap 63 and the desiccator 65 ensure that the air in the nozzles 24 and 26 and issuing from the nozzle openings 84 has a sufficiently low dew point to prevent condensation or the accumulation of water or oil in the system and in particular to prevent condensation in the air issuing from the nozzles.

It has been found that unheated air, as opposed to superheated steam, produces a brighter product and a somewhat larger spangle formation. Also a slightly thinner alloy layer is present between the spelter and the steel base. The spelter is a conventional zinc spelter with a slight addition of aluminium (up to 0.30%) to inhibit the alloying of the zinc with the base metal.

Whilst the temperature of the portion 20 of the galvanising bath is shown as being controlled by a coolant passed through tubes 50 immersed in the bath, one alternative means of maintaining the temperature of this portion of the bath constant is that described in Application No. 1012/68 (Serial No. 1,153,552). The apparatus described in the latter application comprises at least one trough having an open bottom for confining a liquid coolant in contact with an upper surface portion of the molten metal coating bath and means for supplying liquid coolant to the trough and for controlling the rate of flow of liquid coolant into the trough. In the use of this alternative apparatus, the

liquid coolant should have a vaporisation temperature lower than the temperature of molten metal in the hot dip metal coating bath and is conveniently water.

- 5 Whatever method of cooling is used for maintaining the temperature of the portion 20 of the bath substantially constant, this temperature is conveniently kept at around 820°F. to 880°F. and preferably around 860°F. for strip steel galvanizing operations in which the temperature of the remainder of the bath 16 is around 950°F. to 1000°F.

- 10 In certain instances, e.g. when the temperature of the strip entering the bath is on the high side in producing dull coat galvanized product, it has been found that the temperature of the bath at the strip-entry side may reach so high that an objectionably thick layer of zinc-iron alloy may be formed on the strip or the composition or crystalline structure of this iron-zinc alloy may be altered by the high temperature from that produced at optimum temperatures. Thus it may be preferable for the controlled temperature zone to be at the strip entry side of the bath as described in copending Application No. 38455/69 (Serial No. 1,272,604), rather than at the strip exit side. In other words, at least one trough as described above can be arranged adjacent the chute 14. Alternatively it may be satisfactory and convenient to provide one cooling trough at the back of the bath behind the chute 14 and another cooling trough at the front of the bath and in front of the exiting strip. In this case the temperature of substantially the whole of the bath is controlled.

- 40 Whilst the invention has been illustrated in the case of the use of unheated air for the control of the coating weight of zinc-coated steel, the invention includes the use of other unheated gases, such as nitrogen and other hot-dip coating processes, such as aluminium hot dip coating.

- 45 Attention is drawn to Patent Application No. 25,065/65 (Serial No. 1,127,831) which relates to gaseous barrier coating weight control with substantially perpendicular impingement.

- 50 Attention is also drawn to Patent Applications Nos. 10,309/68 and 26891/68 (Serial Nos. 1,127,833 and 1,272,747) which are directed to the automatic continuous control of the coating weight utilizing a gas barrier coating weight control zone.

#### WHAT WE CLAIM IS:—

- 60 1. A continuous metallic strip hot-dip metal coating process in which molten coating metal in excess of desired coating weight is applied to the continuous metallic strip by passing the strip longitudinally through a bath of molten coating metal having an upper surface which is exposed to a gas-

eous atmosphere, the temperature of at least a portion of the bath contiguous to the strip immersed in the molten coating metal being controlled and the continuous strip is passed in planar configuration from the upper surface of the molten coating metal bath, in control zone located above the upper surface of the molten coating metal bath, in which coating weight control zone the molten coating metal applied to the strip in the bath remains molten and there is no mechanical contact with the coated strip, and in which a linearly extended narrow stream of unheated gas is impinged against each of the opposite planar sides of the coated strip in the coating weight control zone across the full width of the strip in a line uniformly spaced from the upper surface of the bath and the rate of mass flow of the unheated gas impinging against each side of the strip in the coating weight control zone is controlled to obtain a desired uniform weight of coating metal remaining on the strip leaving the coating weight control zone.

2. A process as claimed in claim 1 in which two streams of unheated gas are impinged against the strip in substantially opposed relationship.

3. A process as claimed in claim 1 or 2 in which the mass rate of flow of unheated gas in one stream is greater than the mass rate of flow of unheated gas in the other stream to thereby produce different coating weights on the opposite sides of the strip.

4. A process as claimed in any of claims 1 to 3 in which each stream of unheated gas is directed against the strip from a nozzle to which the unheated gas is supplied under pressure.

5. A process as claimed in claim 4 in which the gas is supplied to the nozzles at a pressure of at least twenty pounds per square inch.

6. A process as claimed in claim 5 in which the gas is supplied to the nozzles at a pressure between twenty five and two hundred pounds per square inch.

7. A process as claimed in claim 4, 5 or 6 in which control of the weight of coating metal remaining on the strip at a desired strip speed is achieved by adjusting the distances of the nozzles from the strip.

8. A process as claimed in claim 7 in which one nozzle is positioned closer to the strip than the other nozzle to thereby produce different coating weights on the opposite sides of the strip.

9. A process as claimed in claim 7 or 8 in which the coating weight remaining on at least one side of the strip after it has left the coating weight control zone, is continuously measured and the distance of the respective nozzle from the strip is continuously controlled responsively to the coat-



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liquid coolant should have a vaporisation temperature lower than the temperature of molten metal in the hot dip metal coating bath and is conveniently water.

- 5 Whatever method of cooling is used for maintaining the temperature of the portion 20 of the bath substantially constant, this temperature is conveniently kept at around 820°F. to 880°F. and preferably around 10 860°F. for strip steel galvanizing operations in which the temperature of the remainder of the bath 16 is around 950°F. to 1000°F.

- 15 In certain instances, e.g. when the temperature of the strip entering the bath is on the high side in producing dull coat galvanized product, it has been found that the temperature of the bath at the strip-entry side may reach so high that an objectionably thick layer of zinc-iron alloy may be formed 20 on the strip or the composition or crystalline structure of this iron-zinc alloy may be altered by the high temperature from that produced at optimum temperatures. Thus it may be preferable for the controlled temperature zone to be at the strip entry side 25 of the bath as described in copending Application No. 38455/69 (Serial No. 1,272,604), rather than at the strip exit side. In other words, at least one trough as described above can be arranged adjacent the 30 chute 14. Alternatively it may be satisfactory and convenient to provide one cooling trough at the back of the bath behind the chute 14 and another cooling trough at 35 the front of the bath and in front of the exiting strip. In this case the temperature of substantially the whole of the bath is controlled.

- 40 Whilst the invention has been illustrated in the case of the use of unheated air for the control of the coating weight of zinc-coated steel, the invention includes the use of other unheated gases, such as nitrogen and other hot-dip coating processes, such as 45 aluminium hot dip coating.

- Attention is drawn to Patent Application No. 25,065/65 (Serial No. 1,127,831) which relates to gaseous barrier coating weight control with substantially perpendicular impingement. 50

- Attention is also drawn to Patent Applications Nos. 10,309/68 and 26891/68 (Serial Nos. 1,127,833 and 1,272,747) which are directed to the automatic continuous control of the coating weight utilizing a gas barrier coating weight control zone. 55

#### WHAT WE CLAIM IS:—

1. A continuous metallic strip hot-dip metal coating process in which molten coating metal in excess of desired coating weight 60 is applied to the continuous metallic strip by passing the strip longitudinally through a bath of molten coating metal having an upper surface which is exposed to a gas-

eous atmosphere, the temperature of at least 65 a portion of the bath contiguous to the strip immersed in the molten coating metal being controlled and the continuous strip is passed in planar configuration from the upper surface of the molten coating metal bath, in control zone located above the upper surface of the molten coating metal bath, in which coating weight control zone the molten coating metal applied to the strip in the bath remains molten and there is no mechanical contact with the coated strip, and in which a linearly extended narrow stream of unheated gas is impinged against each of the opposite planar sides of the coated strip in the coating weight control zone across the full width of the strip in a line uniformly spaced from the upper surface of the bath and the rate of mass flow of the unheated gas impinging against each side of the strip in the coating weight control zone is controlled to obtain a desired uniform weight of coating metal remaining on the strip leaving the coating weight control zone. 70 75 80 85

2. A process as claimed in claim 1 in which two streams of unheated gas are impinged against the strip in substantially opposed relationship. 90

3. A process as claimed in claim 1 or 2 in which the mass rate of flow of unheated gas in one stream is greater than the mass rate of flow of unheated gas in the other stream to thereby produce different coating weights on the opposite sides of the strip. 95

4. A process as claimed in any of claims 1 to 3 in which each stream of unheated gas is directed against the strip from a nozzle to which the unheated gas is supplied under pressure. 100

5. A process as claimed in claim 4 in which the gas is supplied to the nozzles at a pressure of at least twenty pounds per square inch. 105

6. A process as claimed in claim 5 in which the gas is supplied to the nozzles at a pressure between twenty five and two hundred pounds per square inch. 110

7. A process as claimed in claim 4, 5 or 6 in which control of the weight of coating metal remaining on the strip at a desired strip speed is achieved by adjusting the distances of the nozzles from the strip. 115

8. A process as claimed in claim 7 in which one nozzle is positioned closer to the strip than the other nozzle to thereby produce different coating weights on the opposite sides of the strip. 120

9. A process as claimed in claim 7 or 8 in which the coating weight remaining on at least one side of the strip after it has left the coating weight control zone, is continuously measured and the distance of the respective nozzle from the strip is continuously controlled responsively to the coat- 125

ing weight so measured to maintain the coating weight substantially constant at that side of the strip.

10. A process as claimed in any of claims 4 to 8 in which the coating weight remaining on at least one side of the strip, after it has left the coating weight control zone, is continuously measured and the pressure of unheated gas supplied to the respective nozzle is continuously controlled responsively to the coating weight so measured to maintain the coating weight substantially constant at that side of the strip.

11. A process as claimed in any of claims 1 to 10 in which a substantially planar configuration is imparted to the strip entering the coating weight control zone by mechanically contacting the strip while the strip is submerged in the molten metal coating bath immediately prior to passage of the strip through the upper surface of the molten coating metal.

12. A process as claimed in claim 11 in which the strip is contacted by a first guide roll submerged just below the coating metal surface and by a second guide roll above the coating weight control zone and above the point at which the coating metal has solidified.

13. A process as claimed in any of claims 1 to 12 in which a portion of the molten bath of coating metal contiguous to the immersed strip is cooled to provide a zone of controlled temperature at a temperature substantially lower than the remaining portion of the molten bath of coating metal.

14. A process as claimed in claim 13 in which the strip is steel strip.

15. A process as claimed in claim 14 wherein the molten bath of coating metal comprises galvanizing spelter and the zone of cooled spelter is maintained in a temperature range between 800°F and 860°F, inclusive.

16. A process as claimed in claim 13, 14 or 15 wherein said portion of the molten bath of coating metal is cooled by coolant flow through conduit means submerged in the molten bath of coating metal.

17. A process as claimed in claim 13, 14 or 15 wherein said portion of the molten bath of coating metal is cooled by confining a liquid coolant within a trough arrangement having an open bottom in direct contact with a portion of the upper surface of the bath.

18. A process as claimed in claim 17 in which the coolant has a vaporization temperature lower than the temperature of the bath.

19. A coating process as claimed in any of claims 13 to 18 in which heat is continuously added to the bath of coating metal

by heating the strip prior to entry of the strip into the bath.

20. A process as claimed in any of claims 1 to 19, in which the unheated gas is unheated air substantially free of water and oil.

21. A process as claimed in any of claims 1 to 20, in which the controlled temperature zone is contiguous to the strip as the strip approaches said exposed upper surface.

22. A process as claimed in any of claims 1 to 21, in which each stream of gas impinges against the strip at an angle of incidence between five degrees below the perpendicular and fifteen degrees above the perpendicular, inclusive.

23. A process as claimed in claim 22, in which said angle of incidence of gas impingement lies between zero and fifteen degrees above the perpendicular, inclusive.

24. A process as claimed in claim 22 or 23, in which said angle of incidence of gas impingement is not more than ten degrees above the perpendicular.

25. A process as claimed in claim 22, in which said gas impinges substantially perpendicularly (as hereinbefore defined) against said strip.

26. A continuous metallic strip hot-dip metal coating process substantially as herein described with reference to the drawings accompanying the provisional specification.

27. Metallic strip when metal coated by the process claimed in any of claims 1 to 26.

28. Continuous metallic strip hot-dip metal coating apparatus comprising a hot-dip bath for containing molten coating metal, guide rolls defining a travel path for longitudinal movement of the continuous metallic strip through a portion of the molten coating metal, then through a coating weight control zone located immediately above the molten coating metal, and then upwardly to a point where coating metal applied to the strip has solidified, the coating weight control zone extending upwardly from the molten coating metal through a portion of the travel path of the continuous metallic strip in which the weight of the molten coating metal applied to the strip in the bath can be controlled, a device disposed for heat exchange with molten coating metal in the bath to control the temperature of at least a portion of the coating metal in the bath contiguous to the travel path of the strip through the molten coating metal, means for imparting a planar configuration to the strip during passage through the upper surface of the molten coating metal and through the coating weight control zone, such means including a rotatable guide roll submerged just below the coating metal surface level so as to cooperate with the metallic strip immediately prior to the passage of the strip through the upper surface of the molten coating metal, a





nozzle arrangement positioned in the coating weight control zone and having two opposed linearly extended, narrow-width gas outlets, each gas outlet having a length at least equal to the transverse edge to edge dimension of the metallic strip to be coated and each gas outlet being shaped to deliver a concentrated, narrow-width stream of unheated gas and being disposed to direct said stream of gas against a respective side of the strip with the gas impinging against the strip to prevent passage of molten coating metal in excess of desired coating weight and to provide a substantially uniform coating weight on the continuous metallic strip, a gas compressor for supplying unheated gas under pressure to the nozzle arrangement and means for obtaining a desired coating weight remaining on the strip by controlling the flow of unheated gas to the nozzle arrangement.

29. Apparatus as claimed in claim 28 in which the hot-dip bath contains a molten metal whose upper surface is exposed to a gaseous atmosphere so that the metallic strip is free of mechanical contact between a point below the upper surface of the molten coating metal and a point above the coating weight control zone.

30. Apparatus as claimed in claim 28 or 29 in which each linearly extended gas outlet is positioned to face an opposite planar surface of the strip and is uniformly spaced from the strip and from the upper surface level of the bath.

31. Apparatus as claimed in claim 28, 29 or 30 in which the spacing between each gas outlet and the coated strip in the coating weight control zone is adjustable during impingement of the strip by the unheated gas to thereby control the coating weight remaining on the strip.

32. Apparatus as claimed in claim 31 in which the means for obtaining a desired coating weight includes means for continuously measuring the coating weight remaining on at least one side of the strip, after it has left the coating weight control zone, and means for continuously controlling the distance of the respective gas outlet from the strip responsively to the coating weight so measured to maintain the coating weight substantially constant at that side.

33. Apparatus as claimed in any of claims 28 to 31 in which the means for obtaining a desired coating weight includes means for continuously measuring the coating weight remaining on at least one side of the strip, after it has left the coating weight control zone, and for continuously controlling the pressure of gas supplied to the gas outlet at the respective side of the strip responsively to the coating weight so measured to maintain the coating weight substantially constant at that side.

34. Apparatus as claimed in any of claims 28 to 33 in which said device for controlling the temperature of at least a portion of the coating metal in the coating bath comprises cooling means located in the coating bath and means for providing fluid coolant for the cooling means.

35. Apparatus as claimed in claim 34 wherein the cooling means include at least one conduit for fluid coolant flow submerged in the molten coating metal.

36. Apparatus as claimed in claim 34 wherein the cooling means comprises a trough arrangement having an open bottom for confining a liquid coolant in contact with the upper surface of the coating metal and means for supplying liquid coolant to the trough arrangement.

37. Apparatus as claimed in claim 34, 35 or 36 wherein means are provided for controlling fluid coolant flow responsively to the temperature of the cooled molten coating metal.

38. Apparatus as claimed in any of claims 28 to 37 in which each linearly extended narrow-width gas outlet defines a nozzle opening having a uniform width dimension of between 0.005" and 0.015", inclusive, measured transversely to the direction of gas flow.

39. Apparatus as claimed in any of claims 28 to 38 in which the nozzle arrangement includes two linearly extended manifolds substantially co-extensive with and opening throughout the length thereof into a respective one of the linearly extended gas outlets.

40. Apparatus as claimed in claim 39 in which each manifold has several gas supply conduits connected thereto at points spaced apart along the length of that manifold for supplying unheated gas thereto, the gas supply conduits having a direction of entry into the respective manifold transverse to the direction of gas discharge through the gas outlet.

41. Apparatus as claimed in claim 40 in which the direction of entry of the gas supply conduits into the respective manifold is perpendicular to the direction of gas discharge.

42. Apparatus as claimed in any of claims 28 to 41, in which the compressor is an air compressor and means are provided for removing oil and moisture from the compressed air.

43. Apparatus as claimed in any of claims 28 to 42, in which the bath contains molten zinc.

44. Apparatus as claimed in any of claims 28 to 43, in which the height of the nozzle arrangement above the upper surface level of the bath is adjustable.

45. Apparatus as claimed in any of claims 28 to 44, in which said heat exchange device is disposed to establish said

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controlled temperature zone contiguous to the strip as the strip approaches the upper surface level of the bath.

- 5 46. Apparatus as claimed in any of claims 28 to 45, in which each gas outlet is disposed to direct said stream of gas against a respective side of the strip in substantially direct opposition to and in substantially the same plane as the stream of gas from the other gas outlet with the gas impinging against the strip at an angle of incidence between five degrees below the perpendicular and fifteen degrees above the perpendicular to prevent passage of molten coating metal in excess of desired coating weight and to provide a substantially uniform coating weight on the continuous metallic strip.
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- 20 47. Apparatus as claimed in claim 46, in which the nozzle arrangement is such that the angle of incidence of gas impingement lies between zero and fifteen degrees above the perpendicular, inclusive.

48. Apparatus as claimed in claim 46 or 47, in which the nozzle arrangement is such that the angle of incidence of gas impingement is not more than ten degrees above the perpendicular. 25

49. Apparatus as claimed in claim 46, in which the nozzle arrangement is such as to impinge the gas substantially perpendicularly (as hereinbefore defined) against said strip. 30

50. Continuous metallic strip hot-dip metal coating apparatus constructed and adapted to operate substantially as herein described with reference to and as illustrated in the drawings accompanying the provisional specification. 35

51. Metallic strip when metal coated in the apparatus of any of claims 28 to 50. 40

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1972.  
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY  
from which copies may be obtained.



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