

Nov. 28, 1967

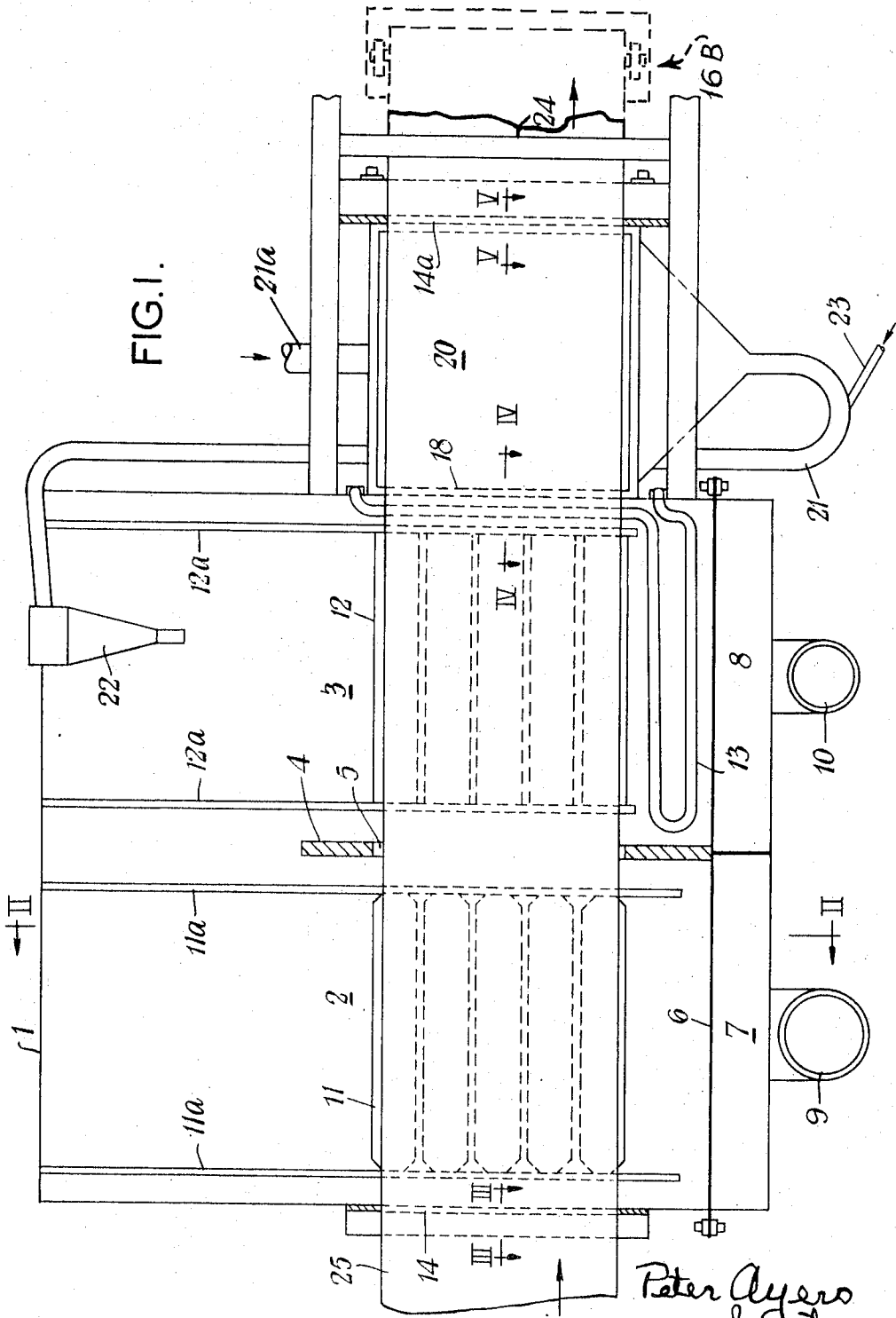
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3,355,159

APPARATUS FOR CONTINUOUS HEAT TREATMENT OF
SHEET OR STRIP MATERIAL

Filed May 22, 1963

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

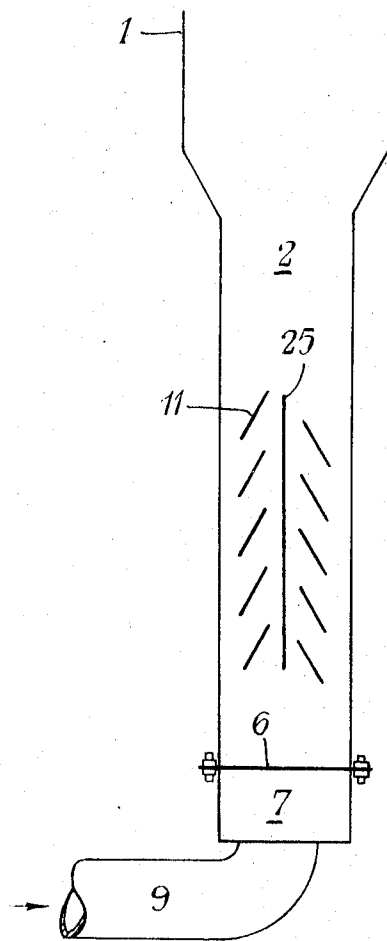


FIG. 2.

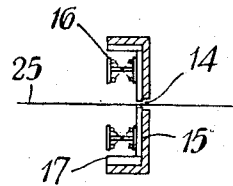


FIG. 3.

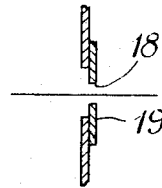


FIG. 4.

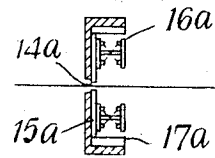


FIG. 5.

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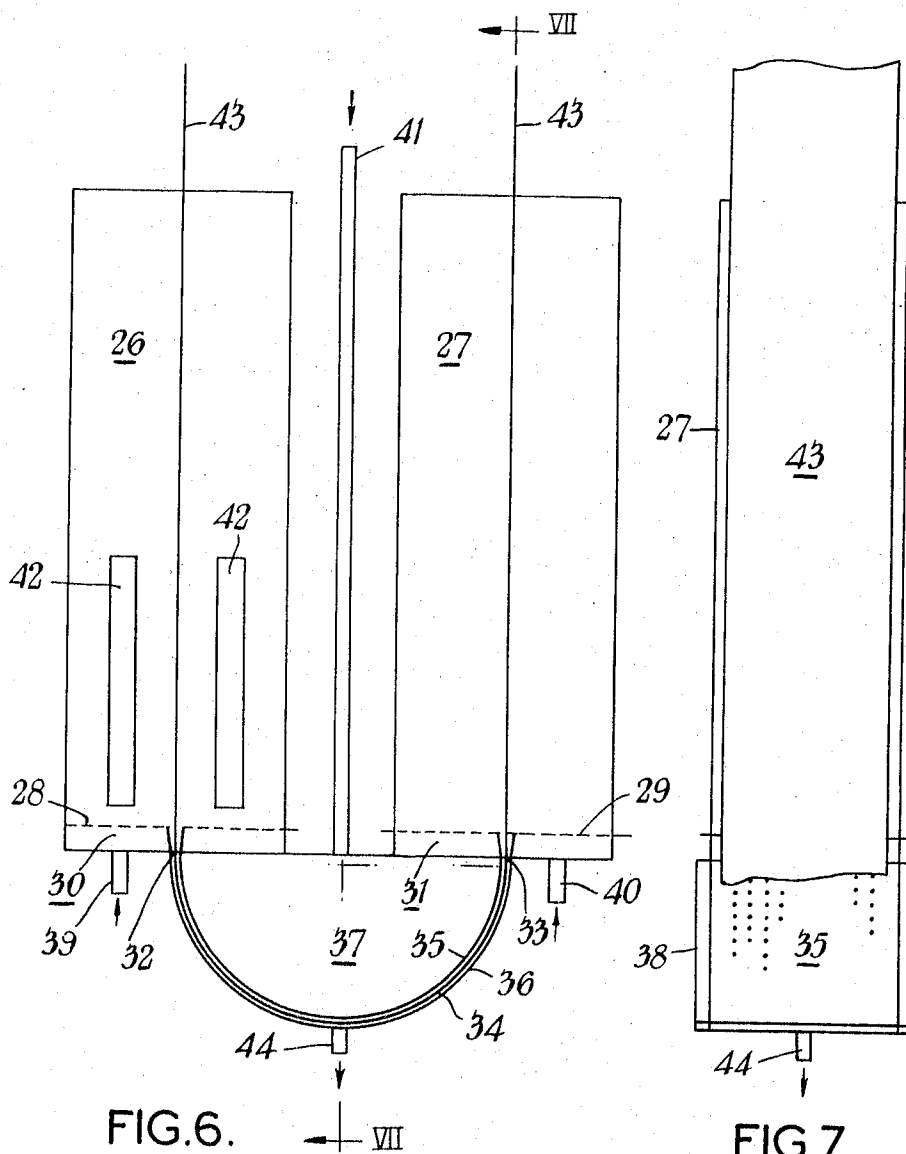
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3 Sheets-Sheet 3



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APPARATUS FOR CONTINUOUS HEAT TREATMENT OF SHEET OR STRIP MATERIAL

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Claims priority, application Great Britain,

May 23, 1962, 19,867/62

10 Claims. (Cl. 266—3)

This invention relates to improvements in the continuous heat treatment of sheet or strip material (hereinafter referred to as strip material).

It is often desirable to heat strip material to some elevated temperature as rapidly as possible and immediately to cool it again. In the case of annealing of aluminium and aluminium alloy sheet, for example, rapid heating of the metal to a suitable temperature, followed by a short holding time at that temperature, could lead to a fine grain size, could minimise high temperature oxidation staining in these alloys prone to show this defect, and where ventilation is adequate could eliminate oil staining. Rapid cooling of the metal immediately after heat treatment would facilitate handling and would reduce the possibility of mechanical damage during handling. The chief problem associated with carrying out these operations continuously on strip material, in many cases, lies in the transference of heat with sufficient speed, both to and from the strip, without at the same time causing it mechanical damage.

Known methods for continuously heat treating strip material generally comprised heating it by forced convection using air at a temperature higher than that to which it is desired to heat the strip; heating by radiant or by induction heating; or by a combination of these methods. Cooling is usually done by forced convection. However, these methods suffer from certain disadvantages. If the strip stops for any reason, or if it changes speed, then overheating and damage to the strip may result. Further, accurate control of the temperature of the strip is difficult to attain. Another known method for continuously heat treating strip material involves passing an electric current transversely through strip and making use of the resistance heating. This technique can only be successful if the material to be treated possesses a suitable electrical resistance, and it is very difficult to arrange suitable electrical contacts at the edges of the strip.

It is an object of the present invention to provide an improved method of and apparatus for continuously heat treating strip material whereby the disadvantages referred to above shall be materially reduced or entirely obviated and whereby heat may be rapidly transferred to and from the strip material without mechanical damage to the latter.

According to one aspect of the present invention, a method of continuously heat treating strip material comprises passing the strip in succession through two fluidised beds, the first of which is at a temperature greater than the second, and maintaining the strip with its wider faces in substantially vertical planes during its passage through the beds.

Preferably, the strip is passed directly from the second bed into a chamber supplied with gas under pressure to reduce any tendency of the second bed material to escape.

According to another aspect of the present invention, apparatus for heat treating strip material comprises two chambers for fluidisable material, an outlet slot from one chamber and an inlet slot to the other chamber, both slots being dimensioned and arranged to permit the passage therethrough of the strip material with its wider faces contained in substantially vertical planes, means for

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heating, and fluidising the fluidisable material in the one chamber and means for fluidising and cooling the fluidisable material in the other chamber

According to one feature of this other aspect of the present invention, apparatus for heat treating strip material comprises a container for fluidisable material having a partition defining two chambers and having a slot for the passage therethrough of the strip, an inlet slot to the first chamber to admit the strip thereto, an outlet slot from the second chamber for the passage therethrough of the strip, means for heating and fluidising the fluidisable material in the first chamber and means for fluidising and cooling the fluidisable material in the second chamber, the inlet, outlet and partition slots being arranged and dimensioned to permit the passage of the strip material therethrough with its wider faces contained in substantially vertical planes.

Preferably, the outlet slot communicates directly with a gas chamber intended to be supplied with gas under pressure to reduce the tendency of the fluidisable material in the second chamber to escape through the outlet slot, the gas chamber having a further outlet slot for the passage of the strip therethrough.

Advantageously, the outlet slot of the second chamber has a dimension normal to the wider faces of the strip which is substantially equal to the thickness of strip plus twice the diameter or major dimension of the largest particle of fluidisable material.

Desirably, the longitudinal edges of the inlet slot and the further outlet slot are defined by a resilient material, e.g. polytetrafluorethylene, which resilient material is arranged to bear on the strip in its passage through the slot defined thereby.

Conveniently, the longitudinal edges of the outlet slot from the second chamber are defined by a resilient material, e.g. rubber.

It is preferred to provide means for recycling to the second chamber any fluidisable material escaping through the outlet slot to the gas chamber.

According to another feature of the second aspect of the invention, apparatus for heat treating strip material comprises two chambers for fluidisable material, an outlet slot in the floor of one chamber, an inlet slot in the floor of the other chamber, both slots being dimensioned and arranged to permit the passage therethrough of the strip material with its wider faces contained in substantially vertical planes, an intermediate chamber connecting the outlet and inlet slots and defined by two spaced curvilinear walls, means for supplying fluid under pressure to the intermediate chamber to cushion the strip material, means for heating and fluidising the fluidisable material in the one chamber and means for fluidising and cooling the fluidisable material in the other chamber.

Some embodiments of the invention will now be described by way of example, reference being made to the accompanying drawings in which:

FIG. 1 is a somewhat diagrammatic longitudinal sectional view of an apparatus according to the invention,

FIG. 2 is a transverse section taken on the line II—II of FIG. 1,

FIG. 3 is a fragmentary section taken on the line III—III of FIG. 1,

FIG. 4 is a fragmentary section taken on the line IV—IV of FIG. 1,

FIG. 5 is a fragmentary section taken on the line V—V of FIG. 1,

FIG. 6 is a diagrammatic longitudinal section through an alternative form of apparatus, and

FIG. 7 is a fragmentary section taken on the line VII—VII of FIG. 6.

The apparatus of this example comprises a container

1 divided into two chambers 2 and 3 by a partition 4 of heat insulating material, e.g. Sindanyo sheet, having a slot 5 therein for the free passage therethrough of the strip 25 being treated. The chambers 2 and 3 contain 0.5 mm. diameter glass ballotini (not shown) up to a level above the slot 5 and the container 1 has a false bottom provided by wire cloth 6 to provide at the bottom of the container plenum chambers 7 and 8 intended separately to be supplied with air under pressure from pipes 9 and 10 respectively in order to fluidise the glass ballotini in the chambers 2 and 3. The chamber 2 is provided with heaters 11 supported by pillars 11a and disposed on either side of the path of travel of the strip through the chamber 2 (see FIG. 2) and inclined to the vertical so as to direct the fluidised medium towards the strip 25 passing through the chamber. The chamber 3 is provided with baffles 12 supported on pillars 12a and similarly arranged and also has a cooling pipe 13 immersed in the glass ballotini through which a cooling medium such as water is intended to flow to extract heat from the fluidised bed.

The chamber 2 has an inlet slot 14 the vertical longitudinal edges of which are defined by strips of resilient material 15 which, in this example, are strips of polytetrafluoroethylene. The strips 15 are spring loaded by means of coil springs 16 and strip steel springs 17 so as to bear continuously on the sheet 25 as it enters the chamber 2 through the slot 14.

The chamber 3 has an outlet slot 18 the vertical longitudinal edges of which are defined by a resilient material 19 such as rubber, the slot having a dimension transverse to the wider face of the sheet or strip 25 which is just sufficient to allow the passage of the strip through the slot 18 plus two of the largest particles of the glass ballotini placed side by side, i.e. this dimension is approximately 1 mm. plus the thickness of the sheet. The outlet slot 18 opens directly into a gas chamber 20 intended to be supplied with air under pressure along the pipe 21 so that there is an air flow from the chamber 20 through the slot 18 to the chamber 3 whereby the tendency of the glass ballotini to escape through the slot 18 is reduced. The lower end of the gas chamber 20 is of inverted conical shape and communicates by way of a pipe 21 with a cyclone separator 22, air being injected into the pipe 21 by way of a further pipe 23 such that any of the glass ballotini which escapes into the chamber 20 is returned to the chamber 3 along the pipe 21 through the cyclone separator 22. An outlet slot 14a is provided to the chamber 20 and is similar in most respects to the inlet slot 14, like reference numerals followed by the suffix *a* being used to indicate like parts. Adjacent the outlet slot 14a there is provided a pair of rubber covered rollers 24 between the bite of which the strip 25 is passed to a winding coil.

As can be seen in FIGS. 1 and 2, the container 1 has a width normal the direction of travel of the strip 25 which is small in relation to its height and its dimension parallel to the direction of travel of the strip 25. This width is increased towards the open top of the container to reduce the velocity of the air escaping therefrom.

In the operation of the apparatus described the glass ballotini in the chamber 2 is heated by the heating means 11 and fluidised by hot air supplied from the pipe 9 to provide a fluidised bed which is maintained at a selected temperature. The glass ballotini in the chamber 3 is fluidised by air at ambient temperature supplied by way of the pipe 10 and heat is extracted from this fluidised bed both by the cold air flow and by the cold water flow along the pipe 13. The strip 25 to be heat treated is fed from a coil (not shown) at a selected rate with its wider faces in substantially vertical planes through the inlet slot 14, through the chamber 2, through the slot 5 in the partition 4, through the chamber 3, through the outlet slot 18, through the chamber 20, through the further outlet slot 14a and between the rollers 16 to a conventional winding coil 16b. During the passage of the strip 25 through the

chamber 2 a rapid transfer of heat takes place to the strip and an equally rapid transfer of heat from the strip takes place in the chamber 3. The rate of travel of the strip is selected in accordance with the nature of the heat treatment required.

Although any number of pulverulent materials may be suitable for use in the fluidised beds, the glass ballotini described has been found to be very suitable as it does not adhere to the strip and there is little or no dust from the top of the bed. The term "ballotini" is a standard and recognized term to define the pulverulent material which consists of small spherical glass particles which are commonly known as ballotini. The term "ballotini" is Italian for "small balls." Smaller particles can be employed and this would reduce the quantity of air required for fluidisation. However, smaller particle sizes may increase the difficulty of sealing at the inlet and outlet slots and of avoiding damage to the sheet. Larger particles would require larger quantities of air and would give poorer quality fluidisation.

Three examples of aluminium strip treated by the above process and apparatus will now be described.

Example 1

A length of half hard temper NS5 aluminium alloy strip 6 ins. wide and 0.01 in. thick was annealed in the apparatus described. This alloy is one containing 3.5% by weight of Magnesium and 0.4% by weight of manganese as alloying constituents. Each bed was 12 ins. long, 3 ins. wide and 8 ins. deep, and the fluidised bed in the chamber 2 was maintained at a temperature of 370° C. The strip was fed at a rate of 2 ft. per minute and the properties of the annealed material were as follows:

0.1% proof stress	6.85 tons/sq. in.
U.T.S.	14.4 tons/sq. in.
Elongation	18.0%.
Grains/mm. ²	2000.
Surface condition	Free from mechanical damage.
	Free from oil staining.
	Free from high temperature oxidation discolouration.

Example 2

A length of hard temper 99.0% aluminium strip having the same dimensions as that described in Example 1 was fed at the same rate through the same apparatus but, in this case, the temperature of the fluidised bed in the chamber 2 was maintained at 400° C. The properties of the annealed material were as follows:

0.1% proof stress	2.33 tons/sq. in.
U.T.S.	5.0 tons/sq. in.
Elongation	20%.
Grains/mm. ²	2000.
Surface condition	Free from mechanical damage.
	Free from oil staining.
	Free from high temperature oxidation discolouration.

Example 3

A length of hard temper NS3 aluminium alloy strip having the same dimensions as that described in Example 1 was fed at the same rate through the same apparatus but, in this case, the temperature of the fluidised bed in the chamber 2 was maintained at 440° C. This alloy contains 1.2% by weight of manganese as alloying constituents. The properties of the annealed material were as follows:

0.1% proof stress	3.08 tons/sq. in.
U.T.S.	6.84 tons/sq. in.
Elongation	28.5%.
Grains/mm. ²	2000.
Surface condition	Free from mechanical damage.
	Free from oil staining.
	Free from high temperature oxidation discolouration.

The alternative apparatus illustrated in FIGS. 6 and 7 comprises two open-topped spaced chambers 26 and 27 for fluidisable material each having a false bottom 28 and 29 of wire cloth or similar air-permeable material to provide plenum chambers 30 and 31 respectively at the bottom of each chamber. The floor of the chamber 26 is formed with a horizontally extending slot 32, the direction of length of which is normal to the direction in which the chambers 26 and 27 are spaced. An inlet slot 33 is formed in the floor of the chamber 27 and extends parallel to the slot 32. An intermediate chamber 34 connects the slots 32 and 33 and is defined by two spaced walls 35 and 36 which are curvilinear about an axis substantially parallel to the direction of length of the slots 32 and 33. The inner wall 35 is perforated and defines a semi-cylindrical plenum chamber 37 closed by end plates 38 (FIG. 7) which also close the intermediate chamber 34. Air inlet pipes 39, 40, and 41 are respectively provided to the plenum chambers 30, 31, and 37. Heating means 42 similar to the heaters 11 of the previous example, is provided in the chamber 26 on either side of the path of travel of the metal strip indicated at 43 and cooling means (not shown) similar to the pipe 13 of the previous example, is disposed in the chamber 27.

In the operation of the apparatus described, the chambers 26 and 27 are partly filled with glass ballotini which is fluidised by the air supplied from the plenum chambers 30 and 31. The strip 43 is passed under tension vertically downwards through the open-top of the chamber 26 and out through the slot 32 in the floor thereof, through the intermediate chamber 34, up through the inlet slot 33 to the chamber 27 and out through the open top of the latter. The air supplied to the plenum chamber 37 passes through the perforations in the inner wall 35 of the intermediate chamber 34 to form a cushion of air which supports the metal strip during its passage through the intermediate chamber 34 and prevents it touching the sides of the slots 32 and 33 or the wall 35 and hence prevents mechanical damage to the strip 43. As the strip 43 is under tension, any tendency to the formation of a double curvature is materially reduced so that the width of the slots 32 and 33 can be a minimum, e.g. equivalent to the thickness of the strip plus twice the average dimension of the glass ballotini. Air supplied to the intermediate chamber 34 escapes through the slots 32 and 33 and materially reduces any tendency of the fluidised beds in the chambers 26 and 27 to escape through the respective slots. The strip, during its passage through the fluidised beds in the chambers 26 and 27, has its wider faces disposed in substantially vertical planes and, during its passage through the intermediate chamber 34 undergoes a 180° change in its direction of advance.

It is preferred to provide means for recycling any fluidised bed material which escapes to the intermediate chamber 34, this being in the form of a pipe 44 extending from the chamber 34 to a cyclone separator (not shown) and means for returning the material from the separator to one or other or both of the beds.

What I claim is:

1. Apparatus for heat treating strip material comprising two chambers for fluidisable material, an outlet slot from one chamber and an inlet slot to the other chamber, both slots being dimensioned and arranged to permit the passage therethrough of the strip material with its wider faces contained in substantially vertical planes, means for heating and fluidising the fluidisable material in the one chamber and means for fluidising and cooling the fluidisable material in the other chamber.

2. Apparatus for heat treating strip material comprising two chambers for fluidisable material, a first gas pervious fluidisable material supporting surface in one of said chambers defining a first plenum chamber, a second gas pervious fluidisable material supporting surface in the other of said chambers defining a second plenum chamber, means for supplying gas under pressure

to said first plenum chamber to fluidise the fluidisable material in said one of said chambers, heating means disposed in said one of said chambers, means for supplying gas under pressure to said second plenum chamber to fluidise the fluidisable material in said other chamber, heat extracting means disposed in said other chamber and means for advancing the strip successively through both chambers with the wider faces of the strip in substantially vertical planes.

3. Apparatus for heat treating strip material comprising first and second chambers for fluidisable material, a third chamber, a partition wall between said second and third chambers, a vertically extending slot in said partition wall dimensioned to permit the passage of the strip therethrough with the wider faces thereof in substantially vertical planes, a first gas pervious support in said first chamber defining a first plenum chamber, a second gas pervious support in said second chamber defining a second plenum chamber, heating means in said first chamber, heat extracting means in said second chamber, means for supplying gas under pressure to said first plenum chamber, means for supplying gas under pressure to said second plenum chamber, means for supplying gas under pressure to said third chamber to maintain the pressure in said third chamber at a level greater than that prevailing in said second chamber and means for advancing the strip through said first, second and third chambers with the wider faces thereof in substantially vertical planes.

4. Apparatus for heat treating strip material comprising a container, a partition wall of heat insulating material dividing said container into first and second chambers, a vertically extending slot in said partition wall dimensioned to permit the passage therethrough of the strip with the wider faces thereof in substantially vertical planes, a first gas pervious support in said first chamber defining a first plenum chamber, a first bed of fluidisable material in said first chamber supported on said first support and of a depth so as to extend to a level above said partition slot, means for supplying gas under pressure to said first plenum chamber to fluidise said first bed, a vertically extending inlet slot to said first chamber dimensioned to permit the passage of the strip therethrough with the wider faces thereof in substantially vertical planes, strips of resilient material defining the vertical edges of said inlet slot and arranged to bear against the strip entering said first chamber, heating means disposed in said first bed on either side of the path of travel of the strip between said inlet slot and said partition wall slot and arranged to direct the material of said first fluidised bed towards said path of travel, a second gas-pervious support in said second chamber defining a second plenum chamber, a second bed of fluidisable material in said second chamber supported on said second support and extending above the level of said partition slot, means for supplying gas under pressure to said second plenum chamber to fluidise said second bed, a vertically extending outlet slot from said second chamber dimensioned to permit the passage therethrough of said strip with the wider faces thereof in substantially vertical planes, strips of resilient material defining the longitudinal vertical edges of said outlet slot providing a horizontal dimension to said slot substantially equal to the thickness of said strip plus twice the major dimension of the largest particles of said second bed and heat extracting means in said second bed.

5. Apparatus according to claim 4 including a third chamber into which said outlet slot opens and means for maintaining the gas pressure in said third chamber at a level greater than that prevailing in said second chamber.

6. Apparatus according to claim 5 including means for returning from said third chamber to said second chamber any of the fluidisable material escaping through said outlet slot.

7. Apparatus according to claim 4 including baffles

disposed in said second chamber on both sides of the path of travel of the strip from the partition slot to the outlet slot and arranged to direct the material of said second bed towards said path of travel of the strip through said second chamber.

8. Apparatus for heat treating strip material comprising two chambers for fluidisable material, an outlet slot in the floor of one of said chambers, an inlet slot in the floor of the other of said chambers, both said slots being dimensioned and arranged to permit the passage therethrough of the strip with its wider faces contained in substantially vertical planes, an intermediate chamber connecting said outlet and inlet slots and defined by two spaced curvilinear walls, means for supplying fluid under pressure to said intermediate chamber to cushion the strip material, means for heating and fluidising the fluidisable material in said one chamber and means for fluidising and cooling the fluidisable material in said other chamber.

9. Apparatus for heat treating strip material comprising first and second chambers, a first gas permeable support in said first chamber defining a first plenum chamber in the lower part of said first chamber, a first bed of fluidisable material in said first chamber, means for supplying gas under pressure to said first plenum chamber to fluidise said first bed, heating means disposed in said first chamber, an outlet slot in the floor of said first chamber to permit the passage therethrough of the strip, a second gas permeable support in said second chamber defining a second plenum chamber in the lower part of said second chamber, a second bed of fluidisable material in said second chamber, means for supplying gas under pressure to said second plenum chamber to fluidise said second bed, heat extracting means disposed in said second bed, an inlet slot in the floor of said second cham-

ber, an intermediate chamber connecting said inlet and outlet slots and defined by an inner perforated curvilinear wall and an outer curvilinear wall, means for advancing the strip in succession vertically downwards through said first chamber, through said outlet slot, said intermediate chamber, said inlet slot and vertically upwards through said second chamber and means for supplying through said perforated inner wall to said intermediate chamber a gas under a pressure sufficient to maintain the strip out of contact with said inner wall.

10. Apparatus according to claim 9 including means for recycling from said intermediate chamber to at least one of said first and second chambers any fluidisable material escaping to said intermediate chamber.

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