Feb. 27, 1968 C. G. BIGELOW, JR., ET AL 3,370,648

JET COOLING OF STRIP METAL

Filed Jan. 21, 1966 2 Sheets-Sheet 1

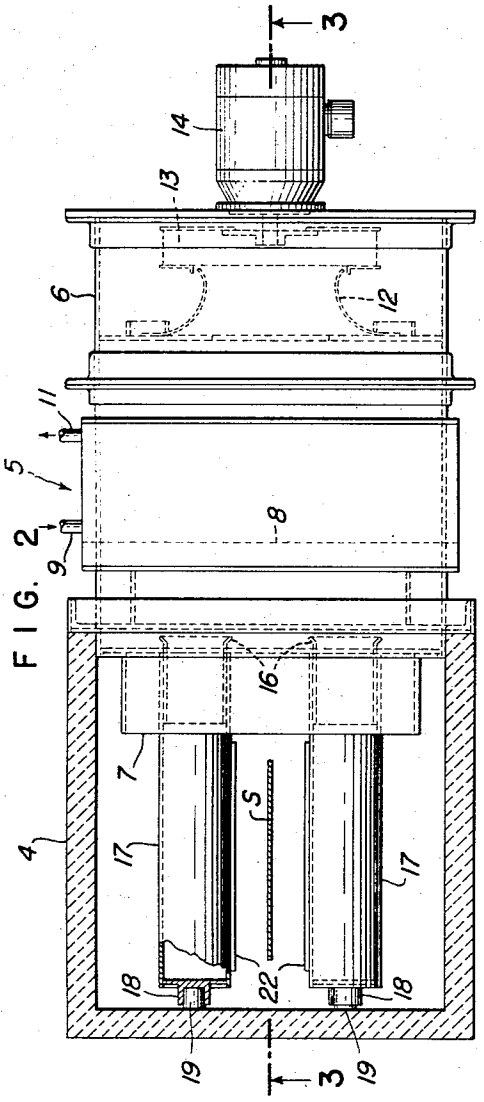


FIG. 2

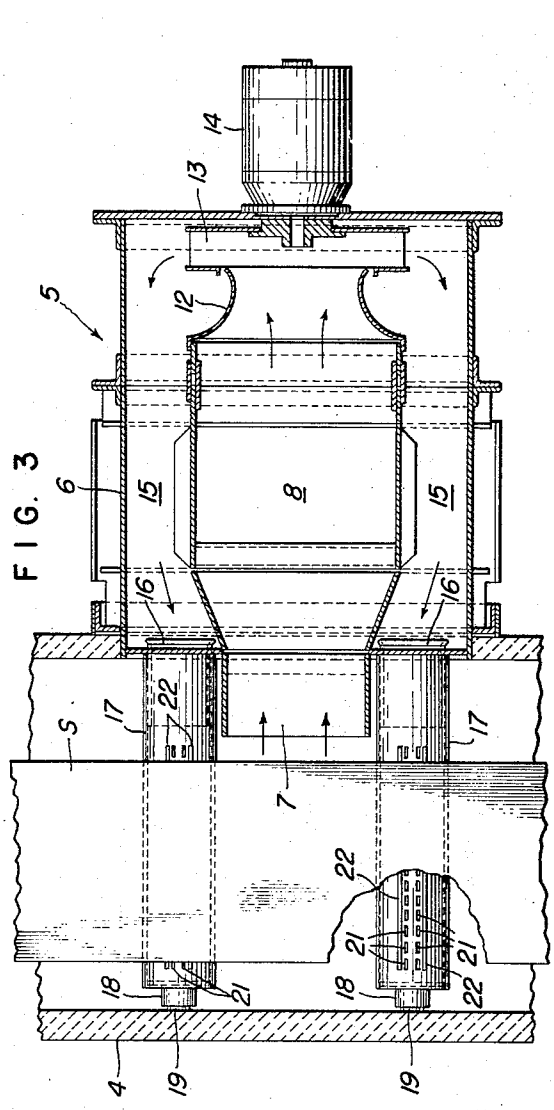


FIG. 3

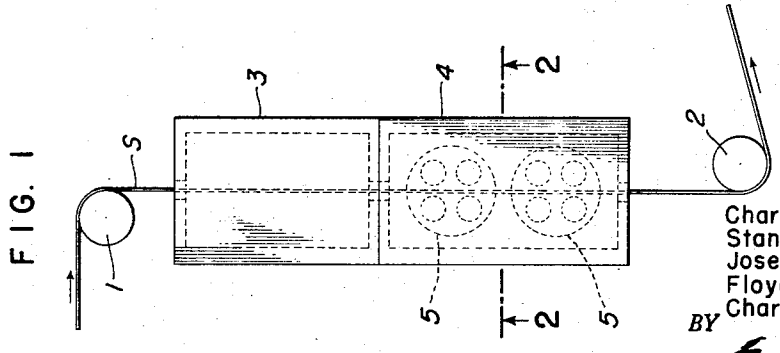


FIG. 1

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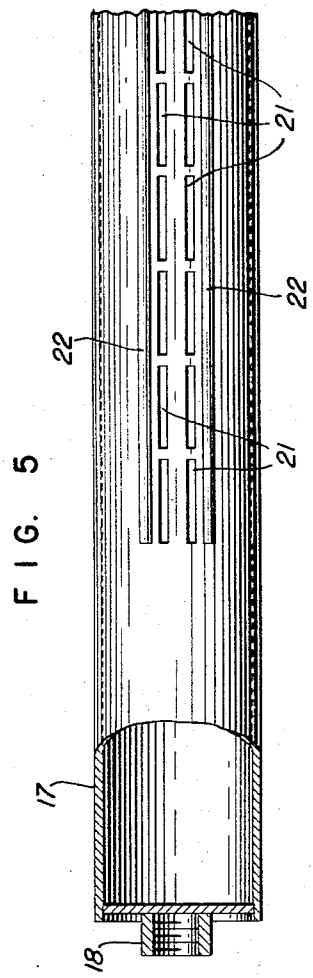


FIG. 5

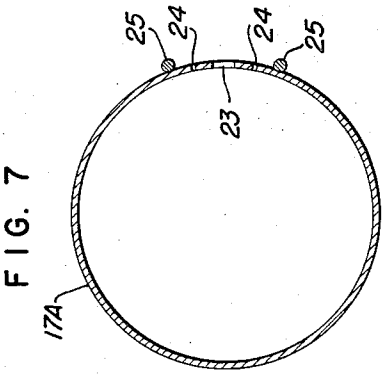


FIG. 7

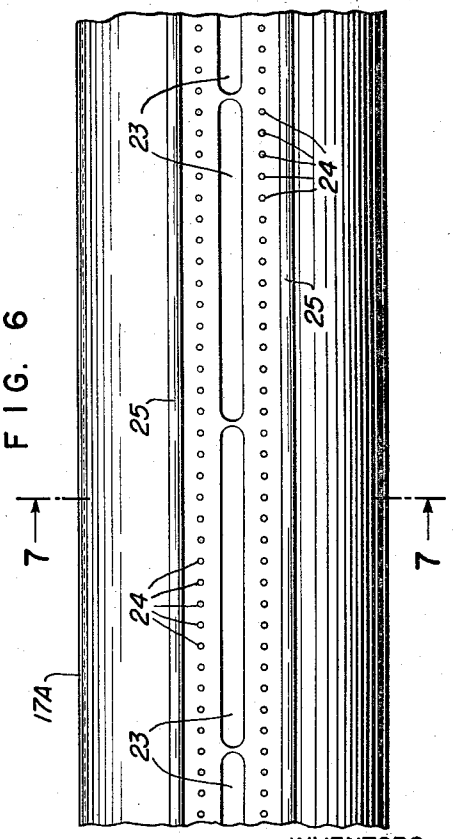


FIG. 6

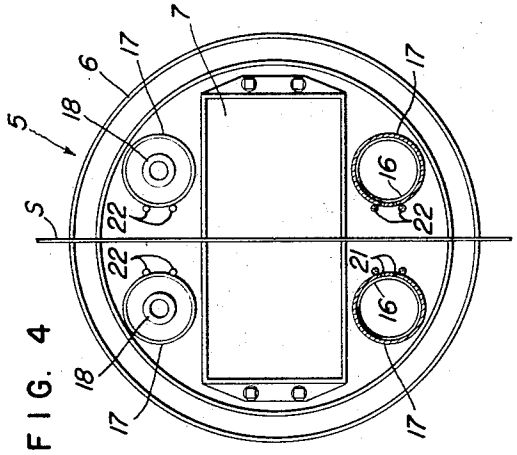


FIG. 4

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JET COOLING OF STRIP METAL

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ABSTRACT OF THE DISCLOSURE

A continuous strip of metal is cooled by a plurality of jets blown against its opposite sides as it moves from a furnace. The jet producing elements are constructed to produce eddy currents in the jets that overcome the tendency for the jets to move the strip toward the elements.

The present invention relates to apparatus for cooling strip material and more particularly to a jet cooler used for the continuous cooling of heat treated strip metal.

When strip metal such as steel is heated for annealing or other purposes, it must be cooled to a temperature suitable for a following operation to be performed on it. During the cooling, the strip surface must not be contacted since the surface of a hot strip is easily marred. This is particularly true with a strip that is to be coated or used for a decorative purpose.

It is an object of the invention to provide apparatus for rapidly cooling a moving strip of metal. A further object of the invention is to provide apparatus for cooling strip material by directing jets of a cooling gas against its opposite surfaces in such a manner that the strip will not be touched.

In practicing the invention, the strip being cooled is moved through a duct with cooling gas being blown against both sides of the strip at a plurality of locations. The jet producing means is so designed that the jets produced thereby will not cause any substantial fluttering of the web and will prevent its surface from being scratched or otherwise marred.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a diagram showing a conventional heat treating line for strip material;

FIG. 2 is a view taken on line 2—2 of FIG. 1 looking toward a cooling unit;

FIG. 3 is a section of a cooling unit taken on line 3—3 of FIG. 2;

FIG. 4 is an end view of a cooling unit, partly in section, looking from the left of FIG. 2 and FIG. 3;

FIG. 5 is an enlarged view of a portion of a tubular jet producing member;

FIG. 6 shows a modified form of tubular jet producing member; and

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

Referring to FIG. 1 of the drawing, there is shown diagrammatically one type of continuous strip heat treating line. The strip S is guided downwardly between guide roll 1 and guide roll 2. The strip passes first through a furnace 3 where it is heated to desired temperature and immediately into a cooling duct 4 where it is cooled, generally to a temperature below which it will oxidize in the

atmosphere. The furnace and the cooling duct may be of a type shown in which there is a single pass of the strip or it may be of other conventional type in which there are a plurality of passes of the strip while it is being heated and cooled. The size of the furnace and the cooling duct will depend upon the temperature to which the strip is to be heated and the speed of the strip. These features are well known in the continuous strip heating art.

The cooling duct has in it a number of jet cooling units 5 with which this invention is particularly concerned. These units are shown in detail in FIGS. 2 to 7 inclusive. Each of the cooling units includes a housing 6 having a portion which extends out of and having a portion extending into the cooling duct 4 through an opening provided in the wall thereof. The housing may be bolted to the duct in any suitable fashion. The housing 6 has extending from it to the left, in FIGS. 2 and 3, and into the cooling duct a gas intake 7 which directs the gas through a heat exchanger 8 that is supplied with a cooling medium through pipes 9 and 11 to cool the gas. Beyond the heat exchanger there is a duct 12 leading into a fan 13 that is driven by a motor 14. The fan draws gas from duct 4 and directs the cooled gas outwardly through two side ducts 15 where the gas flows back toward cooling duct 4 and through two pairs of vertically displaced tubes 16 which are rigidly attached to the housing and extend into the cooling duct.

A tubular jet directing member 17 is slid over and supported on each of the tubes 16. These jet directing members extend across the cooling duct and each is provided on its outboard end with a cup 18 that receives a stud 19 in the duct wall in order to hold them rigidly in position. Each of the tubular members 17 is provided with two horizontal extending rows of slots 21 which are spaced respectively slightly above and below a horizontal plane through the diameter of the tube 17 and are directed toward the strip. These slots can be accurately positioned by rotating tubes 17 on their supports 16. Above the upper row of slots 21 and parallel thereto is a rib or projection which can take the form of a rod 22 fastened to the tube surface and below the lower row of slots there is provided a second similar projection 22. The rows of slots 21 and the projections 22 extend axially along member 17 a distance slightly greater than the width of the strip being cooled. As an example, if the tubular member 17 is 7" in diameter, the slots would be about ¼" wide and would be spaced about ⅝" above and below, respectively, the horizontal of the tube. The projections would consist of ¼" rods that were welded to the surface of the tube and would be about 1¼" above and below the horizontal of the tube.

Another form of tubular jet producing member 17A is disclosed in FIGS. 6 and 7. In these figures the member 17A is provided with jet producing slots 23 that are located on a horizontal diameter of the member and these slots are about ½" in width. There is provided a row of openings 24 above and below the row of slots. These openings are spaced close together and are located above and below the row of slots and have a diameter slightly smaller than one half the width of the slots. Ribs or projections 25 similar to ribs 22 are attached to the exterior of the tubular member respectively above and below and parallel to the rows of openings 24. These projections may also be in the form of rods that are suitably welded to the surface of the tubular member.

In operation of the system, the strip being treated first moves through furnace 3 where it is heated to the proper temperature for the treatment it is being given. The strip then moves through cooling chamber 4, passing between the pairs of jet producing tubes 17.

The cooling gas, which is the same as the atmosphere in chamber **4**, is discharged through the openings in the jet tubes against opposite sides of the strip to cool it. The volume and pressure of the gas as well as its temperature, of course, can vary. For most applications, however, it has been found satisfactory for the fan to move about 3300 cubic feet of gas per minute at from 2 to 3 inches water column and about 160° F. to produce satisfactory and rapid cooling.

It is a well-known phenomenon that a jet of a gas flowing from an orifice or slot against a sheet of material in front of it creates pressure differentials which cause the sheet to be drawn toward the slot or orifice. This tendency to move the strip toward the jets can be accentuated by the use of opposing jets, particularly if the strip is not tracking properly. The drawing action of a jet on a strip can and does cause a strip of metal being cooled to flutter and, not infrequently, to strike against the jet directing element. Such striking will mar the surface and reduce the value of the strip. This is particularly true if the surface of the strip has been polished, or if the strip is stainless steel.

The jets of gas forced from slots **21** of the jet tube **17** are directed toward the moving strip and impinge upon it to cool it. As these jets move toward the strip eddy currents are created by the rods **22** that are sufficient to upset the normal pattern of pressure differences and increase the pressure on the jet side of the strip sufficiently so that there will be no tendency for the strip to move toward the jet. With the construction of FIGS. 6 and 7, the small jets from ports **24**, in connection with ribs **25**, create eddy currents sufficient to eliminate the drawing tendency of the main cooling jet from slot **23**.

Therefore, with jets of gas of substantially equal velocity striking the strip from opposite sides, and with no tendency for the jets to move the strip toward them, the strip will travel through the cooling duct with no danger of it moving to one side or the other sufficiently to strike the jet producing tubes. Therefore, the moving strip will be cooled rapidly with a minimum of fluttering and without danger of marring its surface.

The above description mentions cooling of the strip below a temperature at which it will oxidize in air. It will be obvious, however, that the strip can be cooled to other temperatures for other purposes, such as cooling to approximately zinc temperature if the strip is to be galvanized. The apparatus was designed for strip cooling and is particularly useful for that purpose. It is within the scope of the invention, however, that the apparatus can be used for convection heating of the strip. In this use hot gas will be discharged through the jet openings. Whether cooling or heating the mechanical action of the jets on the strip will be the same.

While in accordance with the provisions of the statutes we have illustrated and described the best form of embodiment of our invention now known to us, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention set forth in the appended claims, and that in some cases certain features of our invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. Apparatus for directing jets of gas against a moving strip of material including

a housing having a gas inlet and a gas outlet,

means to move gas through said housing,

a tubular member connected to the outlet of said housing, said member being adapted to extend across the strip and parallel thereto, and presenting a curved surface toward the strip,

said member being provided with jet producing openings extending axially thereof, and directed toward the strip, and

means forming ribs projecting above the curved surface of said member and extending parallel to and spaced from opposite sides of said openings, said ribs serving to produce eddy currents beside the jets of gas discharged from said openings.

2. The combination of claim **1** in which said member is adapted to be substantially perpendicular to the path of travel of the strip.

3. The combination of claim **1** including a heat exchanger in said housing to cool the gas flowing therethrough.

4. The combination of claim **1** in which said housing is provided with a pair of gas outlets, one of said tubular members being connected to each outlet, said members in operation of said apparatus being disposed on opposite sides of the strip, with the gas being discharged from the openings of one member directed toward the other member.

5. The combination of claim **1** in which the openings in said member are in the form of a row of elongated slots aligned end to end.

6. The combination of claim **1** in which said openings comprise a pair of parallel rows of slots extending at least the width of the sheet.

7. The combination of claim **1** in which said openings comrise a series of slots end to end and said member being provided with a row of openings smaller in diameter than the width of said slots extending axially of said member between said slots and said ribs.

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