FIG. 1.

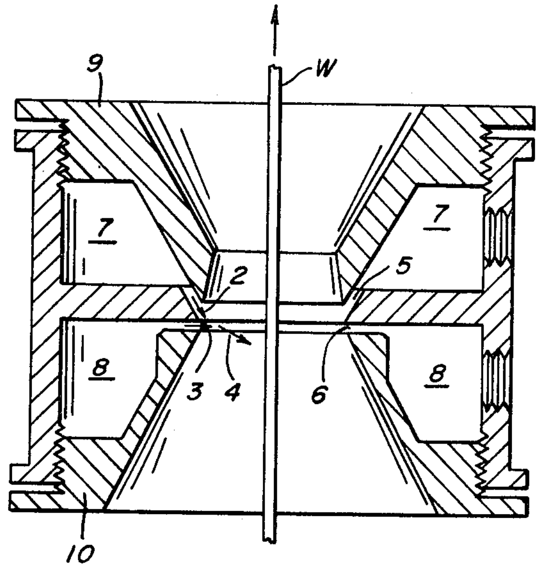

9
W
7
7
2
5
8
8
3
4
6
10

FIG. 2.

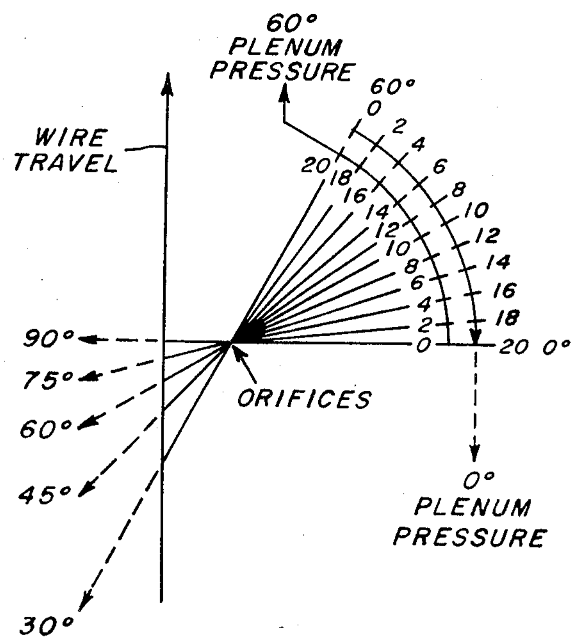

60°
PLENUM
PRESSURE
60°
0
2
4
6
8
10
12
14
16
18
20 0°
WIRE
TRAVEL
20
18
16
14
12
10
8
6
4
2
0
90°
75°
60°
45°
30°
ORIFICES
0°
PLENUM
PRESSURE

FIG. 3.

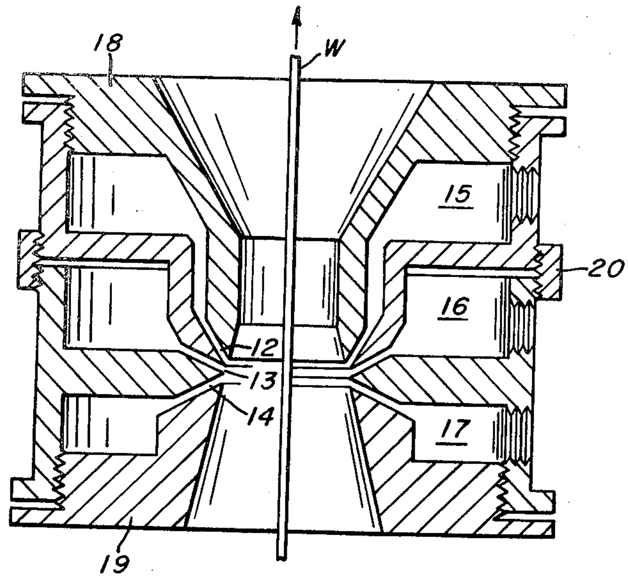
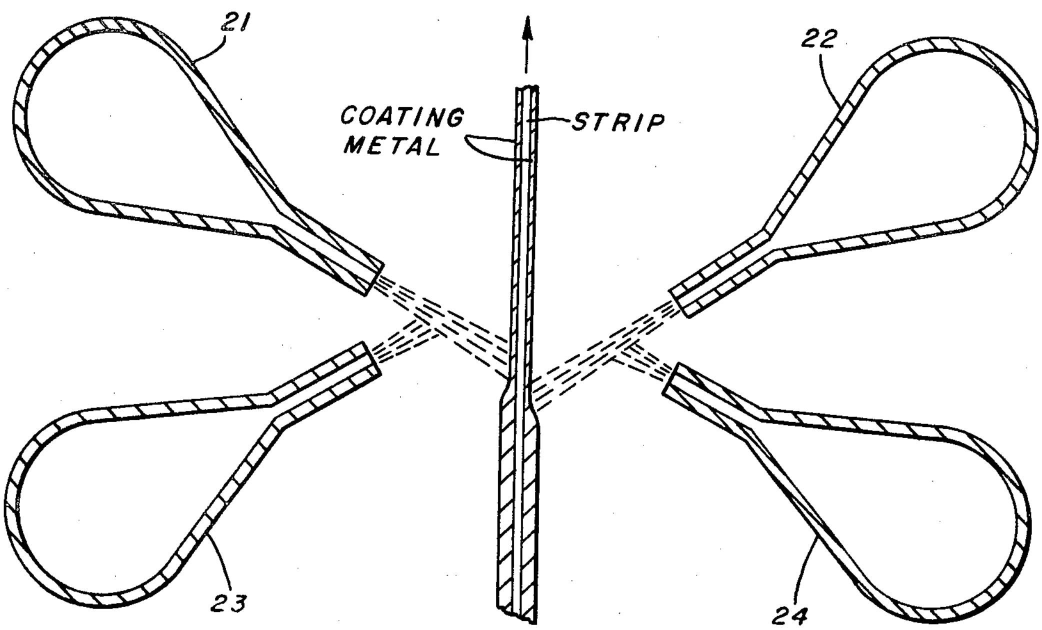


FIG. 4.



United States Patent Office 3,736,174
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3,736,174

VARYING ANGLE OF GAS IMPINGEMENT IN GAS KNIFE PROCESS FOR REMOVING EXCESS COATING

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U.S. Cl. 117—102 M 6 Claims

ABSTRACT OF THE DISCLOSURE

In the gas knife process for controlling the weight of an applied coating, the angle of gas impingement on the strand is varied, by employing at least two thin gaseous streams which are caused to impinge upon each other, prior to striking the strand. The resultant jet (analogous to the resultant vector of several forces acting on a particular body) is then employed to act as a gaseous barrier to excess liquid on the strand. The angle of impingement of the resultant jet is easily manipulated by varying the ratio of the flow rates of the individual gaseous streams.

This invention is related to a method for providing a continuously variable impingement angle for use in the gas wiping of strand (wire, strip and sheet) materials.

Fluid wiping methods have long been employed for controlling the coating weights of various liquids which are continuously applied to strand materials. Thus, for well over three decades gas knives have been employed in the paper industry to control coating weights at line speeds of up to 1400 f.p.m. Analagous procedures have also been employed in the application of paints and lubricants and have now come to the forefront in controlling the quality and quantity of the film applied in the hot-dip coating of metals. In employing these various gas knife methods, it is not only desirable to control the weight or thickness of the coating, but the control of features such as uniformity, texture and brightness is equally important. In attempting to control these various features which contribute to the overall quality of the coating, it has been found that many operating variables play an important role. Thus, such variables as gas flow rate, distance from nozzle to strand, strand speed, strand temperature, liquid bath temperature and angle of gas impingement may play a singificant role, depending on the particular coating being applied. With respect to the angle of impingement, variation in the angle will not only change the extent of the wiping action (i.e. thickness) but will also alter the degree of cooling and the splatter pattern exerted by gas barrier. These latter effects being especially important in hot-dip metal coating applications. Thus, as described in U.S. Pat. 3,459,587, a positive impingement angle has been found to be most effective for terne coating, while a negative angle is preferred for galvanized coatings. Therefore, the ability to conveniently change the impingement angle from one coating operation to another would be most desirable. Similarly, during any particular coating procedure it is also desirable to be able to automatically vary the impingement angle to compensate for changes in any of the above enumerated variables, e.g. strand speed, bath temperature, etc.

Heretofore, the only manner by which such a continuously variable impingement angle could be achieved was by use of rather cumbersome mechanical linkages for rotation of the nozzles. The instant method, on the other hand, permits such variation to be achieved easily and with a high degree of control by merely varying the ratio of gas flow rates through two or more convergently directed nozzles. It has now been found, that if at least two nozzle orifices are disposed at increasing distances

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(along the length of the strand) from the liquid bath and the gaseous streams from these nozzles are directed at convergent angles with respect to each other so that they impinge upon each other prior to striking the strand, the streams will, in effect, fuse into one resultant jet, which in turn may be employed to impinge upon the strand at the desired angle.

The objects and advantages of the instant method will be better understood by reference to the following detailed description, when read in conjunction with the appended claims and the accompanying drawings, in which:

FIG. 1 is a cross-sectional representation of an integral double orifice, variable angle gas knife for performing the method of the instant invention;

FIG. 2 is a nomographic representation of the variation in angular coverage which may be achieved by use of the device of FIG. 1; and

FIG. 3 is a cross-section of an integral triple orifice device useful in yet another embodiment of the invention; and

FIG. 4 is a cross-section of a further embodiment, showing the use of a separate, double orifice system for use in the instant method.

The devices and methods described in FIGS. 1 to 3 are specifically adopted for use in the gas wiping of strand materials of circular cross-section, such as wire or tubing. However, it will be apparent to those skilled in the art, the manner in which similar devices may be employed for the wiping of strand materials of rectangular cross-section, such as sheet and strip.

FIG. 1 is a cross-sectional illustration of a device for wire wiping in which two convergent nozzle orifices are fixed in relation to each other in an integral, generally cylindrical apparatus. In this device, a 60-degree conical wiping range is achieved through the use of converging annular streams **2** and **3** which fuse into resultant jet **4**. Streams **2** and **3** are formed respectively by orifices **5** and **6** supplied through independent plenums **7** and **8** in which the working pressures may be varied. The pressures within plenum **7** (for control of the 60° jet) and plenum **8** (for control of the 0° jet) will directly affect the velocity of gaseous streams **2** and **3**, thereby controlling both the velocity and angle of the resultant wiping jet **4**. While variation in the ratio of pressures will generally be sufficient to provide the required control of the angle of the resultant wiping jet, further control can be obtained by varying the throat widths of orifices **5** and **6**. Thus, to adjust the throat of the 60 degree orifice, top component **9** is merely screwed up or down until the desired width is obtained. Similarly, base component **10** may be turned to achieve the desired throat width of the 0° orifice. Lock rings (not shown) may be then be employed to secure both the top and base components in place.

FIG. 2 illustrates the wipe-angle pressure relationship of the double orifice device shown above. With no pressure in 60 degree plenum **7** and a working pressure of 20 ounces per square inch in plenum **8** feeding the 0 degree orifice, the wiping jet will issue perpendicular to the wire. Under normal operation, with both orifice throat widths equal, and the pressure varied within a constant total amount, (in this case 20 oz./in.^{2}) the complete 60 degree wiping range can be covered. The device may be operated to require no more gas than a conventional, single orifice unit, since the total of the throat widths of the two orifices need not be greater than that of a conventional single orifice.

A three orifice, three-plenum wipe design which provides a 90 degree wiping range (−30° to +60°) is shown in FIG. 3. For purposes of this invention, wipe angles are described with respect to the horizontal, therefore, gaseous streams co-current with the direction of strand travel are considered negative and those countercurrent to strand travel are positive. Thus, referring to FIG. 3, orifices **12** and **13** are inclined at +60 degrees and +30 degrees respectively, and orifice **14** is inclined at −30 degrees. Analogous to the device of FIG. 1, the gasous streams which combine to form the resultant wiping jet are formed by orifices **12**, **13** and **14**, which are in turn supplied through independent plenums **15**, **16** and **17**, respectively. Orifice openings **12** and **14** are adjusted by turning top component **18** and base component **19** respectively. Opening **13** is adjusted by turning adjusting ring **20**; one thread being left handed and the other right handed. Thus, depending on the direction of turning the walls which define opening **13**, will either separate or come together.

FIG. 4 presents a schematic illustration of a further embodiment, with discrete nozzles, i.e., wherein the individual plenums are not contained within an integral wiping device. Here, for example, the plenum pressures in the nozzles **21** and **22** need not be equal, thereby providing the further capability of simultaneously achieving both different impingement angles and different gaseous flow rates on opposing sides of the strip. This feature is especially desirable for achieving the incongruent overlap discussed more fully in U.S. Pat. 3,459,587 and/or for the production of strip with differential coating weights on opposing sides.

The instant method provides a degree of versatility and control which can greatly enhance the capability of a process employing the gas knife principle. It provides a convenient method for close control of gas impingement angle which may easily be adapted to automatic control. Merely varying the impingement angle will not affect a corresponding change in the effective distance between orifice mouth and the coated strand, and thereby, undesirably introduce a further variable in the coating process. It is adaptable for use with any of the well-known wiping gases (e.g. air, stream, inert gas) and may be employed, equally as well, for systems in which the strand emerges either horizontally or vertically from the coating bath.

I claim:

1. In the gas knife process for controlling the film applied from the dip coating of a strand of material through a liquid bath, an improved method for varying the angle of gas impingement on said strand, which comprises:

projecting gaseous streams at converging angles with respect to each other from at least two nozzle orifices, disposed at increasing distances from said liquid bath, whereby said streams are caused to interact with one another and thereby combine into a resultant jet, which in turn is caused to impinge upon said strand at the desired angle and act as a gaseous barrier to control the thickness and quality of said liquid film,

the variation in the angle of the resultant jet being achieved by varying the ratio of the flow rates of each of said gaseous streams.

2. The method of claim **1**, wherein the nozzle orifice closest to said bath is inclined at an angle of −30 degrees and the orifice furthest from said bath is inclined at an angle of +60 degrees to achieve an angular wiping range of 90 degrees.

3. The method of claim **1**, wherein said strand is of circular cross-section, and said gaseous streams define a conical pattern.

4. The method of claim **1**, wherein said strand is of rectangular cross-section and said gaseous streams define a substantially planar pattern.

5. The method of claim **4**, wherein the nozzles orifices disposed on opposite sides of said strand are substantially equidistant from said bath and are fed from independent plenums.

6. The method of claim **1**, wherein said liquid bath is molten metal.

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U.S. Cl. X.R.

34—155; 117—102 L, 114 A, 114 B, 114 R, 115, 128; 118—63