United States Patent

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[54] **APPARATUS FOR DETERMINING THE BOUNDARY BETWEEN DISPARATE LIGHT-EMITTING AREAS**
2 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **219/10.61,** 210/219
[51] **Int. Cl.** **H05b 5/00,** G01n 21/32
[50] **Field of Search** 250/219DF, 219F, 227, 237; 219/10.61, 10.77; 356/199, 201, 206, 239

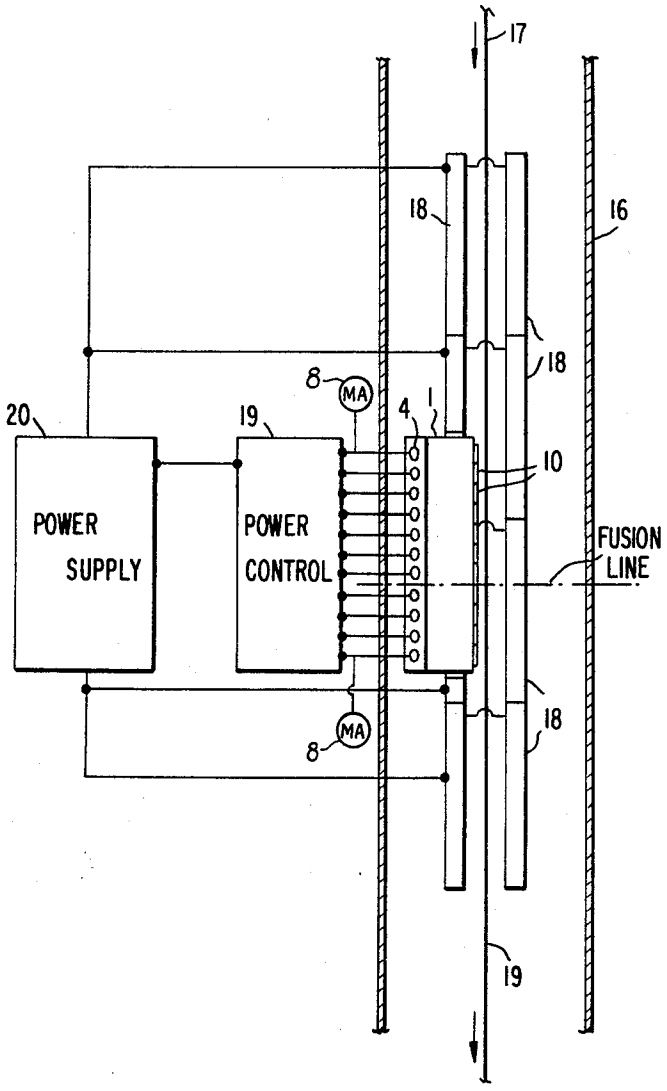
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ABSTRACT: A photoelectric apparatus for determining the boundary between areas giving off different amounts of light, e.g. the fusion line on a tinplate strip moving through a fusion furnace where unfused matte surfaced tinplate becomes fused bright surface tinplate. The apparatus contains several photoelectric cells and the boundary's position is indicated where a difference occurs in the outputs of adjacent cells. The cells are aligned with the output ends of light-conveying conduits whose input ends face portions of the areas on both sides of the boundary. Only light rays parallel to the axes of the conduits are allowed to pass through them, so that only light from those portions of the area directly in line with the conduits stimulates the cells. The apparatus may include gates adapted to adjust the size of the openings at the input ends of the conduits, and which are preset to regulate the amount of light impinging on each of the cells. In this manner, the gates may compensate for differences in cell sensitivity or provide a desired pattern of cell outputs.



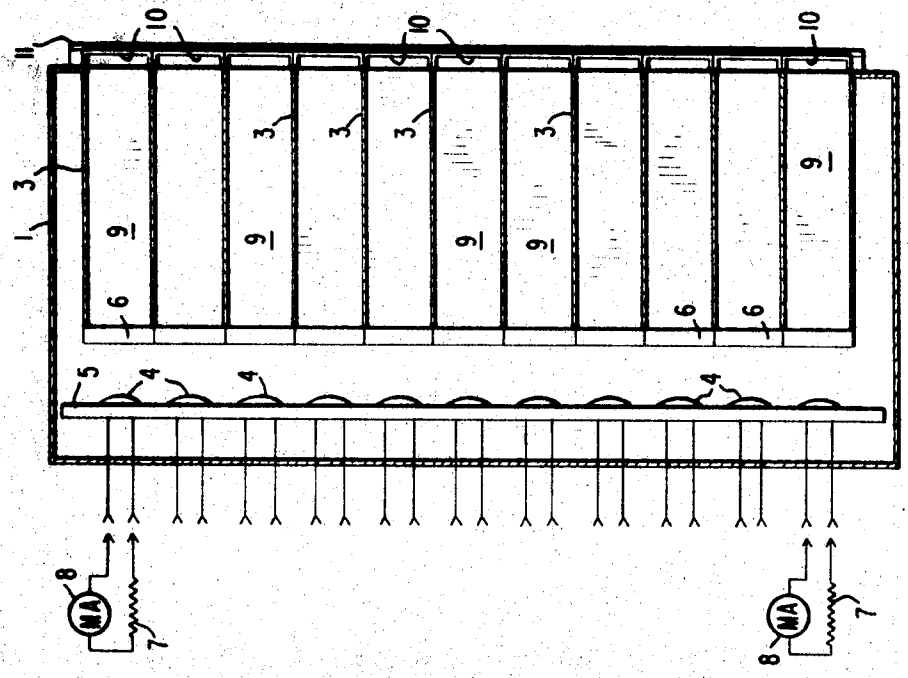


FIG 2

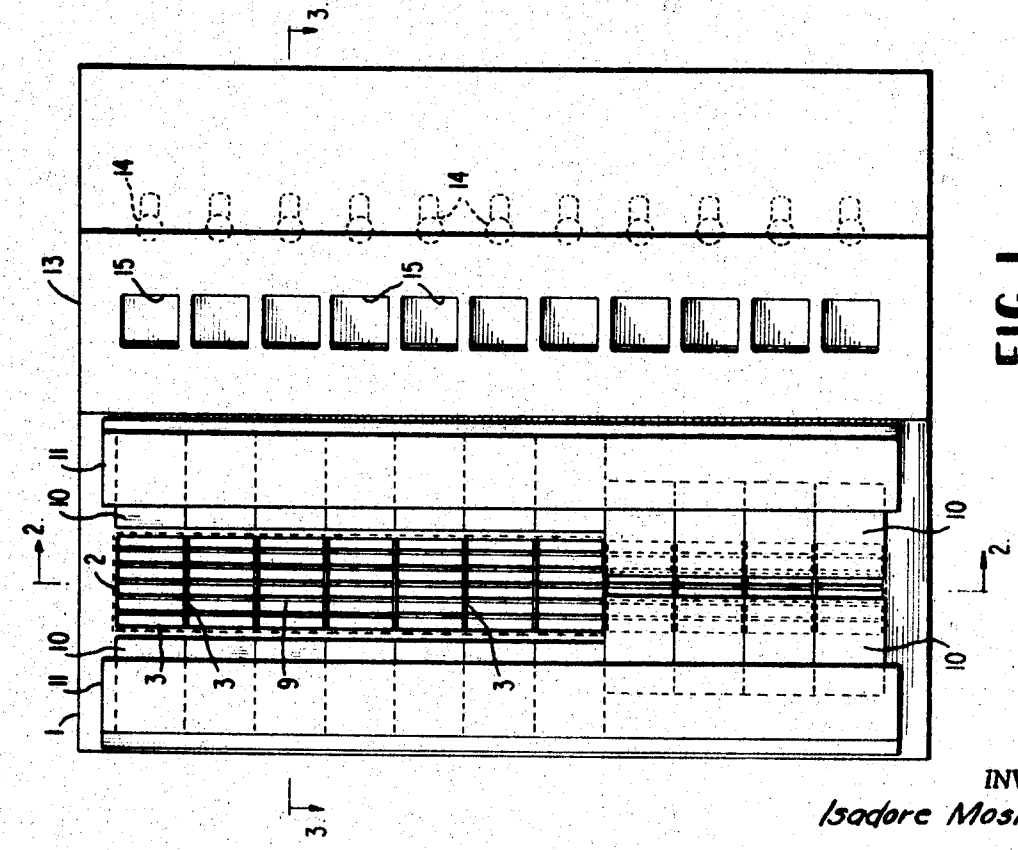


FIG 1

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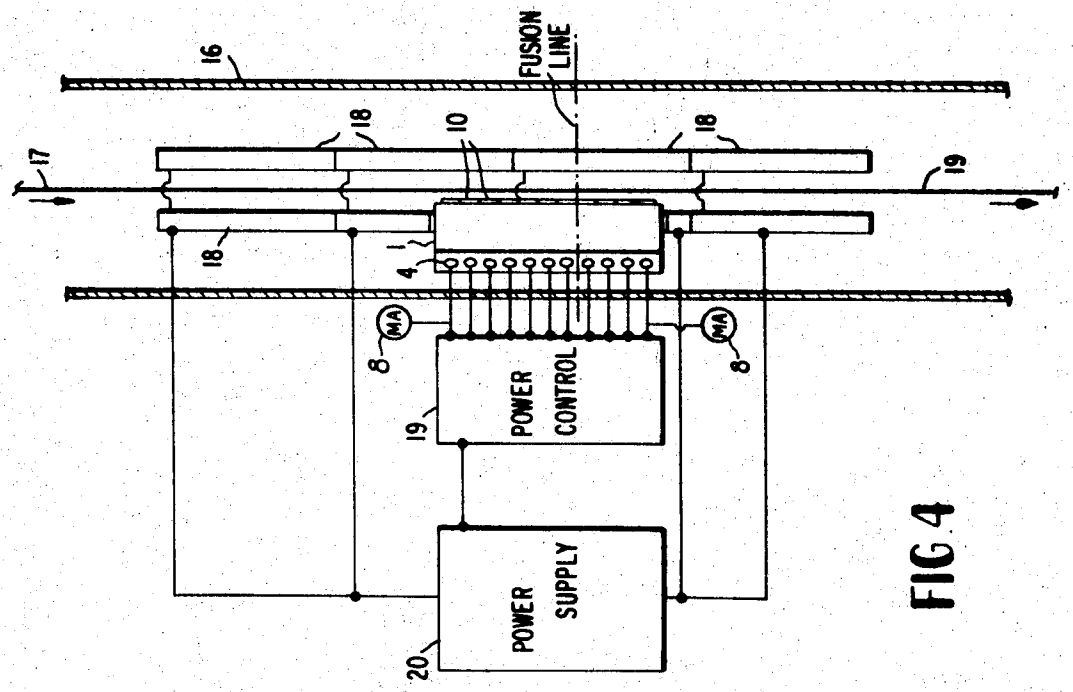


FIG 4

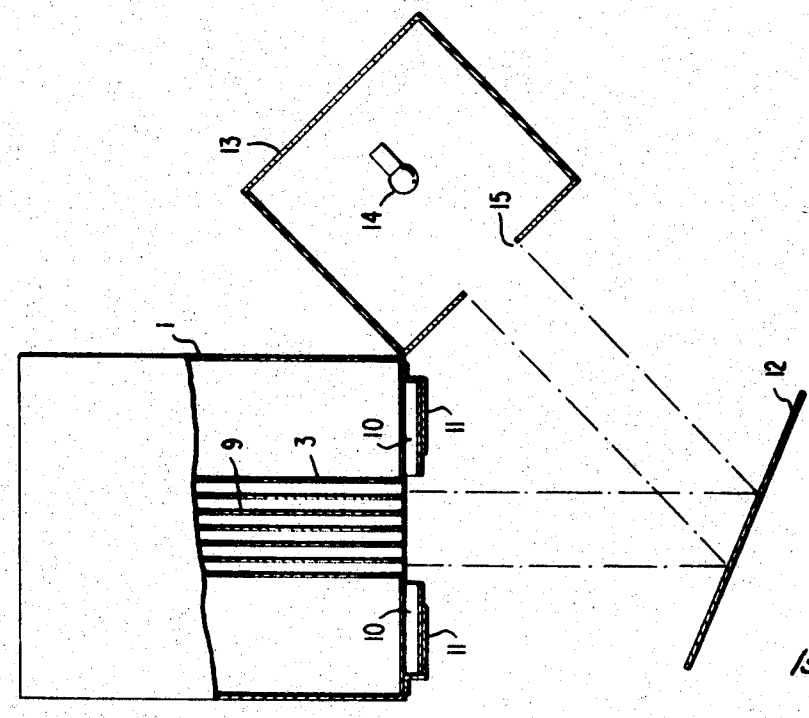


FIG 3

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APPARATUS FOR DETERMINING THE BOUNDARY BETWEEN DISPARATE LIGHT-EMITTING AREAS

BACKGROUND OF THE INVENTION

Upon emergence from the plating operation, tinplated metal strip has a matte surface. However, for most uses in this country a brightened surface is required. To produce such a surface the tinplate is heated to slightly above the melting point of tin, generally, by passing the strip downwardly through a vertically disposed fusion furnace. The section across the strip at which matte surfaced unfused tinplate becomes bright surfaced fused tinplate is called the fusion or flow line, and its location is controlled by the heat of the furnace.

Some tinplate, for corrosion resistance purposes, must contain a certain alloy of iron and tin at the interface between the base metal and tin coating. To obtain this alloy, the tinplate must attain a predetermined temperature above that of fusion when it leaves the vertically disposed furnace. Therefore, the distance within which the strip is heated between the fusion line and furnace exit is critical; of course, since the furnace's exit is fixed, the fusion line must be properly positioned. By increasing the furnace's heat the fusion line is raised, while, conversely, a decrease in heat lowers the line.

In regulating this line of fusion, apparatus has been used containing two photocells positioned adjacent the strip and straddling the desired fusion line position. Light reflected from the matte surfaced tinplate impinged upon one cell, while a greater amount of light reflected from the bright surface tinplate impinged upon the other. When the fusion line moved out of position, both cells became exposed to the same amount of light. In this situation, the cells electrically signaled a control regulating the heat of the furnace and thereby repositioned the fusion line.

However, this apparatus is incapable of determining the extent to which the fusion line is out of position. Different wearing out rates of the two cells lessen its accuracy and so they must be periodically replaced. Light which is not reflected from the two portions of the strip directly adjacent the cells may impinge upon them and additionally compromise accuracy.

SUMMARY OF THE INVENTION

My invention may be used to ascertain the position of a fusion line on a tinplated strip moving through a fusion furnace, or any other boundary between areas giving off different amounts of light. The apparatus of my invention comprises several photoelectric cells aligned with the output ends of light-conveying conduits whose input ends face portions of the areas on both sides of the boundary. Only light rays parallel to the axes of the conduits are allowed to reach the cells which, therefore, are only responsive to light from those portions of the areas directly in line with the conduits. Different outputs between adjacent cells indicate that the boundary's position is located between these cells. Gates adapted to adjust the openings at the input ends of the conduits may also be included in the apparatus. By setting the gates to regulate the amount of light impinging on each of the cells, differences in cell sensitivity may be compensated for, or a desired pattern of cell responses obtained.

Where the apparatus is used in determining the position of a fusion line in a tinplate fusion furnace, it will give notice of an improperly positioned line to the furnace operator who may then regulate the furnace heat and reposition the fusion line. Alternatively, the cells may be electrically connected to an automatic control for regulating the furnace.

In addition to tinplate fusion line determination, the apparatus may be utilized for many other purposes, e.g., ascertaining the width and edges of a reflective strip.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a front elevation of an apparatus embodying my invention.

FIG. 2 is a section taken along line 2–2 of FIG. 1.

FIG. 3 is a section taken along line 3–3 of FIG. 1 and shows the apparatus scanning the surface of a strip.

FIG. 4 is a diagrammatic representation of the apparatus shown in FIGS. 1, 2 and 3 being used to determine the fusion line on a tinplate strip, DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus shown in FIGS. 1 and 2 comprises a closed housing 1 having a vertically elongated opening 2 in its front. This opening is occupied by the input ends of a vertical series of rectangular conduits 3 extending horizontally into the housing. Several photoelectric cells 4, held by photocell holder 5, are located within the housing, and each is aligned with an output end of one of the conduits 3. In order to focus light passing through the conduits onto the photocells, a lens 6 is located at the output end of each conduit. Each photocell's response to light conveyed through its aligned conduit is measured with an electrical circuit having a resistor 7 and milliammeter 8. As seen in FIG. 1, each conduit 3 contains a plurality of vertical light-absorbing plates 9 which extend parallel to the conduit's axis. These plates allow only light rays parallel to them to pass through the conduits.

FIGS. 1 and 2 also show several pairs of channel-shaped gates 10 slidably mounted in gate housings 11 which are secured to the front of housing 1. Each pair of gates may be set to regulate the amount of light passing through the opening at the input end of a conduit and impinging on one of the photocells. By adjusting the gates, differences in cell sensitivity may be compensated for. Additionally, if for any reason a uniform or nonuniform pattern of cell outputs is desired, irrespective of the actual amount of light being given off by the areas scanned by the apparatus, the gates may be adjusted accordingly. In FIG. 1, the lower four pairs of gates are partially closed and thereby restrict light passing through the openings at the input ends of the lower four conduits. By properly setting these gates, this arrangement could be utilized to obtain uniform cell outputs where the lower four conduits face an area giving off a greater amount of light than the area faced by the rest of the conduits, e.g., where the apparatus is being used to check the location of a tinplate fusion line whose proper position is just above the fourth conduit from the bottom of the housing.

FIGS. 1 and 3 show the apparatus of my invention connected to a device for providing light which may be reflected off the surface of an elongated object, as strip 12 in FIG. 3. The device comprises an enclosure 13 mounted to a font side edge of housing 1 at an angle with the housing's sides. Within this enclosure is located a vertical series of uniform light sources 14, each of which emits light through an aperture 15 in the enclosure horizontally level with one of the conduits. As seen in FIG. 3, the light-providing device, the photoelectric apparatus, and the reflecting strip are located such that light rays from the device become aligned with and pass into conduits 3 after they are reflected from the strip 12.

FIG. 4 shows the apparatus being utilized to determine the position of a fusion line on a tinplated strip moving through fusion furnace 16. The light-providing device (not shown) is properly located beside the apparatus to reflect light off the strip and into the apparatus' conduits. Unfused matte surfaced tinplate 17 enters the furnace, is heated by four series of induction heating coils 18, and becomes fused at the fusion line indicated. Below the line, the fused strip 19 possesses a bright highly reflective surface. The apparatus is placed so that the conduits' input ends will receive light reflected from vertically spaced portions of the stip's surface on both sides of the fusion line's proper position. The photocells 4 are thereby responsive to the reflectivity of these portions of the strip, and different readings between adjacent milliammeters 8 indicate the position of the fusion line.

As with any use of the apparatus, the gates 10 may be preset to compensate for differences in cell sensitivity, or obtain a desired pattern of cell responses. If, for convenience in controlling the fusion line, it is desired that all the cells have equal outputs and the milliammeters 8 give the same reading when the fusion line is properly positioned, those gates below the

line's proper position may be preset partially closed. The correct amount of this gate adjustment may easily be ascertained before the fusion operation by scanning with the apparatus a suitable tinplate strip having a fusion line.

Upon being put on notice of an improperly positioned line by the milliammeter readings, the operator of the fusion furnace may make any necessary adjustments. Or, as illustrated in FIG. **4**, the cells may be electrically connected to a control **19**, responsive to their total outputs, for regulating the power supply **20** of the furnace. In this manner, any error in the fusion line's position may be automatically corrected.

We claim:

1. In an apparatus for fusing a strip of tinplate comprising heating means adapted to fuse said tinplate as it passes therethrough, the improvement comprising:

a. a source of light directing light toward said strip;

b. a plurality of light-conveying conduits disposed longitudinally of said strip and facing said strip at an angle such that light from said source is reflected from said strip in a direction substantially parallel to the longitudinal axes of said conduits;

c. means, disposed within said conduits, for allowing only light substantially parallel to the axes of said conduits to pass therethrough;

d. a plurality of photoelectric cells, each of said cells being adapted to receive light which passes through one of said conduits;

e. means connected to each said cells for determining the electrical output thereof; and

f. means for varying the location of the line of fusion of the tinplate whereby the strip is maintained at a predetermined temperature above that of fusion as it leaves said heating means.

2. The improvement as recited in claim **1**, further comprising

g. means to vary the amount of light passing through each of said conduits.