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Atkinson

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[54] **CONTINUOUS STRIP ENCODING**

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[73] Assignee: **National Steel Corporation,** Pittsburgh, Pa.

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Related U.S. Application Data

[62] Division of Ser. No. 886,997, Dec. 22, 1969, abandoned.

[52] **U.S. Cl.** ..... **219/121 LM;** 156/18

[51] **Int. Cl.** **B73k 27/00**

[58] **Field of Search** ..... 219/121 L, 121 M; 209/111.5; 204/143 R; 156/18

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[57] **ABSTRACT**

Method and apparatus for selective control of laser beam energy for encoding strip in a continuous manner resulting in positive identification for end products cut from the strip without inhibiting end product usage. Laser beam coding of the base metal prior to metal plating, or of a finished surface, can be made discernible or substantially non-discernible to unaided inspection. Supplementary aids for discernment of coding, such as use of magnetic flux or chemical etching, readily bring out coding otherwise not apparent on unaided inspection.

4 Claims, 3 Drawing Figures

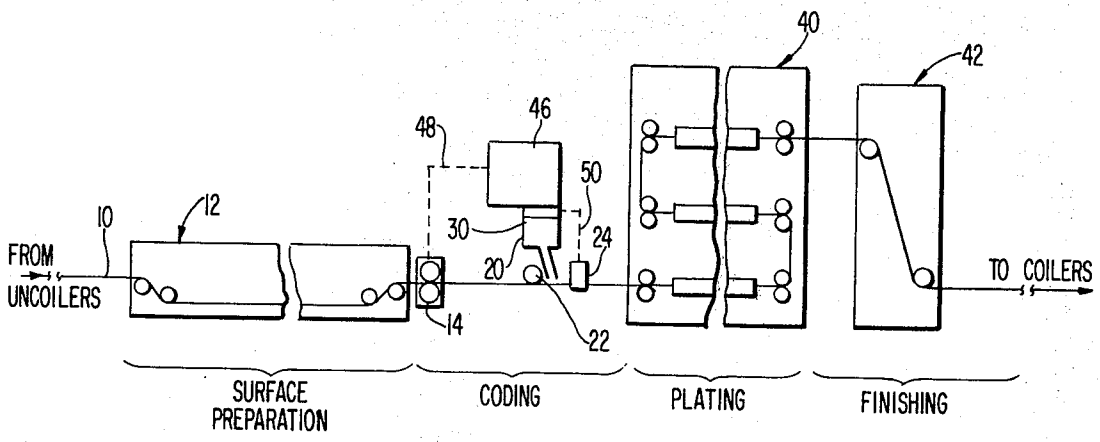
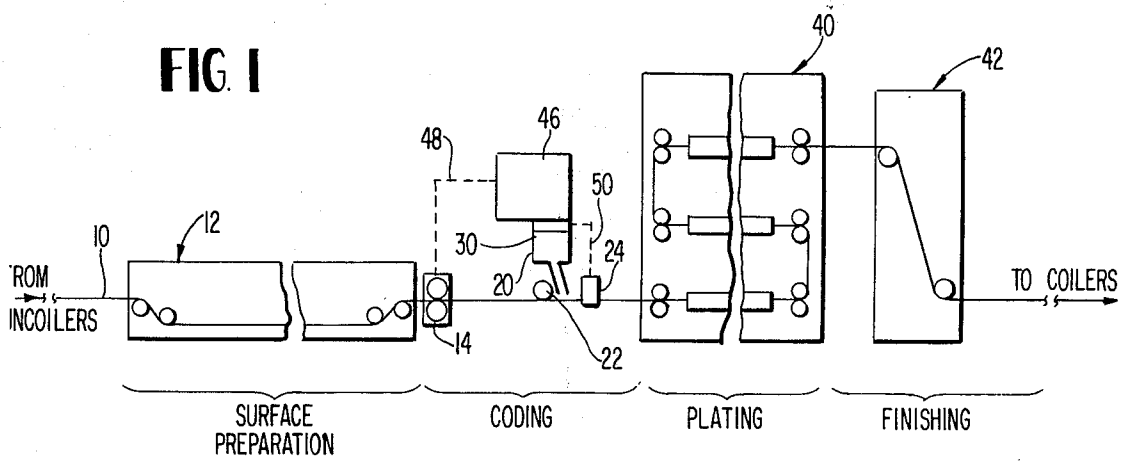


FIG. 1



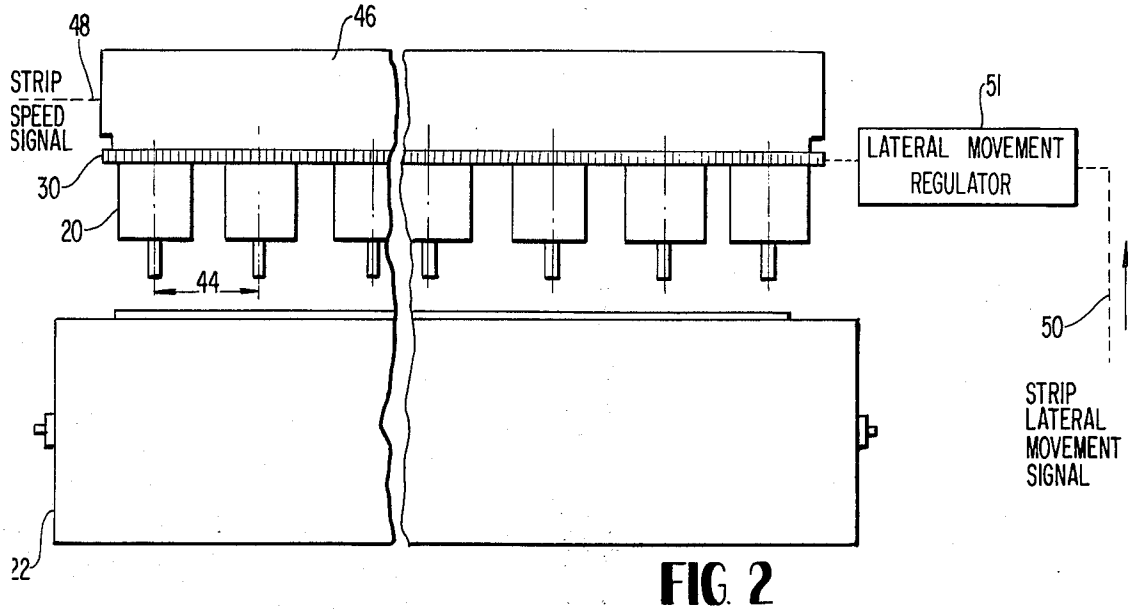
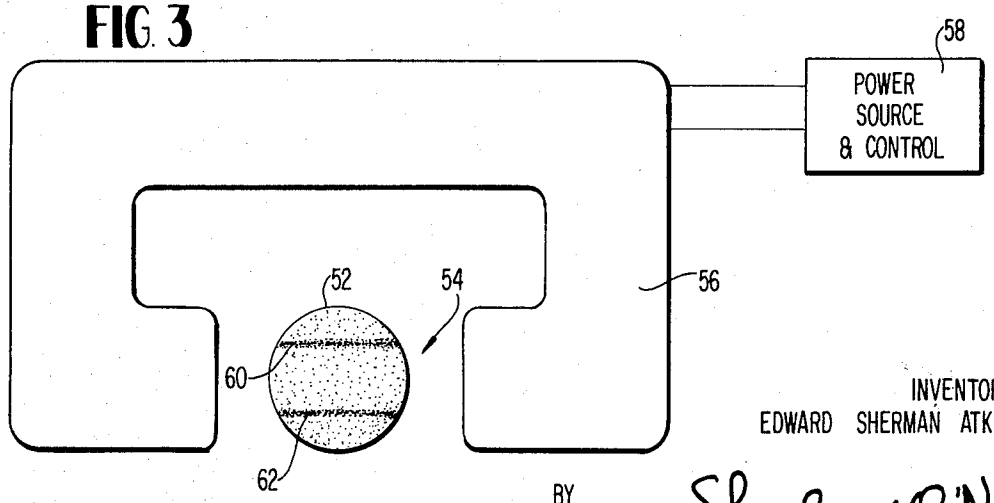


FIG. 2

FIG. 3



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CONTINUOUS STRIP ENCODING

This is a division of application Ser. No. 886,997, filed Dec. 22, 1969, now abandoned.

This invention is concerned with encoding of flat rolled product for subsequent indentification. More particularly, the invention is concerned with encoding strip metal in a continuous manner permitting positive identification of end products cut from such strip.

The invention will be described in relation to the processing and encoding of tinplated steel. Can manufacturers ordinarily use tinplated steel from a number of different sources during fabrication of containers. Often, when a fault is discovered, only a single can end will be the basis for a rejection or complaint. Flat rolled steel producers expend enormous amounts of time and money in attempts to identify tinplated specimens cut from their product. However, no positive way for a steel producer to identify its steel after fabrication has been available.

In practice, chemical and physical analysis tests are run in an attempt to determine whether or not a returned specimen came from a particular producer. Data from heat chemistry tests, surface density tests, and other tests are gathered and attempts made to match such data with records kept during production. The answer is seldom definite. The problem is further compounded by increasing use of basic oxygen processes. The chemistry of basic oxygen heats from different sources are either non-distinctive or not available in sufficient detail to permit identification.

Although the need has existed for years prior to the present invention, no satisfactory apparatus has been advanced for physically marking strip. Ink markings, and the like, cannot be maintained on the end product since it is usually totally covered with labelling. An acceptable means of identification must not mar the finish or the coating so as to hamper end usage for beverage containers, and the like. In brief, there has been no acceptable way of identifying flat rolled metal product beyond the as-shipped stage.

A primary objective of the present invention is to provide methods and apparatus for economical encoding of flat rolled metal product for subsequent identification in which the coding will not mar the product or inhibit end usage and yet will provide identification of individual end products. Further, to provide coding subject to universal use to distinguish separate producers, mills, producing lines, heats, and the like. In addition, to provide for discernment of the code in a way which is simplified and economical, while maintaining positive identification.

The accompanying drawings will be used in describing a specific embodiment of the invention. In these drawings:

FIG. 1 is a schematic presentation of a continuous-strip processing line embodying the invention,

FIG. 2 is a schematic presentation of apparatus for use in a processing line such as that of FIG. 1, and

FIG. 3 is a schematic presentation of apparatus embodying the invention for use in discerning strip coding.

In the encoding of coated flat rolled steel, such as tinplated steel, the encoding system must avoid damage to the protective coating as well as impairment of the appearance of the product which would limit end usage. The objective is to bring about encoding which is permanent, invisible or substantially invisible to the naked eye after coating, and yet readily discernible with simplified supplementary apparatus or materials.

In applying the teachings of the invention to tinplated steel, encoding is carried out prior to plating. Laser beam energy is generated and controlled to properly encode the steel base metal. The laser beam can be controlled to produce a surface marking which is as small as 10^{-7} square centimeters in cross-section and of a depth such as to be discernible from the remainder of the surface finish of the product only by use of a sensitive feeler gage.

It is known that laser beam energy can be used to cut or burn through heavy steel plate. Therefore, selection of beam energy level is an important concept of the invention permitting marking without damaging the appearance of the end product. The invention teaches control of the beam energy level, and other variables, to produce surface etching providing encoding which is non-damaging and non-limiting to the end product usage.

An economically important contribution of the invention is the provision for encoding continuously without impairing production rate of the flat rolled product. The methods and apparatus of the invention can be used without interruption of continuous strip processing and without significant structural modification of existing continuous-strip processing lines.

The invention teaches control of laser light to produce a narrow-width surface etching having a longitudinal direction by impinging the controlled laser light onto the strip during travel of the strip through a continuous-strip processing line. The width of the surface etching can be narrowed so that it will not be visible to the naked eye and will not mar the end product regardless of whether or not the flat rolled product is coated after marking.

The laser beam energy available from commercial units is, however, adaptable to certain applications where the lateral width of the coding should be increased to permit discernment without supplementary aids. The width used will be dependent in part upon the nature of the flat rolled product, the type of coating, if any, and thickness of the coating to be applied, the end usage of the product, the degree of naked eye discernment desired, and the type of supplementary equipment, if any, to be used in making identification.

The minimum and maximum width marking available depend on the laser beam equipment and focusing equipment used. However, in the manufacture of tinplate for container use, the optimum width for practice of the invention should be one which is substantially invisible to the naked eye after coating yet be readily discernible with simplified supplementary equipment. Typically such a marking would have a width of 0.001 inch.

In one embodiment taught, the narrow width coding takes the form of a continuous line etched on the surface of the strip. Establishing a plurality of such continuous, longitudinally directed lines permits identification based on spacing. That is, the lateral spacing between such lines is selected to identify a particular producer. Optical splitting and fine focusing of the laser beam makes a great number of identifications available within a short lateral dimension.

Special provision is made for control of the number and location of such continuous surface etchings applied while the strip is in its wide, continuous-strip pro-

cessing form. Where lateral spacing between longitudinally directed continuous surface etchings is used for identification, at least two such surface etchings must appear on each end product. For example, can ends for frozen fruit juice cans are approximately two inches in diameter. Therefore, the lateral spacing between the continuous longitudinally directed surface etchings should be less than an inch when using the lateral-spacing type of coding for this product. The spacing selected for this product can be any discernible value below such maximum. In accordance with the teachings of the invention, the longitudinal direction surface etchings are imparted, during continuous line processing with predetermined lateral spacing, across the full width of the strip so as to identify each end product to be cut from the strip.

In another method of encoding taught, cyclically pulsed laser beam energy is used. Gas lasers or laser crystals cyclically pulsed from the build-up of electrical energy in capacitor banks can be used. Output pulses of laser beam energy from crystal can be cycled as low as five microsecond intervals. The output from the laser can be further controlled as to energy level and pulse duration in a Kerr cell, or the like, and impinged on the surface of the strip to provide a dot-dash code extending longitudinally of the strip.

Coded pulses and/or lateral spacing between the longitudinal direction lines of coding are selected such that sufficient coding appears on each end product to be cut from the strip being processed to permit positive identification.

Coordinated control of the laser and the strip speed has a number of important aspects. For example, laser beam energy level is coordinately controlled with the longitudinal speed of strip through a line in order to control the degree of marking. Considering pulsed coding, the invention teaches synchronism of the pulsing mechanism for the laser with the speed of the line. Interconnection of a bridle roll on the continuous-strip line and the pulsing mechanism for the laser crystal for such synchronization can be carried out in a number of suitable ways which are within the skill of a mechanic in the art so that a detailed description of synchronization means is not required for an understanding of the invention.

Pulse coding considerably extends the amount of information which can be carried. In addition to a dot-dash code, directional spacing both laterally and longitudinally can be used to identify a company, a particular mill owned by a company, a particular processing line in a mill, any particular heat of metal being processed, the date, and whatever further data it would be helpful to establish on the flat rolled product.

Location and placement of the laser beam impingement can be carried out optically or by placement of a plurality of laser beam producing means in predetermined relationship across the width of the strip or both. The number of laser beam producing means required is dependent on such factors as lateral spacing between the coding lines, the amount of optical splitting of the laser beam used, the particular code adopted and the degree of etching desired.

In the continuous processing line of FIG. **1**, continuous-strip **10** is fed from uncoilers through a looping tower (not shown) into a surface preparation unit **12.** Wet pickling or other surface preparation is carried out in unit **12.** Preferable the strip is dried in surface preparation unit **12,** or otherwise, before being directed to the coding zone on the line. At the exit side of surface preparation unit **12** a bridle roll stand **14** is provided for control of the strip and for synchronization of coding equipment with strip speed.

Laser beam producing means **20** are located in the coding zone for use after surface preparation. Control of the strip during coding is an important concept of the invention. One objective is to prevent strip flutter and any strip movement which would interfere with proper encoding. In the simplified apparatus shown schematically in FIG. **1,** roll means **22** prevents vertical flutter of the strip providing a stable marking surface maintaining a predetermined distance from the laser.

Edge sensing means **24** can be used to either control lateral movement of the strip during its travel through the coding zone or to measure such movement for coordinated control of the location of the laser beam producing means **20.**

After passage through the coding zone the strip passes through a plating zone **40,** finishing zone **42** for example finish brighteners, and on to coiling means not shown.

Referring to FIG. **1,** strip **10** passes in contact with guide roll means **22** beneath the laser beam producing means **20.** Laser beam producing means are positioned to impinge laser beams across the full width of the strip with the number of units required being dependent upon the type of coding being established and the amount of optical splitting of the beam or beams employed.

As shown schematically in FIG. **2,** laser beam producing means are mounted on support means **30.** The lateral spacing **44** between each laser beam is accurately controlled utilizing calibration means of support means **30.** Such lateral spacing can be effected by physical placement or optically. Control is exercised for a number of reasons mentioned earlier, such as to be certain that the coding signal is established on each end product to be cut from the strip and to accurately establish the lateral spacing between coding marks where lateral-spacing type of encoding in employed.

Laser beam control means **46** can be mounted above the line as shown or more remotely. The speed-of-line signal is obtained from roll bridle **14** and delivered over line **48** (shown in dot-dash) to laser beam control means **46.** A representative value of the laser beam energy required for an individual marking is 1/**100** to 1/**1000** joule at line speeds between about 1500 and about 2000 feet per minute. Such values will establish a coding line which is not readily discernible with the unaided eye after electrotinplating. The laser beam energy requirement increases with increasing line speeds.

In practice, any lateral movement of strip **10** during passage through the coding zone is relatively small and is considered chiefly in order to assure marking across the full width of the strip. Roll means can help control such lateral movement on some lines but, preferably, on strip steel finishing lines, the edge sensing means **24** is utilized to measure such movement. Where lateral spacing between center lines of the laser beam producing means **20** has been preset slight lateral movement of the strip will not affect proper coding. However with certain types of coding, it is important that the individual laser beam producing means be kept in proper alignment with the strip. For this purpose a signal from edge sensing means **24** is directed over line **50** (shown

in dot-dash) to support **30.** Lateral movement of support **30** can effectively be controlled and coordinated with any lateral movement of the strip by conventional equipment such as that provided by General Precision Systems Control, Inc. of Morton Grove, Ill. Such controls are customarily used in the strip steel art for sensing lateral movement of the strip and control coiling of continuous strip. Using air for edge sensing, these systems are commonly known as Askania controls; photocell systems based on the same principles of operation are highly suitable for the present use.

With the apparatus described the proper coding of the strip can be carried out utilizing synchronization of strip speed with beam energy, and strip placement with placement of the laser beam producing means. As shown the strip is encoded before plating. However identical coding means and synchronization means can be utilized to code strip material which is not subsequently plated or can be utilized to effect coding of plated strip by location of the coding means on the line subsequent to the plating zone.

With most commercially available laser beam producing units optical beam splitting is utilized in order to obtain desired energy levels at conventional strip processing line speeds. Beam energy levels in the range of 1/**100** to 1/**1000** joule are satisfactory for producing markings of 0.001 to 0.03 at the various line speeds used in the steel industry. Markings of a width of less than 0.001 inch can readily be made and are discernible, but this figure is representative for a marking which is not discernible by the naked eye. Markings of a width greater than 0.03 inch may also be used, but such width is readily seen by the naked eye and wider widths would only be called for in special applications. Beam energy requirements increase with increasing width markings.

FIG. **3** shows, schematically, supplementary equipment which can be utilized to detect coding lines which are invisible or substantially invisible to the naked eye. End product sample **52** is positioned in the gap **54** of flux producing core **56.** Electrical power to coil windings (not shown) on core **56** is provided and controlled from source **58.**

Prior to inspection, iron powder in dry form or in a liquid carrier is spread on end product **52.** With placement of the end product **52** in the concentrated field in gap **54,** magnetic flux lines will concentrate along the surface discontinuities present from the surface etch codings. With the concentration of magnetic flux lines along the surface discontinuities, the iron powder will concentrate along these lines making coding line **60** and **62** visible to the naked eye. Flux producing means for use in the present invention are available commercially, for example from the Magnaflux Company, Chicago, Ill.

Another supplementary way for making coding lines more visible involves chemical etching. In this process the plating, if any, on the end product is removed. The end product is chemically etched, for example in nitric acid. The narrow-width surface etching caused by the laser beam, while invisible or substantially invisible to the naked eye prior to etching, in effect constitute surface imperfections which will be etched more readily by the chemical etchant than the remainder of the end product surface. With this etching technique the coding lines therefore become more readily visible.

While encoding of electrotinplated steel strip has been specifically described, it is understood that the invention may be utilized for encoding galvanized steel, blackplate, uncoated aluminum, and other continuous strip material. Also, other strip processing lines, strip guiding and control means than those specifically set forth may be utilized without departing from the invention so that the scope of the invention is to be determined from the appended claims.

What is claimed is:

1. Method for encoding continuous strip metal for subsequent identification of container end product cut from the strip comprising the steps of

passing a continuous strip longitudinally through a continuous-strip processing line at a predetermined line speed,

directing laser beam energy onto a surface of such strip along its longitudinal direction as the strip passes through the continuous processing line,

controlling the laser beam energy level in coordination with the line speed of the continuous processing line to produce predetermined etching of the surface of the strip to provide perforation-free encoding of such strip, such surface encoding being free of damage which would limit container end product usage and extending longitudinally along the surface of the strip,

selecting such surface encoding and the lateral location of such longitudinally extending encoding of the surface of the strip to be less than the smallest dimension container end product to be cut from the strip so as to encode each such end product,

measuring lateral movement of the continuous strip at a location contiguous to such impingement of laser beam energy during passage of such strip through the continuous strip processing line, and

coordinating control of such lateral movement and the direction of such laser beam to provide encoding across the full width of the strip, and

rigidly supporting such continuous strip to prevent strip flutter during encoding.

2. The method of claim **1** in which the laser beam is controlled so that such predetermined surface etching has a lateral dimension of between about 0.001 inch and about 0.03 inch.

3. The method of claim **1** in which the laser beam is controlled to produce a surface etching comprising a continuous longitudinally extending line.

4. The method of claim **1** in which the laser beam is pulsed to produce an intermittent surface etching in a longitudinal direction.

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