PRODUCING SIGNALS DENOTING LOCATION OF EDGES OF A FINISHED SURFACE ON A PARTLY FINISHED WORKPIECE

Inventor: Benkt Sanglert, Jonkoping, Sweden
Assignee: Saab-Scania Aktiebolag, Linkoping, Sweden
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ABSTRACT
An elongated workpiece having unfinished side surfaces inclined laterally downwardly and outwardly from a finished top surface is scanned to produce signals denoting location of the longitudinal edges of the top surface at numerous points along them. An elongated scanning zone, extending across the workpiece, is translated along the workpiece. In synchronism with scanning zone translation the workpiece is alternately illuminated from opposite sides at a low angle of incidence to the top surface to shadow first one side surface, than the other. Scanning lengthwise along the scanning zone is synchronized with translation of that zone and lighting alternation.

3 Claims, 3 Drawing Figures
PRODUCING SIGNALS DENOTING LOCATION OF EDGES OF A FINISHED SURFACE ON A PARTLY FINISHED WORKPIECE

This invention relates to measurement of the area and configuration of a finished surface on a partly finished workpiece, for the purpose of determining the trimming that will convert the workpiece to a finished piece of optimum size; and the invention is more particularly concerned with the production of signals which can be utilized by a computer and which denote the location of edges of a finished surface on a partly finished workpiece.

The type of workpiece that presents the problem with which the present invention is concerned is exemplified by an unedged cant that has been sawed from a log. It will be understood, however, that invention is also applicable to the finishing of other types of partly finished workpieces, such as the cropping of a steel bloom in a rolling mill. Hence the following discussion and explanation is limited to cants merely for purposes of simplification and by way of example.

A cant is an elongated piece having substantially flat and parallel top and bottom finished surfaces but having unfinished longitudinal side surfaces which may be very irregular and which are usually oblique to the top and bottom surfaces. Since the cant is to be made into one or more finished pieces that have side surfaces which are accurately perpendicular to the already-finished top and bottom surfaces, a certain amount of wood will be discarded in the finishing process. In the interests of economy, the finishing cuts must be so planned that the least possible amount of wood will be discarded. It will be evident that the orientation and spacing of the finishing cuts that will achieve best economy of material are dependent upon the configuration of the narrower one of the two finished surfaces of the cant, which narrower surface can be regarded as its top surface.

It has been recognized for some time that a computer could be utilized for calculating the most advantageous orientation and spacing of the finishing cuts. Obviously the computer requires inputs denoting the location of each edge of the top surface of the workpiece at each of a large number of points along its length. Heretofore, however, there has been no satisfactory expedient for producing such inputs quickly and accurately. As a result, reliance continues to be placed upon the skill and judgment of experienced craftsmen to plan the finishing of cants.

In one prior art device, a cant was moved transversely to its length beneath spaced apart photoelectric cells that were arranged in a row extending lengthwise of the cant. As the cant approached the photoelectric cells, it was illuminated by light from a first source that shone upon it from behind its trailing edge and at a low angle of incidence to its top surface, so that its leading oblique side surface was unilluminated. Each of the photoelectric cells therefore produced an output signal that underwent an abrupt increase in magnitude as the front edge of the top surface came under it. At about the time that the longitudinal centerline of the cant came under the row of photoelectric cells, the first source of light was extinguished and simultaneously a second light source was turned on that illuminated the cant, again at a low angle of incidence to its top surface, but this time from in front of its leading edge so that its rear oblique side surface was unilluminated. Hence the signal from each photocell underwent an abrupt decrease in magnitude as the rear edge of the top surface passed under it.

While offering a theoretical solution to the problem, such apparatus was not practical. For accurate results, the cant had to be transported through the scanning zone beneath the photocells with a purely translatory motion, and it could not be allowed to undergo any joggling or reorientation during the course of such travel. More important, the need for moving the cant transversely to its length required the allotment of a considerable amount of floor space to that part of a sawmill in which the scanning operation was performed. Furthermore, the accuracy of the calculation made by the computer depended upon the closeness of spacing of the photocells, and hence required either that an awkwardly large number of photocells be used or that accuracy be sacrificed in using a lesser number of photocells spaced at larger intervals. The fact that signals containing the data input to the computer were issued from all of the photocells simultaneously was also a disadvantage, inasmuch as it greatly complicated the problem of interfacing the scanning apparatus with the computer.

The general object of the present invention is to overcome these disadvantages and to enable suitable inputs to be delivered to a computer from a single photocell that produces a rapid succession of signals which denote the location of each of the opposite longitudinal edges of the top surface of a cant or similar partly finished workpiece at each of a large number of stations that extend across the workpiece and are spaced from one another at close intervals along its length. It is also a general object of this invention to provide a method and apparatus for very rapidly scanning a cant or similar elongated partly finished workpiece that has a substantially flat top surface defined by opposite more or less irregular longitudinal edges, and for producing sharply defined signals that accurately denote the location of each of said edges at each of a large number of closely spaced points along the length thereof, all without requiring any motion of the workpiece.

Another object of the invention is to provide a method and means for making rapid, automatic measurements of cants and similar workpieces in a manner that is practical for computer control of the finishing operation, thus making possible the elimination of a tedious and rather difficult type of labor and the attainment of substantial savings of valuable material.

With these observations and objectives in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings, which exemplify the invention, it being understood that changes may be made in the specific apparatus disclosed herein without departing from the essentials of the invention set forth in the appended claims.

The accompanying drawings illustrate several complete examples of embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIG. 1 is a more or less diagrammatic perspective view of apparatus embodying the principles of the present invention; and

FIGS. 2a and 2b are diagrammatic perspective views which illustrate alternative methods of illuminating the
workpiece for scanning in accordance with the method of this invention.

Referring now to the accompanying drawings, the numeral 5 designates generally an elongated partly finished workpiece, here illustrated as a cant that has been sawed from a log and has only its top and bottom surfaces finished. The opposite longitudinal side surfaces 6 and 7 of the cant, which are unfinished and may be somewhat irregular, extend obliquely downwardly and laterally outwardly from the finished top surface 8.

The cant 5 is to have its opposite side portions removed, so that it will be brought to the form of a parallelepiped, with side surfaces accurately parallel to one another and perpendicular to the top and bottom surfaces. Such finishing is accomplished by means of an edging machine that can comprise a pair of cutters, illustrated as saw blades 9 and 10. The cuts made by the cutters must provide for one or more finished workpieces of standardized width or widths, with a minimum wastage of stock.

The amount of material in the cant that is available for finished product obviously depends upon the configuration of the narrower of the two finished surfaces of the partly finished workpiece. This is to say that the finishing cuts are calculated upon the basis of the shape and spacing of the longitudinal side edges 11 and 12 of the finished top surface 8, said edges being defined by the junction of that top surface with the respective side surfaces 6 and 7.

Information about the configuration of the top surface 8, obtained as described hereinafter, is fed into a suitable computer 13, in the form of input signals that correspond to the distance between an arbitrarily chosen reference line and each of the edges 11 and 12. The computer 13 can comprise known apparatus that utilizes such signals to make a calculation of the orientation of the cant and the spacing between the cutters 9 and 10 that will afford the economically optimum finishing cut or finishing cuts. The computer issues output signals that automatically effect the proper cant orientation and cutter spacing.

The means for spacing the cutters 9 and 10 in response to computer outputs is not shown, inasmuch as such apparatus is well known.

The means for orienting the cant comprises a pair of endless belts or bands 14 and 15, one under each end portion of the cant and extending transversely to the length of the cant. It will be understood that each of the endless belts or bands 14 and 15 is driven by a reversible servo (not shown) that is controlled by outputs from the computer, and that proper coordination of the movements of the two bands effects the necessary edgewise rotation and/or translation of the cant to present it to the cutters 9 and 10 for the desired cut.

The cant can be advanced lengthwise into the area at which measurement takes place, and out of that area for cutting by the cutters, by means of a roller conveyor 16 that has its rollers extending transversely to the length of the cant and parallel to the length of the belts or bands 14 and 15.

From what has been said above, it is apparent that the key to a successful and economical finishing of the workpiece is the rapid generation of signals which accurately denote the locations of the edges 11 and 12 and which are in a form that can be utilized by the computer 13.

For the purpose of such signal generation, the present invention contemplates that the workpiece shall be illuminated alternately from opposite sides thereof, with illumination from each side being at a low angle of incidence to the top surface. As shown in FIG. 14, such illumination can be provided by means of two parallel rows of lights 17 and 18 at laterally opposite sides of the workpiece, each row extending parallel to the top surface 8 of the cant and generally parallel to the longitudinal centerline thereof and being at a level a little above the top surface 8 of the workpiece.

It will be evident that when the lights 17 illuminate the cant, they shine upon its top surface 8 and upon its side surface 6 that is near them, but by reason of their low angle of incidence to the top surface they leave the opposite side surface 7 unilluminated so that they cast a shadow that sharply defines the longitudinal edge 12 of the top surface. Similarly, when the lights 18 shine on the cant, they illuminate its side surface 7 and its top surface 8 but leave the opposite side surface 6 in a shadow that sharply defines the longitudinal edge 11.

In general, according to the method of this invention a long, narrow scanning zone 20 is defined which has its length transverse to the longer dimension of the workpiece and which extends entirely across it. A relative translation is effected between the strip-like scanning zone and the workpiece, in a direction lengthwise of the workpiece and hence transversely to the scanning zone. By such relative translation the scanning zone is caused to traverse the entire workpiece from one end to the other. In synchronism with such translation of the scanning zone, the workpiece is alternately illuminated first from one side and then from the other, as described above.

Also synchronized with such translation of the scanning zone is a scanning operation that takes place lengthwise along the scanning zone. The scanning is effected with the use of a photo-responsive detector or photo-electric cell 21, which produces an output signal that varies in correspondence with variations in the intensity of light reflected upwardly from the workpiece. Thus, if the scanning zone is scanned in the direction from the lights 17 towards the lights 18 at a time when the workpiece is illuminated only by the lights 18, there will be a zero or very low signal output from the photo-electric cell during the initial portion of the scan, and then, precisely as the scan crosses the longitudinal edge 11, there will be an abrupt increase in signal output to a relatively high level as the cell picks up the light reflected from the upper surface 8. The time during the scan at which that change in signal magnitude occurs is of course a function of the location of the edge 11.

As the scan crosses the opposite edge 12, there may be some change in signal level, either upwardly or downwardly, depending upon the reflectance of the oblique side surface 7, but there is no need to take account of this minor change in output level because the location of the edge 12 can be accurately ascertained in the next phase of the scanning cycle. As the direction of scan reverses, the lights 18 are extinguished or blanked out, and the workpiece is simultaneously illuminated from the lights 17. During the return scan there is an abrupt change in signal level as the scan crosses the edge 12, affording an indication of the position of that edge at the then-existing location of the scanning zone.
Obviously scanning could always take place in one direction along the scanning zone, with illumination from alternate sides during successive scans. Similarly, the scanning zone could be steadily translated all during the scanning cycle, or, instead, could be advanced incrementally for each scanning cycle or for each phase of a scanning cycle. Thus any of a variety of scanning patterns could be employed, depending upon the accuracy of the desired calculations and the program for which the computer 13 was set up.

The apparatus for carrying out the above described process that is illustrated in FIG. 1 comprises, in addition to the lights 17 and 18, a mirror 22 that is mounted for rotation about a fixed axis that extends transversely to the length of the workpiece and parallel to its upper surface, and guided actuator means 23 by which the photocell 21 is carried for bodily back and forth scanning motion in directions parallel to the rotational axis of the mirror. Both the mirror and the photocell are mounted above the workpiece.

The mirror 22 is elongated in the direction of its axis, having a length great enough to span the widest expected cant. It is mounted at a location spaced beyond one end of the cant, while the photocell 21 is spaced from the mirror in the direction toward the other end of the cant.

At any given instant the photocell receives the light reflected from an incrementally small area of the top surface 8 of the cant, which light is re-reflected to the photocell from the mirror. It will be apparent that the strip-like scanning zone on the surface of the cant is defined by the mirror, as it reflects from the cant into the scanning path of the photocell; and it will also be apparent that rotation of the mirror about its axis has the effect of translating the scanning zone along the cant in accordance with the principles of this invention as explained above.

To provide for its rotation, the mirror is mounted on a spindle or shaft 24 that has one of its ends connected to a pulse generator 25 and has its other end connected with a suitable rotation servo 26. The servo causes the mirror to swing at a predetermined rate which effects translation of the scanning zone along the length of the cant, as explained above. At each of a predetermined series of increments of swinging motion of the mirror the pulse signal generator 25 emits a pulse signal that is fed to a synchronization element 27. The synchronization element, in turn, controls and coordinates the alternate operation of the lights 17 and 18 and scanning action of the photocell, as explained above. Inasmuch as the pulse signal is a function of the position of the scanning zone lengthwise along the cant, and denotes a reversal or other arbitrary point along the scanning path of the photocell, the pulse signals can be utilized by the computer 13 (to which the synchronizing element 27 is also connected) to define a coordinate axis to which can be related the edge location signals that are fed to the computer from the photocell.

It will be evident that instead of the mirror being tilted to effect translation of the scanning zone, the mirror could be held stationary and the conveyor rollers 16 could be driven, to effect lengthwise movement of the cant at a suitable rate. In like manner, the scanning along the scanning zone could be effected by means of various other known expedients functionally equivalent to bodily movement of the photocell.

FIG. 2a illustrates an alternative method of coordinating illumination of the cant with translation of the scanning zone lengthwise along the cant. In this case light sources 17' and 18' at opposite sides of the cant direct constant illumination towards it, but the cant is partially screened from the light sources at both sides of it by means of upwardly projecting fingerlike screening elements 29, 30 that are of uniform width as measured lengthwise of the cant. The screening elements are spaced apart by distances equal to their width, and those at each side of the cant are in staggered relation to those at the other side thereof, rather than being directly opposite one another. In consequence of this staggered relationship of the screening elements, the scanning zone, during its translation along the length of the cant, passes through successive areas in which the cant is alternately lighted from opposite sides, first from one side as the scan moves through one area, then from the other side as the scan moves through the next area. Movement of the photocell can be so synchronized with translation of the scanning zone that the photocell moves in one direction in one such area and in the opposite direction in the next such area.

FIG. 2b illustrates another arrangement in which the cant is constantly illuminated from light sources at both sides of it. In this case, however, color filters are used to produce the same effect as alternate illumination. By way of example, the light source 17' at one side of the cant can shine through a red filter, while the other light source 18' can be equipped with a blue filter. During scanning, red and blue filters are alternately arranged in the beam path between the cant and the photocell, according to the direction in which scanning is taking place. Thus when the photocell is moving in the direction from the red light source toward the blue one, the red filter will be in front of the photocell so that it will respond to the red light shadow that terminates at the edge 12 and will be non-responsive to the blue light falling on the side surface 7. For the traverse in the opposite direction the blue filter will be in front of the photocell, so that it can produce a marked signal on crossing the edge 11.

From the foregoing description taken with the accompanying drawings it will be apparent that this invention provides a very simple and accurate method, capable of being practiced with inexpensive and compact apparatus, for obtaining signals that correspond to the locations of the longitudinal edges of one finished surface of a partly finished workpiece such as a cant, which signals can be fed to a computer that calculates the best orientation and spacing of cuts that will convert the workpiece to a finished one of optimum size with the minimum of waste.

Those skilled in the art will appreciate that the invention can be embodied in forms other than as herein disclosed for purposes of illustration.

The invention is defined by the following claims:

1. The method of obtaining information about an unfinished elongated workpiece that has a substantially flat top surface and has opposite lengthwise extending side surfaces, each of which extends downwardly from said top surface and at its junction therewith defines a side edge thereof, said information being in the form of signals which are related to the shape and orientation of said side edges and their spacing from one another and which can be utilized for determining the trimming that will convert the unfinished workpiece to a regular-
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4 ly-shaped finished one that is of optimum size in relation to the area of said top surface, said method being characterized by:
A. in a reflector spaced above the top surface of the workpiece, and with the workpiece stationary, imaging a portion of the workpiece comprising a narrow, elongated scanning zone which has its length transverse to that of the workpiece and which extends entirely across the workpiece;
B. rotating said reflector about a horizontal axis which is spaced above the top surface of the workpiece and which extends transversely to the length of the workpiece, to translate the imaged scanning zone of the workpiece along the length thereof;
C. as the reflector rotates, repeatedly scanning the image of said zone to detect variations in the level of illumination along the length of said zone at each of a plurality of locations thereof along the length of the workpiece, to produce signals corresponding to said variations and which contain said information; and
D. in synchronism with scanning, alternately from opposite sides of the workpiece illuminating at least that portion of the workpiece which the scanning zone is crossing, with such illumination at a low angle of incidence to the top surface of the workpiece so that illumination from each side of the workpiece cannot fall upon the opposite side surface of the workpiece.

2. Apparatus for scanning an unfinished elongated workpiece that has a substantially flat top surface which terminates at a pair of opposite longitudinally extending edges, to produce signals which are related to the orientation and configuration of said side edges and their spacing from one another, said apparatus comprising:
A. supporting means for holding a workpiece stationary with its top surface horizontal and its length extending in a predetermined direction;
B. photoresponsive detector means mounted in upwardly spaced relation to the supporting means and facing substantially in said direction;
C. means connected with said detector means for causing the same to scan repeatedly along a horizontal path transverse to said direction;
D. reflector means having a reflecting surface;
E. means mounting the reflector means for rotation about an axis which is parallel to said reflecting surface, said axis being
1. horizontal, spaced above said supporting means, and transverse to said direction, and
2. spaced from the detector in said direction that the reflector means can reflect to the detector means, for scanning thereby, an image of a zone which extends entirely across a workpiece on the supporting means, and which zone moves lengthwise along the workpiece, from one end to the other thereof, as the reflector rotates;
F. means for rotating the reflector at a rate so related to the rate of repetitive scanning that the imaged zone of the workpiece that is scanned by the detector means advances lengthwise along the workpiece from scan to scan; and
G. means comprising at least a pair of light sources located at opposite sides of said supporting means for illuminating at least that zone of a workpiece which is imaged by the reflector means, at a low angle of incidence to the top surface of the workpiece and alternately from opposite sides thereof in synchronism with scanning by the detector means, so that illumination does not extend beyond each of said edges of the workpiece when the scan reaches the vicinity thereof.

3. The method of employing a photosensitive detector device that is capable of producing outputs corresponding to variations in level of illumination along an elongated narrow scanning zone, to obtain information about an unfinished workpiece that has a substantially flat top surface and has lengthwise extending side surfaces, each of which side surfaces extends downwardly from said top surface and at its juncture therewith defines a side edge thereof, said information being in the form of outputs from the detector device which are related to the shape and orientation of said side surfaces and their spacing from one another and being adapted for use in calculating the trimming of the unfinished workpiece that will convert it to a regularly-shaped finished one of optimum size in relation to the area of said top surface, said method being characterized by:
A. establishing the detector device and a reflector having a reflecting surface in such upwardly spaced relation to the workpiece and such horizontally spaced relation to one another that the scanning zone of the detector device in its cooperation with the reflector has its length transverse to the length of the workpiece and extends entirely across the workpiece;
B. with the workpiece stationary, so rotating the reflector during operation of the detector device as to advance said scanning zone, transversely to its length, from one end of the workpiece to the other;
C. in timed relation to rotation of the reflector, alternately from opposite sides of the workpiece illuminating at least that portion of the workpiece which the scanning zone extends, with such illumination at a low angle of incidence to the top surface of the workpiece so that illumination from each side of the workpiece cannot fall upon the opposite side surface of the workpiece; and
D. causing the detector device to produce outputs at intervals during rotation of the reflector so that said outputs denote the position of each of said side edges at each of a succession of points along the length of the workpiece.

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