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[56]

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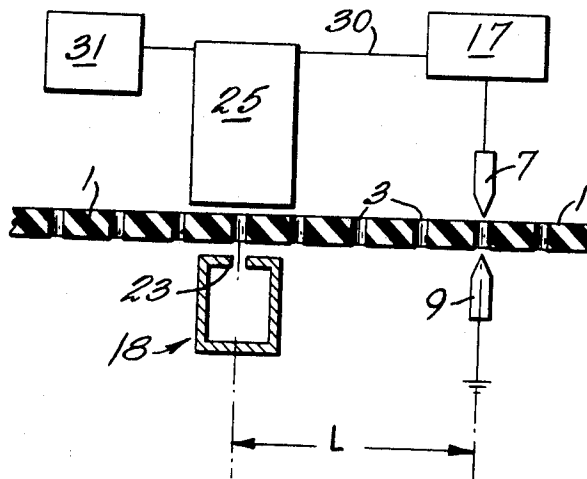
[54] BENCH MARKS IN SHEET OR WEB MATERIAL
8 Claims, 5 Drawing Figs.

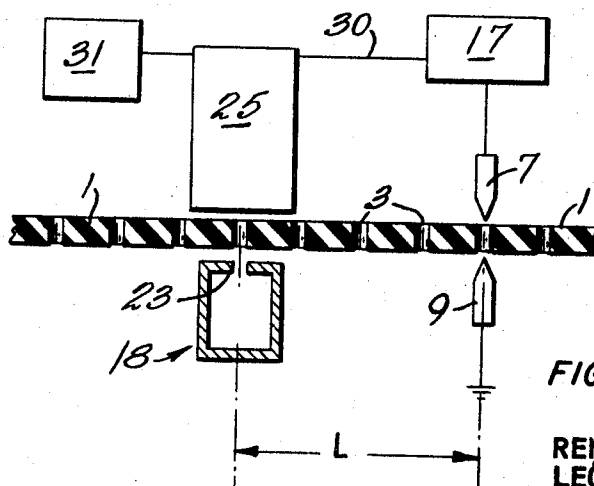
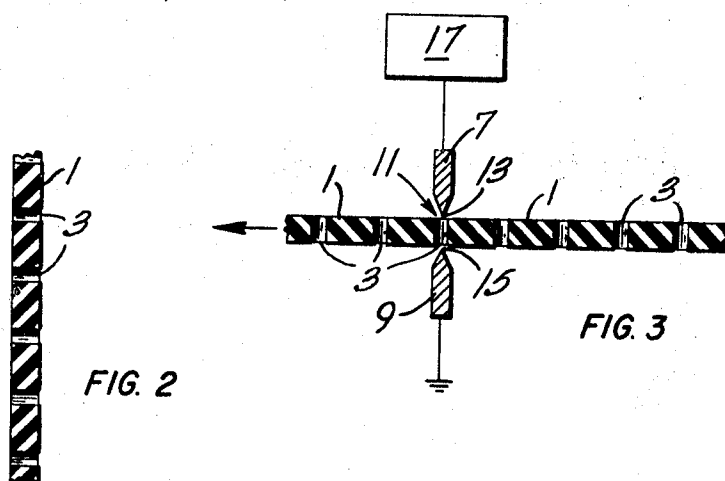
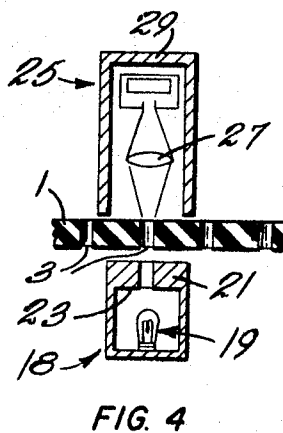
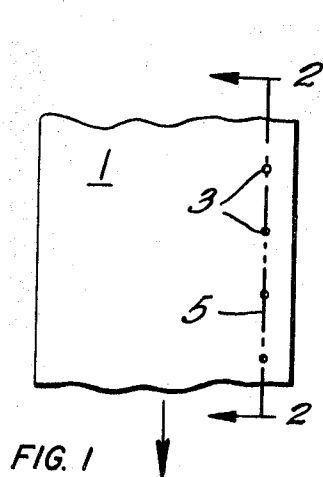
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ABSTRACT: A sheet or web of material with reference marks in the form of tiny perforations. The perforations are preferably formed by sparking holes through the web.





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BENCH MARKS IN SHEET OR WEB MATERIAL

This invention relates to providing a sheet or web of material with reference marks.

In the manufacture and use of sheet or web material such as paper or plastic film, it is desirable to provide reference marks on the material in order to perform various operations. These operations can include using the reference marks to measure the length of the sheet or web, to measure their speed of travel during use, to provide accurate registration of successive sheets or impressions on a continuous web during their travel and even to identify the sheet or web.

Reference marks have been used in the past. However, all of these previously used marks have disadvantages. Printed marks, because of the mechanical nature of application, are difficult to apply when the sheet or web is travelling at high speed and are not too well defined. Further, printed marks can become disfigured and result in inaccurate measurements between one mark and the next. Watermarks, applied to paper, are too vaguely defined and are too large to provide accurate measurements. Any radioactive tracer material or magnetic material used as a mark is usually applied in a mechanical fashion to the sheet or web, and again this is not satisfactory for high speed operation. Many reference marks, when applied, are visible and cannot be used when the sheet or web must have surfaces unmarked in appearance. One of the most important disadvantages, particularly since most known reference marks are applied with mechanical means, is the time required for applying the reference mark on a web travelling at high speed from the instant a command is given to apply the reference mark. Even if it only takes 1/1000 second to apply the mark, for a web travelling at 2500 ft./min., the web will have moved 1/2 inch in the time taken to apply the mark.

It is therefore an object of the present invention to provide reference or reference marks in a sheet or web of material which overcome the disadvantages of the prior art while providing positive advantages which include ease of application, particularly when the sheet or web is travelling at high speed, which are not visible under casual observation and which do not substantially affect the quality of the sheet or web.

It is a more particular object of the invention to provide a sheet or web of material having reference marks in the form of perforations. The perforations can be provided at spaced locations on the sheet or web and preferably are substantially circular having a diameter in the range of from 0.002 inches to 0.02 inches.

It is another object of the invention to provide a method of reference marking a moving sheet or web of material, particularly a sheet or web of material travelling at high speed, comprising forming perforations in the material at spaced locations, the perforations being substantially circular and having a diameter in the range of from 0.002 inches to 0.02 inches. Preferably, the perforations are formed by burning a hole through the sheet or web.

The perforations formed in the sheet or web material must be small enough so that they are not normally visible to the naked eye so as to detract from the surface appearance of the sheet or web and yet are large enough to allow detection of the perforations through the use of sensing means such as a light source and light detector. The size of the perforations will depend to some extent on the quality, nature and thickness of the web being perforated. Newsprint, for example, has more specks of dirt in it than white bond quality paper and, for the same thickness of paper, larger perforations may be used in newsprint than in the bond paper, since the perforations will not be as visible among the specks in newsprint as on the clean surface of the bond. The larger the perforations, the easier they are to detect using the sensing means.

The invention is particularly useful in the papermaking industry. The invention allows many paper products, particularly those which must have an unmarked appearance, to be provided with reference marks. In the manufacture of a paper

web, the marks can be used, for example, to measure the speed of travel of the web, the length of a web, and the amount of dimensional change in the web during its manufacture. The perforations can be formed when the web is travelling at speeds up to 20,000 ft./min. and when the web has a moisture content up to 60 percent by weight of water.

The invention will now be described in detail having reference to the accompanying drawings, in which:

FIG. 1 is a plan view of a sheet or web material showing the reference marks of the invention;

FIG. 2 is a cross-sectional view of the sheet shown in FIG. 1 taken along line 2-2;

FIG. 3 shows an apparatus for applying the reference marks to a moving sheet or web of material;

FIG. 4 shows an apparatus for detecting the reference marks in a moving sheet or web of material; and

FIG. 5 shows an apparatus for applying a series of reference marks to a moving sheet or web of material.

FIG. 1 illustrates a sheet or web of material 1 which has reference marks 3. The size of the reference marks are exaggerated in the drawings. The sheet or web is a cellulose material, preferably paper, although other sheet or web materials such as thin plastic film can be provided with the perforations also. As shown in FIG. 2, the reference marks 3 consist of substantially cylindrical holes passing transversely through the web 1. The holes preferably have a diameter at least equal to the thickness of the web or sheet material. The diameter of the holes can preferably range between 0.002 inches to 0.02 inches. If the holes are any smaller than 0.002 inches, they are extremely difficult to detect and therefore not useful as reference marks. If the holes are larger than 0.02 inches, they can normally be seen by the naked eye and thus mar the appearance of the web. As shown in FIG. 1, the reference marks may be applied in a line 5 extending parallel to the direction of movement of the web, as shown by the arrow in FIG. 1, and can be equally spaced from one another.

FIG. 3 illustrates one method of forming the perforations in the travelling web. In this method, particularly suitable when the web is of paper, the perforations are made by burning through the web with a spark. Two electrodes 7, 9 are apart to form a gap 11 through which the web travels as shown. Preferably, the gap between the electrode tips 13, 15 is about 0.125 inches. The tips of the electrodes have a radius of about 0.0015 inches. One electrode is connected to ground. The other is connected to a well-known capacitance discharge device 17 similar to the system used in an automobile ignition system. A battery or DC power supply of approximately 400 volts is used to charge the capacitor. When the capacitor is discharged, a spark will jump between the tips of the electrode burning a hole in a paper web located between the electrodes. The time required to form the perforation from the instant a command signal is given would be approximately 20 microseconds. Because of the random path travelled by the spark in passing between the electrodes, the perforation formed in the web is not always centrally located with respect to the longitudinal center line of the electrodes. To minimize the variations in the path of the spark, the web can be located closely adjacent to the tip of one of the electrodes. The size of the perforation formed by spark burning can be controlled by the input power and configuration of the spark producing circuit. The radius of the electrode tips should preferably be kept as small as possible in order to limit spark wander and more accurately control the placement of the perforation. Where very accurate placement of the hole is not as important, the size of the electrode tips may be made larger to increase the life of the electrodes. Other known spark-producing means can be used which do not require a capacitor or DC power supply.

The perforations are easily detected by passing the web over a light source. As shown in FIG. 4, the light source 18 includes means for emitting light such as a light bulb 19 located adjacent one side of the web. A cover 21 having a slit 23 is located between the light bulb and web. On the other side of

the web is a light detector 25 having a lens 27 and a photomultiplier tube 29. When a perforation passes the slit 23, an image of the illuminated perforation is magnified by the lens 27 and is detected by the photomultiplier tube 29. Preferably, the slit 23 is approximately 0.006 inches in width, and the photomultiplier tube 29 is sensitive enough to detect the perforation passing across the slit in the first 0.001 inch of its travel. The signal from the photomultiplier tube can be amplified and, depending on the use of the perforations, can be transmitted to a counter for counting the perforations when measuring the length of a web, can be used for measuring time intervals for measurement of web velocity, or can be used in other ways which will be apparent.

The perforations formed by the spark may not always be perpendicular to the web or sheet since the spark follows the line of least resistance through the material. Consequently, the perforation could be formed at an angle to the plane of the web or sheet. Detection of the angled perforation by a light source is more difficult since the detecting means is arranged to operate along a line perpendicular to the plane of the sheet. If the diameter of the perforation is less than the thickness of the web or sheet in which it is formed, and if it is formed at an angle, there is the possibility that the perforation may not be detected. It is therefore preferred to form the perforations to at least a diameter equal to the thickness of the web or sheet. The diameter may be larger than the web or sheet thickness provided that it is not large enough to detract from the appearance of the web or sheet.

The pattern and/or method in which the perforations are formed in the web can vary depending on what they are used for. If it is desired, for example, to measure the length of a web, the perforations are made at equally spaced intervals along the length of the web as shown in FIG. 1. To make the holes, an arrangement as shown in FIG. 5 could be used. The electrodes 7, 9 are located a spaced distance L from the center of the slit 23 in the light source 18. After a first perforation is formed by manual operation of the sparking device 17, the following perforations can be formed automatically. Passage of the first perforation past the detector will trigger the sparking device 17 through line 30 to form another perforation. The process of using the detection of each previously formed perforation to form the next following perforation continues. Each detection of a perforation is counted by a counter 31. The distance "L" between the detector and electrode tip is known. The distance "L" multiplied by the number of counts on the counter gives the length of the web.

Other means besides burning the hole with a spark can be used to form the perforations. For example, the perforations may be formed with a laser beam. The laser has the advantage over sparking in providing a more accurate placement of the perforation since it burns a hole perpendicularly through the web while the spark, following a line of least resistance, may form a perforation which is off center. However, the perforation produced by the laser has more ragged edges than a sparked perforation and is not as well defined.

The perforations may be formed in pairs, the perforations in each pair a spaced known distance apart, extending either longitudinally or transversely along the web. The pair of perforations may be applied prior to, during, or after the drying of a web of paper. The distance between each pair can be measured during or after the drying operation and the difference in the distance between the pair of holes when formed and when measured provides an indication of the dimensional change of the web. Thus, variations in the dimensional change can be used to control the drying operation of a web to ensure even drying transversely of the web. If the perforations are formed after drying, they may be used to measure dimensional changes in a roll of web material due to humidity changes or mechanical set of web when in roll form prior to or during use of the rolled web. The perforations can also be used to measure dimensional changes in a preprinted web or sheet between the printing step and a subsequent printing step in order to properly register the web or sheets for the subsequent printing step.

When using a single longitudinal row of perforations and a single detector, a perforation may miss being detected for some reason or the detector may give a false reading on detecting a pin or blow hold formed in the material. To avoid such errors, a plurality of perforations, five for example, may be formed in a row transversely to the direction of movement of the web at each location where reference marks are desired. A detector is provided for each hole at the detecting station. Logic circuitry connected to the detectors would pass a signal if, for example, three of the five detectors gave a signal indicating a perforation. Such an arrangement would ensure proper detection of the reference mark at each location.

Square patterns of four holes may be provided with four detectors to detect both longitudinal and transverse changes in the web. Coded information may be applied to the web in forming the perforations in a specific pattern, this information being invisible to the naked eye but being readily read through sensitive light detectors. Various other uses will be apparent to people skilled in the art.

We claim:

1. A method of forming reference marks on a web and measuring comprising:
 - accurately locating a reference mark forming station relative to a reference mark sensing station in spaced relationship;
 - forming a first reference mark in said web at said forming station by electrical means perforating said web;
 - continuously moving said web at high speeds through said forming and said sensing stations;
 - sensing said first mark at said sensing station and actuating said forming station upon sensing of said first mark to perforate said web by said electrical means and form a second reference mark accurately spaced from said first mark;
 - sensing said second mark at said sensing station and actuating said forming station upon sensing of said second mark to perforate said web by said electrical means and form a third reference mark accurately spaced from said second reference mark by the same distance as the spacing between said first and said second marks;
 - continuing this procedure to form a plurality of accurately positioned reference marks on the web, thereby to form a web having a series of accurately spaced reference marks for measuring; and
 - counting the number of said marks by electrical means thereby to obtain an indication of the length of said web.
2. A method as defined in claim 1 wherein said reference marks are formed in said forming station by said electrical means burning through said web.
3. A method as defined in claim 2, wherein said electrical means comprises an electrical spark passing through said web.
4. A method as defined in claim 2, wherein said electrical means comprises a laser beam passing through said web.
5. A method as defined in claim 1, wherein said counting the number of said marks comprises counting said marks sensed at said sensing station in relation to time to obtain a frequency of marks passing the sensing station, and computing with electrical means the velocity of the web from said frequency, thereby to obtain an indication of the velocity of the web.
6. A method as defined in claim 2, wherein said counting the number of said marks comprises counting said marks sensed at said sensing station in relation to time to obtain a frequency of marks passing the sensing station, and computing with electrical means the velocity of the web from said frequency, thereby to obtain an indication of the velocity of the web.
7. A method as defined in claim 3, wherein said counting the number of said marks comprises counting said marks sensed at said sensing station in relation to time to obtain a frequency of marks passing the sensing station, and computing with electrical means the velocity of the web from said frequency, thereby to obtain an indication of the velocity of the web.

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8. A method as defined in claim 4, wherein said counting the number of said marks comprises counting said marks sensed at said sensing station in relation to time to obtain a frequency of marks passing the sensing station, and computing

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with electrical means the velocity of the web from said frequency, thereby to obtain an indication of the velocity of the web.

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