This invention relates to measuring apparatus and methods and more particularly to apparatus and methods for making particular measurements as an article advances along a feed path.

Measuring apparatus and methods of the type to which the present invention is directed, while of general application, are particularly well suited for ascertaining the duration of the application of pressure to an article as it moves along a feed path. As an illustration, such apparatus and methods advantageously may be employed in connection with a papermaking machine, for example, to ascertain the time during which pressure is applied to a papermakers' felt or other paper web carrier as it moves through the nip between a pair of rollers on the machine. As is well known in the papermaking field, paper is formed from a web of water saturated pulp which is transported by one or more papermakers' felts through opposed press rolls and/or other dewatering devices until the moisture content of the web is reduced to a satisfactory level. The felts customarily are arranged in the form of endless belts which are mounted under tension on a series of drive rolls and support rolls with the paper supporting portions extending through the nips between the press rolls. As the paper supporting portion of a particular felt moves along its feed path, the felt picks up considerable moisture from the wet paper web. To operate effectively, a substantial quantity of this moisture must be removed from the felt as it passes between the press rolls.

To insure that a maximum quantity of moisture is removed from the felt as it is led through the nip between the press rolls, pressure should be applied by the rolls for a controlled length of time. In addition, the distance travelled by a given section of the felt while under the pressure and the speed of the felt also should be carefully controlled. It is therefore desirable to accurately measure these characteristics in order that any necessary adjustments can be made to provide effective moisture removal.

Heretofore, difficulties have been encountered in the measurement of particular characteristics of a papermakers' felt or other article moving along a feed path. For example, in prior apparatus and methods for this purpose, the measurements for the most part were made by applying pressure to the felt during one or more static tests, and when the felt was placed in operation on a paper machine additional factors were introduced which greatly reduced the accuracy of the test results. In addition, in many apparatus and methods of the type employed heretofore, the applied pressure was measured over a relatively wide area, with the result that the accuracy and selectivity of the individual measurements were further reduced.

One general object of this invention, therefore, is to provide a new and improved apparatus and method for making particular measurements on papermakers' felts or other articles.

More specifically, it is an object of this invention to provide an apparatus and method for making such measurements as the article is advanced along a feed path.

Another object of this invention is to provide an apparatus and method of the character indicated for measuring the duration of the application of pressure to the article in an accurate and straightforward manner.

A further object of the invention is to provide such an apparatus and method for measuring the rate of movement of the article as it advances along its path.

Still another object of the invention is to provide a measuring apparatus which is economical to manufacture and thoroughly reliable in operation.

In one illustrative embodiment of the invention a switching device of unique construction and arrangement is positioned adjacent a surface of the papermakers' felt or other article to be measured. This device is formed from a pair of flexible, electrically conductive switch elements which are supported within an elongated envelope of dielectric material. The switch elements are separated by insulating means having two longitudinally spaced apertures therein. As pressure is applied to the switching device and the article, the portions of the switch elements adjacent the apertures are urged into contact with each other to close a circuit and provide an electrical signal which is representative of the desired measurements.

In accordance with one feature of the invention, in a representative embodiment, the switch elements are urged into engagement with each other only upon the application of a pressure greater than a predetermined pressure, with the result that a signal is detected only when the applied pressure exceeds the predetermined pressure.

In accordance with another feature of the invention, in certain preferred embodiments, the switching device is advanced along a feed path simultaneously with the article to be measured. As a result, the overall accuracy and reliability of the measurements are greatly enhanced.

In accordance with still another feature of the invention, in certain good arrangements, an alternating current of fixed frequency is supplied to the switching device, and the duration of the detected signal is measured to provide an indication of the time during which the applied pressure exceeds the predetermined pressure.

In accordance with a further feature of certain embodiments of the invention, the switch elements are arranged to contact each other at particular, discrete points, with the result that the device is highly selective and provides an extremely accurate indication of the measured time interval.

The present invention, as well as further objects and features thereof, will be understood more clearly and fully from the following description of certain preferred embodiments, when read with reference to the accompanying drawings, in which:

FIGURE 1 is an exploded perspective view of a switching device forming a part of measuring apparatus in accordance with one illustrative embodiment of this invention which is useful in practicing the method of the invention;

FIGURE 2 is a top plan view of the switching device of FIGURE 1;

FIGURE 3 is a schematic representation of a pair of press rolls and associated components of a papermaking machine, together with the switching device and other portions of the apparatus;

FIGURE 4 is an enlarged fragmentary sectional view of a portion of FIGURE 3;

FIGURE 5 is a fragmentary sectional view in general similar to FIGURE 4 but showing the switching device as it is advanced through the nip between a pair of resilient rollers;

FIGURE 6 is a schematic wiring diagram of the apparatus;
FIGURE 7 is a schematic representation of an illustrative oscilloscope trace showing representative measuring signals from the apparatus; FIGURE 8 is an exploded perspective view of a switching device forming a part of measuring apparatus in accordance with another illustrative embodiment of the invention; and FIGURE 9 is a vertical sectional view of the device of FIGURE 8, taken through a longitudinal, median plane.

Referring to FIGURES 1 and 2 of the drawings, there is shown a switching device indicated generally at 15 which include an elongated, substantially rectangular envelope 16 of insulating material. The envelope 16 is formed from two flat sheets 18 and 19 which are adhesively secured together along abutting portions thereof and are fabricated from epoxy or other material having a comparatively high dielectric constant. The sheets 18 and 19 are flexible and illustratively have a thickness of about two to five thousandths of an inch.

Interposed between the dielectric sheets 18 and 19 are two switch elements 25 and 26 of flexible, electrically conductive material. The elements 25 and 26 comprise relatively small diameter wires and includes insulated portions 27 and 28, respectively, which protrude from one end of the envelope 16. The element 25 extends in a generally longitudinal direction but is bent in the shape of a U adjacent its inner end to form two transversely extending legs 30 and 31. As best shown in FIGURE 2, these legs are the remaining longitudinal portions of the element 25 at right angles.

The switching element 26 extends longitudinally and is laterally spaced with respect to the longitudinal portions of the switch element 25. The element 26 crosses the legs 30 and 31 of the element 25 at right angles. The legs 30 and 31 serve as the contact portions of the element 25 and cooperate with corresponding contact portions 33 and 34, respectively, on the element 26.

The contact portions 30 and 31 are normally maintained in spaced relationship with the corresponding contact portions 33 and 34 by insulating means which, in the embodiment illustrated in FIGURES 1–6, comprises two comparatively thin washers 36 and 37 of dielectric material. These washers include centrally located apertures 38 and 39, respectively, which are each of a diameter greater than the diameter of the wires forming the punch elements 25 and 26. The washer 36 is positioned in the envelope 16 between the contact portions 30 and 33, while the washer 37 is oriented in the envelope between the contact portions 31 and 34.

The arrangement is such that the opposed pairs of contact portions 30 and 33 and 31 and 34 on the elements 25 and 26 form two normally open switches 40 and 41 which are connected in parallel in a circuit 42, as shown schematically in FIGURE 6. The external portion 27 of the element 25 is releasably connected, as at 43, in series with a conductor 44 leading to one terminal of a fixed frequency oscillator 45. The external portion 28 of the element 26 leads to a releasable connection 46 and then through a conductor 48 to one terminal of an oscilloscope 50. A conductor 51 serves to interconnect the remaining terminals of the oscillator and the oscilloscope. As will be understood, the oscillator 45 generates an alternating current of known frequency which is applied across the elements 25 and 26. The generated frequency preferably is in the medium frequency range and illustratively may be of the order of 10 kilocycles at about five volts.

As best shown in FIGURES 3 and 4, the switching device 15 is adapted to be advanced through the nip 54 between a pair of opposed press rolls of a papermaking machine. The roll 55 is mounted on a shaft 58, while the roll 56 is carried by a parallel shaft 59 which is journaled between two elongated arms 60 (only one of the arms 60 being visible in FIGURE 3). One pair of adjacent ends of these arms is pivotally supported, as at 62. The opposite arm ends are suitably connected to one end of an upstanding plunger 63 having a piston 64 at its opposite end which is reciprocally mounted within a hydraulic cylinder 65. The cylinder 65 includes the usual inlet conduit 67 through which fluid under pressure is introduced to control the spacing between the shafts 58 and 59 and hence vary the pressure exerted between the press rolls.

A papermaker's felt 70 is arranged in the form of an endless belt and is supported in the usual manner by a series of rolls 72. The felt is maintained under tension by a pair of take-up rolls 74 and is directed along a path such that the paper-supporting portion 76 thereof extends in a substantially horizontal plane and passes through the nip 54 between the press rolls 55 and 56. In most cases one or more of the rolls 72 serves as a drive roll to advance the felt 70 along its feed path, although in some situations, the felt may be driven by the press rolls. As will be understood, the paper-supporting portion 76 serves to feed the wet paper web (not shown) along this path and through the nip 54, where the action of the rolls 55 and 56 squeezes some of the moisture from the web into the felt. The moisture preferably does not remain in the felt but is discharged as a result of the pressure exerted thereby by the press rolls.

In order to insure the removal of a maximum quantity of moisture from both the wet paper web and the felt as they pass through the nip 54, the degree of compression of the felt should be carefully controlled. The compression of a given felt is determined by its normal, uncompressed thickness minus the compressed thickness at the longitudinal center of the nip 54. These factors are in turn related to the length of the felt under pressure at a given time in accordance with the following formula:

\[ h_n = h_0 - \frac{d}{R} \]

where

- \( h_n \) = normal felt thickness
- \( h_0 \) = compressed felt thickness
- \( d \) = length of felt under pressure
- \( R \) = press roll radius

The length of the felt under pressure (the distance \( d \) in FIGURE 4) corresponds to the distance travelled by a given felt section as it passes through the nip 54 and is referred to herein as "nip distance." This distance is determined by the time required for the felt section to pass through the nip and the speed of the felt. It is important to accurately measure these characteristics so that the degree of compression of the felt can be calculated to ascertain the optimum relative positions of the press rolls 55 and 56 for effective moisture removal.

The switching device 15 is arranged to close the circuit 42 and thereby supply a signal to the oscilloscope 50 only when the pressure applied to the envelope 16 is greater than a predetermined pressure corresponding to the pressure needed between the press rolls 55 and 56 to begin compression of the felt 70. Thus, the thickness and flexibility of the envelope 16 and the switch elements 25 and 26, as well as the dimensions of the washers 36 and 37, are such that the contact portions 30 and 31 engage the contact portions 33 and 34, respectively, only upon the application of the predetermined pressure. For papermaking applications, the pressure in most cases is somewhat less than one pound per square inch, but the pressure may be set at substantially any desired level by varying the configuration, dimensions, materials used, etc., of the device 15. Because of the resiliency of the elements 25 and 26, the pressure is removed from a given pair of contact portions they immediately return to their initial, spaced-apart positions.

In operation, the switching device 15 is supplied with alternating current of known frequency by manually connecting the protruding portion 27 of the element 25 to the conductor 44 leading to the fixed frequency oscilla-
The protruding portion 28 of the element 26 is similarly connected to the conductor 48. The portions 27 and 28 are relatively long, illustratively having a length of about five feet, for example, and are releasably secured to their corresponding conductors by the connections 43 and 46. The elements 25 and 26 are positioned in sufficient proximity with each other so that, upon their connection to the conductors 44 and 48, a small amount of leakage occurs between the opposed contact portions 30 and 33 and 31 and 34. As a result, a low amplitude sign wave signal 78 (FIGURE 7) of a frequency equal to that of the oscillator 45 appears on the oscilloscope 50, for purposes that will become more fully apparent hereinafter.

The switching device 15 is positioned on the portion 76 of the felt 70 and is longitudinally aligned with respect to the direction of movement thereof along its feed path. The device 15 is carried by the felt into the nip 54 between the opposed press rolls 55 and 56. As best shown in FIGURE 4, the device 15 is more or less imbedded in and attached to the upper surface of the felt by the pressure exerted thereon by the press rolls. This pressure is applied to the element 25 and 26 by the roll 56 and the felt and tends to move the elements 25 and 26 toward each other adjacent their contact portions. In cases in which the applied pressure is greater than the predetermined pressure for which the switch 41 is leading, the leading contact portions 30 and 33 (FIGURE 1) are urged into momentary engagement by reason of the aperture 38 in the washer 36. A series circuit is thereby completed from one terminal of the oscillator 45, the conductor 44, the releasable connection 43, the element 25, the switch 40, the element 26, the releasable connection 46, the conductor 48, the oscilloscope 50 and the conductor 51 to the other terminal of the oscillator. Upon the completion of this circuit, the amplitude of the signal applied to the oscilloscope is increased substantially until the switch 40 passes through the nip 54, at which time the amplitude of the applied signal returns to its initial level. The longitudinal spacing between the leading pair of contact portions 30 and 33 and the trailing pair 31 and 34 is such that, after the leading pair makes and breaks the circuit, the trailing pair closes momentarily to operate the switch 41 and again increase the amplitude of the signal. As the switch 41 passes through the nip and the pressure is removed, the signal is again restored to its initial amplitude.

FIGURE 7 is illustrative of a typical oscilloscope trace obtained during the passage of the switching device 15 and the papermakers' felt 70 through the nip 54. For example, a paper machine makes the complete signal sweep, which travels from left to right across the oscilloscope screen, may typically take place in about twenty thousandths of a second. The oscilloscope is adjusted in accordance with well known techniques so that the increased amplitude signal resulting from the closing of the switch 40 is greater than the predetermined signal value at the determined starting position on the left side of the screen, as viewed in FIGURE 7, from which position the trace continues to sweep across the screen to produce the sine wave output signal illustrated in this figure. From left to right in FIGURE 7, the following events are shown: a signal 80 appears on the scope and represents the increased amplitude sine wave produced while the leading switch 40 remains closed due to the pressure exerted upon it as it passes through the nip 54. The signal on the scope then changes to the very low amplitude sine wave signal 78 of the same frequency. This signal 78 is of an amplitude which is illustrated opposite the contact portions 30 and 33 of the signal 80 and results from the small amount of leakage which continues to flow when the switches 40 and 41 are open. Thereafter, an increased amplitude signal 82 appears at the time the switch 41 undergoes compression and is closed as it passes between the rolls 55 and 56. Finally, a second low amplitude signal 79 begins when the switch 41 opens as it passes out of the nip.

To ascertain the time during which a given section of the felt is subjected to a pressure greater than the predetermined pressure as it moves through the nip 54, the number of cycles of exciting frequency in the signal 80 is counted, as by suitable counting apparatus (not shown) or by examining a photograph of the scope trace, for example, and is divided by the fixed frequency, in cycles per unit time, of the oscillator 45. The resulting quotient provides an extremely accurate indication of the time during which a section of the felt is subjected to this pressure. The time between the closure of the switch 40 and that of the switch 41 corresponds to the distance between a given point on the sine wave indicated by the reference character 80 and a corresponding point on the sine wave indicated by the reference character 82. By measuring the elapsed time between sequential switch closures, e.g., the time between the opening of the contact portions 30 and 33 and the opening of the contact portions 31 and 34, for example, the speed of the felt as it passes through the nip 54 is readily calculated. To accomplish this, the elapsed time, which is represented at A in FIGURE 7, is ascertained by adding the total number of cycles of the leakage signal 78 between the signals 80 and 82 and the total number of cycles of the signal 82 and then dividing by the fixed frequency of the oscillator 45. To calculate felt speed, the time is divided into the longitudinal separation between the leading and trailing pairs of contact portions, thereby providing an accurate indication of the speed of the felt (or the peripheral speed of the press rolls) as it advances along its feed path.

In cases in which it is advantageous or desirable to determine the distance d (FIGURE 4) travelled by a given section of the felt while passing through the nip 54 under a pressure greater than the predetermined pressure, the speed of the felt is multiplied by the time the felt section is subjected to this pressure. The time under pressure is calculated from the number of cycles in the signal 80 in the manner indicated heretofore and may be checked by counting the number of cycles in the signal 82. The resulting nip distance is then used to calculate the degree of compression of the felt in accordance with the above formula.

The length of the insulated portions 27 and 28 of the switching elements 25 and 26, respectively, is sufficient to permit the switching device 15 to pass completely through the nip 54. Thereafter, the portions 27 and 28 are automatically disconnected by the releasable connections 43 and 46 of the circuit 42. Should the signals detected by the oscilloscope 50 indicate that the various measured characteristics of the felt are not consistent with the efficient removal of moisture therefrom, the position of the press roll 56 relative to that of the press roll 55 is adjusted by varying the fluid pressure applied to the conduit 67. The apparatus is thereby adapted to provide optimum moisture removal throughout a wide range of operating conditions.

Referring now to FIGURES 8 and 9, there is shown a switching device 85 which is representative of another illustrative embodiment of the invention. The device 85 is enclosed within a suitable housing and the housing which is fabricated from two elongated, substantially flat sheets 88 and 89 of dielectric material in a manner similar to the envelope 16 (FIGURE 1) described heretofore. A pair of opposed switch elements 90 and 91 of spring steel or other electrically conductive sheet material are interposed between the dielectric sheets 88 and 89, and the thickness of these elements illustratively is of the order of two to five thousandths of an inch. The switch element 90 is of substantially E-shaped configuration and includes three legs 94, 95 and 96 which extend in directions transverse to the longitudinal direction of the envelope 86. The legs 94 and 95 are comparatively nar-
row and serve as contact portions, while the leg 96 is substantially wider and is soldered or otherwise electrically connected to a conductor 98. The switch element 91 is in the form of an elongated, flat plate which extends longitudinally with respect to the envelope and is electrically connected to a conductor 99.

Posteriorly, the switch elements 99 and 91 is a thin sheet 100 of high dielectric strength paper, plastic or other insulating material. The sheet 100 is provided with two apertures 102 and 103 therein which are spaced apart in a longitudinal direction and, as best shown in FIGURE 9, are oriented immediately adjacent the contact portions 94 and 95, respectively, of the switch element 90. The apertures 102 and 103 are interposed between the contact portions 94 and 95 and corresponding contact portions 105 and 106 on the switch element 91.

The various components of the switching device 85 are adhesively secured together to form a thickness-limited construction having alternate layers of non-conductive and conductive material. The assembled device is of relatively small thickness which illustratively is in the neighborhood of fifteen to twenty thouyandths of an inch.

The device 85 is supplied with alternating current of known fixed frequency in a manner similar to that described above with respect to the switching device 15. Thus, the conductor 98 is releasably connected to the conductor 44 (FIGURE 6) leading to one side of the oscillator 45, while the conductor 99 is similarly secured to the conductor 48 connected through the oscilloscope 50 and 101 to the opposite side of the oscillator. The device 85 is longitudinally positioned on the paper-makers felt 70 (FIGURE 3) as it moves along its feed path toward the nip 54 between the opposed press rolls 85 and 56. As the device 85 passes between the press rolls, alternating current signals of the type shown at 80 and 82 in FIGURE 9 appear on the oscilloscope. These signals are measured in a manner similar to that discussed heretofore to provide an indication of particular characteristics of the felt as it passes through the nip 54.

In the illustrated embodiments of the invention, the switching devices 15 and 85 each have a thickness that advantageously is less than about twenty thousandths of an inch. With this arrangement, the device may be advantageously employed to make exceedingly accurate measurements under production conditions without marred the surfaces of the press rolls or otherwise damaging the switching mechanism. Additionally, in cases in which the device is advanced through the press roll nip simultaneously with the paper web, the possibility of severing or otherwise injuring the web is substantially eliminated.

In other good embodiments, the thickness of the device 15 or 85, as the case may be, is greater than that specifically indicated, again with good results.

In certain embodiments of the invention, particularly in cases in which various characteristics related to time are to be measured, the configuration and arrangement of the switching device advantageously is such that the opposed contact portions thereof are engageable with each other at a particular, discrete point. Thus, in the switching device 15 illustrated in FIGURES 1–6, for example, the diameters of the wires forming the switching elements 25 and 26 are such, in relation to the diameters of the apertures 38 and 39, that each of the contact portions 30 and 31 on the element 25 engages the corresponding contact portion 33 or 34 on the element 26 only at a single, predetermined point therebetween. Similarly, in the switching device 85 shown in FIGURES 7 and 8, the dimensions of the contact portions 94 and 95 on the switch element 90, when measured in a direction parallel to the longitudinal direction of the device 85, and the diameters of the apertures 102 and 103 are such that the contact portions 94 and 95 engage their corresponding contact portions 105 and 106 on the switch element 105 only at particular, discrete points. By providing such sensing points, as opposed to enlarged contact areas, the precise times at which the contacts close and open are readily ascertainable upon examination of the trace on the oscilloscope.

As indicated heretofore, in certain particularly advantageous embodiments of the invention, the switching device 15 or 85, as the case may be, is advantageously formed with a paper-makers' felt through an opposed pair of pressure-applying rollers to measure particular characteristics of the felt. In other good arrangements, measurements may be made on other articles, and certain of these measurements may be ascertained by maintaining the switching device and the measuring apparatus and applying external pressure thereto. In addition, the switching device may be held stationary and the article advanced thereover to apply the pressure, as in cases in which it is desired to determine the number of articles, for example, passing a given point.

Although the switching devices 15 and 85 have been described as being particularly useful in the measurement of certain characteristics of an article during the application of pressure thereto, it will be apparent to those skilled in the art that the invention also may be employed advantageously for other applications where the making of particular measurements is either necessary or desirable. Thus, as best shown in FIGURE 5, the device 15, for example, illustratively may be used to measure the characteristics of the nip 108 between a pair of opposed rollers 110 and 111 of rubber or other resilient material. The device 15 is advanced through the nip 108 in a direction parallel to the contact portions 30 and 31 into sequential engagement with their corresponding contact portions 33 and 34 and thereby provide successive switch closures. These closures produce an oscilloscope trace of the type shown in FIGURE 7 and enable the calculation, in a manner similar to that described heretofore, of such characteristics as the length of the nip, measured in the direction of travel of the device 15, and the peripheral speed of the rollers.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions, of excluding any equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. Apparatus for measuring the duration of the application of pressure greater than a predetermined pressure to a paper-makers' felt, comprising, in combination, an elongated substantially flat envelope or flexible dielectric material, a first and a second electrically conductive switch element positioned in spaced relationship with each other within a said envelope, each of said switch elements including a contact portion thereon, insulating means interposed between said switch elements for maintaining the same in spaced relationship with each other, said insulating means including an aperture between said contact portions to permit movement thereof into and out of engagement in response to the application of pressure greater than a predetermined pressure to said envelope, means for simultaneously applying pressure to said paper-makers' felt and said envelope, to move said contact portions into and then out of engagement upon the application of pressure greater than said predetermined pressure, and means electrically connected to said switch elements for measuring the time said contact portions are in engagement.

2. Apparatus for measuring the duration of the application of pressure to a paper-makers' felt as it advances along a feed path comprising, in combination, an elongated substantially flat envelope or flexible dielectric material, a first and a second electrically conductive switch element positioned in spaced relationship with each other within a said envelope, each of said switch elements having a contact portion thereon, insulating means interposed between said switch elements for maintaining the same in spaced relationship with each other, said insulating means including an aperture between said contact portions to permit movement thereof into and out of engagement in response...
to the application of pressure to said envelope, pressure-applying means disposed along said feed path, means for advancing said envelope and said papermakers' felt through said pressure-applying means, to move said contact portions into and then out of engagement with each other, means for supplying an alternating current signal to said switch elements, and means connected to said switch elements for measuring the duration of the changes in said signal which result from engagement between said contact portions.

3. In apparatus for making particular measurements as an article advances along a feed path, in combination, an elongated substantially flat envelope of dielectric material, a first and a second flexible, electrically conductive switch element positioned in spaced relationship with each other within said envelope, each of said switch elements having spaced-apart contact portions thereon, insulating means interposed between the contact portions on one of said switch elements and those on the other of said switch element, said insulating means including a pair of spaced apertures to enable movement of the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other said switch element in response to the application of pressure to said envelope, pressure-applying means disposed along said feed path, and means for advancing said envelope and said article through said pressure-applying means to move one pair of corresponding contact portions into and out of engagement and to thereafter move the other pair of corresponding contact portions into and out of engagement.

4. Measuring apparatus of the character set forth in claim 3 in which each of said switch elements comprises an elongated wire extending in a substantially longitudinal direction with respect to said envelope and said insulating means includes a pair of washers of dielectric material respectively disposed between said pairs of corresponding contact portions.

5. Measuring apparatus of the character set forth in claim 3 in which said first switch element includes a pair of legs extending in directions transverse to the direction of movement of said envelope and said second switch element includes a longitudinally disposed plate engageable with each of said legs.

6. Apparatus for measuring the duration of the application of pressure to a papermakers' felt as it passes through the nip between two rollers which comprises supplying an electrical signal to a switching device including a first and a second switch element positioned within an envelope and maintained in spaced relationship with each other, each of said switch elements having a contact portion thereon, advancing said switching device and said envelope through the nip between said rollers to move the contact portions of said switch elements into and out of engagement in response to the application of pressure thereto by said rollers, to thereby provide a switch closure, detecting the changes in said signal which result from said closure, and measuring the time duration of said changes.

8. A method of making particular measurements as an article advances along a path which comprises supplying an alternating current signal to a switching device including a first and a second electrically conductive switch element positioned in spaced relationship with each other within an enclosing envelope, each of said switch elements having spaced-apart contact portions thereon, advancing said switching device and said article through pressure-applying means disposed along said path, to move the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other switch element and thereby provide sequential switch closures, detecting changes in said signal which result from said switch closures, and measuring the time duration of said changes.

9. A method of making particular measurements as an article advances along a feed path which comprises supplying an alternating current signal of known frequency to a switching device including a first and a second electrically conductive switch element positioned in spaced relationship with each other, each of said switch elements having a pair of contact portions thereon, the contact portions on said first switch element being spaced in sufficient proximity with the corresponding contact portions on said second switch element to permit the transmission of a part of said signal therebetween, advancing said switching device and said article through pressure-applying means disposed along said path, to move the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other switch elements and thereby increase the amplitude of the signal transmitted therebetween, each of the contact portions on said first switch element engaging the corresponding contact portion on said second switch element at a particular, discrete point, detecting the increase in amplitude of said signal which results from engagement between at least one pair of said corresponding contact portions, and measuring the time duration of said increase.

10. A method of making particular measurements as an article advances along a feed path which comprises supplying an alternating current signal of known frequency to a switching device including a first and a second electrically conductive switch element positioned within an envelope and maintained in spaced relationship with each other, each of said switch elements having spaced-apart contact portions thereon, advancing said switching device and said article through pressure-applying means disposed along said path, to move the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other switch element in response to the application of pressure thereto, each of the contact portions on said first switch element engaging the corresponding contact portion on said second switch element at a particular, discrete point, detecting changes in the amplitude of said signal which result from engagement between at least one pair of said corresponding contact portions, measuring the time duration of said amplitude changes, and converting said measurement into a factor representative of the distance travelled by the article during the application of said pressure.
11. A method of making particular measurements as an article advances along a feed path which comprises supplying an alternating current signal of fixed frequency to a switching device including a first and a second electrically conductive switch element positioned in spaced relationship with each other, each of said switch elements being spaced-apart contact portions thereon, advancing said switch device and said article through pressure-applying means disposed along said path, to move the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other switch element in response to the application of pressure to said device in excess of a predetermined pressure, detecting changes in said signal which result from engagement between said corresponding contact portions, measuring the time duration of the changes resulting from engagement between at least one pair of contact portions, and measuring the elapsed time between the engagement of successive pairs of contact portions.

12. A method of making particular measurements as an article advances along a feed path which comprises supplying an alternating current signal of fixed frequency to a switching device including a first and a second electrically conductive switch element positioned within an envelope and maintained in spaced relationship with each other, each of said switch elements having spaced-apart contact portions thereon, advancing said switch device and said article through pressure-applying means disposed along said path, to move the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other switch element and thereby provide sequential switch closures when the pressure on said device exceeds a predetermined pressure, each of the contact portions on said device having spaced-apart contact portions thereon, and engaging said switch elements and said article, detecting changes in said signal which result from said switch closures, measuring the time duration of the changes resulting from at least one of said closures, measuring the elapsed time between said closures, and converting said measurements into respective factors representative of the distance travelled by the felt during the application of pressure greater than said predetermined pressure and the rate of movement of said felt through said nip.

13. A method of measuring particular characteristics of a papermakers' felt as it passes through the nip between two rollers which comprises supplying a electrical signal to a switching device including a first and a second electrically conductive switch element positioned in spaced relationship with each other, each of said switch elements having spaced-apart contact portions thereon, advancing said switch device and said papermakers' felt through said nip between said rollers, to move the contact portions on one of said switch elements into sequential engagement with corresponding contact portions on the other switch element and thereby provide sequential switch closures when the pressure on said device exceeds a predetermined pressure, detecting changes in said signal which result from said switch closures, measuring the time duration of the changes resulting from at least one of said closures, measuring the elapsed time between said closures, and converting said measurements into respective factors representative of the distance travelled by the felt during the application of pressure greater than said predetermined pressure and the rate of movement of said felt through said nip.
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