

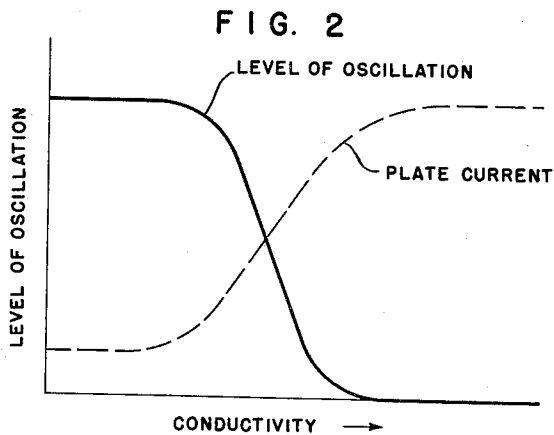
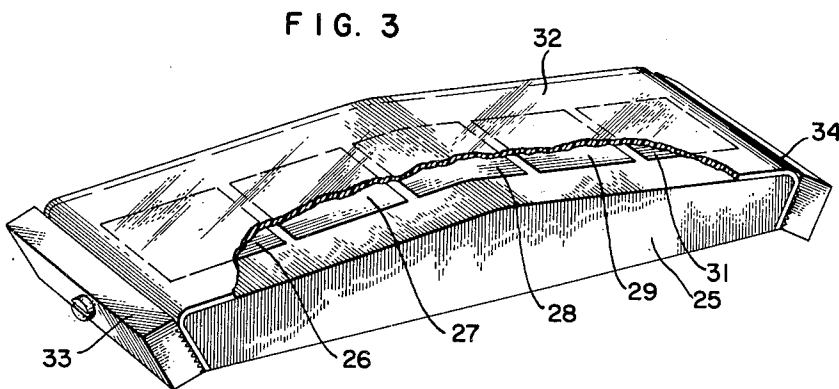
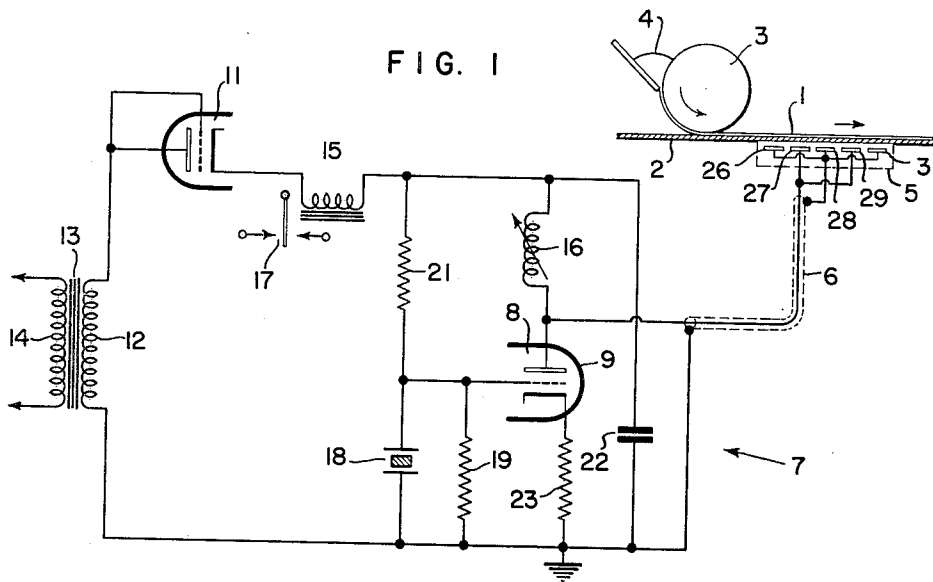
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GLUE DETECTOR

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The present invention generally relates to an apparatus for detecting the presence of glue or other conductive adhesives on paper or like materials. More specifically, the present invention is concerned with a system in which the presence or absence of glue on an article affects the coupling between a plurality of sensing electrodes.

In the manufacture of paper products such as bags, glue is generally applied to the paper as it comes from a supply roll prior to the cutting and folding steps of manufacture. As a result, unless inspection is provided, hundreds of yards of paper can pass through the gluing station, be cut and folded prior to the discovery of a malfunction in the gluing operation. This can result in an enormous waste of raw material, time, and labor. A similar problem exists in the paper box industry, where malfunctioning of a gluing operation can result in the filling of unglued boxes and the like, with the loss of both contents and container. Today, even after a half-century of automation in the production of paper products, it is standard practice to provide an inspector at each machine to insure proper gluing. In specific cases, however, production rates are such that even manual inspection is inadequate to insure proper gluing of the product.

Accordingly, it is an object of the present invention to provide an inexpensive, reliable, automatic means to detect the presence or absence of glue on paper or the like which can be added to existing machines without modification thereof.

One characteristic of substantially all of the commercially used glues and pastes is a conductivity which is, in general, several orders of magnitude higher than that of the paper products to which the glue is applied. Accordingly, this characteristic can be utilized in detecting the presence of glue on such products. It is obvious, however, that it is impractical to accomplish a conductivity measurement by making direct contact with the glued surface.

It is therefore, another object of the present invention to provide means for utilizing the conductivity of glue to detect its presence or absence from the material without directly contacting the glued paper.

Still another object of the present invention is to provide a new and improved sensing element adapted to provide capacitive couplings to the glued surface in such a manner that the presence or absence of glue provides a usable impedance change.

It is, accordingly, a further object of the present invention to provide a glue-detecting apparatus in which the sensing elements may be positioned on the reverse side of the material from which the glue is applied thereby avoiding contamination of the sensing element with glue.

A still further object of the present invention is to provide a glue detecting apparatus which is insensitive to the moisture content of the material to which the glue is applied.

In an apparatus designed to be sensitive to moisture, as typified by that disclosed by Wilfred H. Howe, in U. S. Patent 2,718,620, a capacity change caused by the so-called fringe effect, that is, the electrostatic field that bulges out from the edge of condenser plates at the gap between the plates and which penetrates material placed adjacent to the surface of the plates, is utilized to effect a moisture measurement. In glue detection, however, the effects of the fringe field is to introduce errors, and hence this effect must be minimized. This is because any

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fringe field present will penetrate the material on which the glue is applied, not the glue, since it is desirable to have the material between the sensing electrodes and the glue. In addition, glue is often applied to material which has a high or varying moisture content. Thus, in detecting glue, it is necessary to utilize a sensing element which will provide coupling with the glue through the material to which the glue is applied without any substantial fringe field effect.

Since the fringe field occurs primarily at the gap between the capacitor electrodes it is desirable in apparatus depending upon the effect to utilize a plurality of thin, closely spaced electrodes to increase the sensitivity of the apparatus, with the sensitivity increase achieved being proportional to the increase in the number of capacitor plates. In the present invention, the effect of the fringe field is minimized by utilizing relatively few electrodes having dimensions which are large compared to their spacing. In addition, an insulating spacing member is employed between the electrodes and the material to which the glue is applied to minimize the fringe field penetrating the material. As a result of this construction, the system is made insensitive to the characteristics of the material to which the glue is applied.

It is also an object of the present invention to provide a sensing element for the detection of glue having a wipeable insulating film adapted to protect the sensing electrodes from wear and contamination.

In accordance with the present invention, there is provided a sensing element adapted to be positioned adjacent to a moving web of paper or the like on the reverse side of said paper from which glue is applied and opposite to the applied glue. The sensing element comprises one or more of energized electrodes spaced from each other by grounded electrodes and arranged in an in-line relationship, each of the said electrodes being adapted to provide capacitive coupling with the glue applied to the paper. The sensing element has a wipeable insulating film adapted to protect the sensing electrodes from abrasion and contamination and minimizing fringe field effects. The sensing element is connected to control the tuning of the plate circuit of a tune-plate and an tune-grid oscillator. In this manner, the presence or absence of glue on an article positioned adjacent to the sensing element controls the oscillation or non-oscillation of the oscillator. A relay is provided in the plate circuit of the oscillator which may be adapted to give an indication of or perform a control function in accordance with the presence or absence of glue on the article tested.

A better understanding of the present invention may be had from the following description when read with reference to the accompanying drawings of which:

FIG. 1 is a schematic wiring diagram of the glue detector of the present invention;

FIG. 2 is a graph showing the level of oscillation and plate current plotted against glue conductivity for the apparatus shown in FIG. 1; and

FIG. 3 is a perspective view of the capacitor sensing element of the present invention.

Referring now to FIG. 1, there is shown an embodiment of the present invention adapted to detect the presence or absence of a layer of glue 1 upon a moving strip of paper 2. As shown schematically, the paper 2 moves in the direction of the arrow, as from a supply roll, past a glue wheel 3 which applies a layer of glue thereto from a hopper 4. After being glued, the strip of paper 2 moves past a sensing element 5, which is positioned adjacent to the path of paper travel on the side of the paper opposite to which the glue is applied. The sensing element 5 is connected by means of a shielded cable 6 to an oscillator 7 to control the oscillation or non-oscilla-

tion of the oscillator 7 in accordance with the presence or absence of glue on the strip of paper 2.

The oscillator 7 is a tuned-plate, tuned-grid crystal controlled oscillator utilizing the triode section 8 of a dual triode vacuum tube 9 as its amplifying element. Direct current energization for the triode 8 is supplied by means of the other triode section 11 of the dual triode 9, operated as a diode with the grid directly connected to the plate. The plate of the triode 11 is connected through the secondary winding 12 of a transformer 13 to ground. The transformer 13 has a primary winding 14 adapted to be connected to a suitable source of alternating current, not shown. The cathode of the triode 11 is connected to the plate of the triode 8 by means of a relay coil 15 and a variable inductor 16. The relay coil 15 has associated therewith contacts 17, which may be utilized to control the energization of an alarm, a recorder, or other form of exhibiting device to indicate the presence or absence of glue on the paper 2. The grid circuit of the oscillator 7 includes a crystal 18 and a resistor 19, both connected between the grid of the triode 8 and ground. The grid of the triode 8 is also connected to the cathode of the triode 11 by means of a resistor 21 and the relay coil 15. As will be explained in more detail hereinafter, the resistor 21 has substantially no effect on the operation of the circuit when it is in oscillation, but serves to increase the plate current flowing when the circuit is not oscillating. The tuned-plate circuit of the oscillator 7 comprises the sensing element 5, connected between ground and the plate of the triode 8 by means of the shielded cable 6 and the variable inductor 16. A capacitor 22 connected between ground and the relay coil 15 provides a radio frequency ground for the tuned circuit. As shown, the cathode of the triode 8 is connected to ground by means of a resistor 23.

In operation, the feedback necessary to sustain oscillation in the oscillator 7 is provided by means of the grid-plate capacity of the triode 8. The frequency of circuit oscillation is determined by the resonant frequency of the crystal 18. In the absence of glue, the inductor 16 is adjusted such that resonant frequency of the plate circuit is the same as the crystal frequency and the system oscillates. The presence of glue over the electrodes of the sensing element 5 loads and detunes the plate circuit and oscillations stop. The inductor 16 can be adjusted to vary the amount of glue necessary to prevent oscillation. In this manner the apparatus can be made to respond not only to the complete absence of glue but to an inadequate amount of glue. With no glue present and the system oscillating, sufficient grid bias is developed to reduce the plate current and deenergize the relay coil 15. Thus, any failure of the vacuum tube 9 will also de-energize the relay. In this manner the system is made substantially safe-failing.

Referring now to FIG. 2, the level of oscillation and plate current are shown plotted against sensing element capacity. As the value of the resistor 23 is made larger the conductivity change necessary to provide relay operation is decreased. It has also been found, however, that without the bias provided by the resistor 21 that as the conductivity change becomes smaller, the plate current differential between oscillation and non-oscillation also becomes smaller. Thus, as the sensitivity of the circuitry to glue becomes higher the current change available to perform the control or indicating function becomes smaller. It has been found, however that this undesirable mode of operation can be overcome by the inclusion of the resistor 21. In this respect it has also been found that it is desirable to maintain the value of the resistor 21 high. When this is done, the resistor 21 does not affect the conductivity differential necessary to initiate or stop operation but serves to substantially increase the current differential between the oscillatory and non-oscillatory states of the circuit. Thus, it has been

found possible to provide both improved relay reliability and high sensitivity.

By way of illustration and not by way of limitation, the following are typical values for the components of a practical embodiment of the present invention as shown in FIG. 1 which is adapted to operate the relay 15 in response to the proximity to the sensing element 5 of a glue strip which has a resistivity of 400,000 ohms per inch:

10	Vacuum tube 9	-----	6SN7.
	Resistor 19	-----	1 meg. ohms.
	Resistor 21	-----	10 meg. ohms.
	Resistor 23	-----	2200 ohms.
	Crystal 18	-----	1 megacycle crystal.
15	Variable inductor 16	-----	200-300 Henries (micro).
	Capacitor 22	-----	1000 mmfd.
	Transformer 13	-----	Primary 110 volts, secondary 250 volts.

Referring now to FIG. 3 there is shown a perspective view of the sensing element 5. The sensing element 5 comprises a base 25 made of hard rubber, Bakelite, or other suitable insulating material. As shown, the top surface of the base 25 is curved with the high point at its mid-section. The surface presented by the sensing element 5 as a result of the curved shape of the base 25 aids in maintaining the sensing element in contact with or in close proximity to the material being tested, particularly when that material is a rapidly moving web. While contact with the material being tested is not essential to the operation of the system, there are distance limitations, beyond which sufficient capacitive coupling cannot be obtained for reliable operation of the system. Where glue is to be applied to relatively stiff material such as cardboard, it has been found more expedient to provide the sensing element 5 with a flat surface.

A plurality of sensing electrodes 26, 27, 28, 29, and 31 are positioned in an in-line relationship on the top surface of the base 25 so as to be substantially flush therewith. For this purpose, printed circuit techniques have been found applicable. As shown schematically, in FIG. 1 the electrodes 26, 28 and 31 are connected together and to ground by means of the shielded cable 6 and the electrodes 27 and 29 are connected to the plate of the triode 8 by means of the cable 6. The top surface of the base 25 and hence the electrodes 26 through 31 are covered by a sheet of insulating material 32 which is folded over the ends of the base 25 and gripped by means of the clamping members 33 and 34. These clamping members are adapted to be tightened against the ends of the base 25 by means of screws and are provided with knurled inner surfaces adapted to grip and hold the insulating film 32 against the base 25.

The insulating film 32 provides the sensing element 5 with a replaceable wipable, surface adapted to protect the electrodes from wear due to the abrasive action of material being drawn across the surface of the element and from contamination with glue. The insulating film 32 also serves as a spacing member making the sensing element 5 substantially insensitive to the moisture content of the material to which the glue is applied since it is in any fringe electrostatic field which may exist between the electrodes. The insulating film 32 is preferably a thermoplastic resin such as tetrafluoroethylene, polyethylene or nylon, which are by nature highly hydrophobic and nonporous.

As hereinbefore stated, the glue detection system of the present invention does not depend on the fringe effect existing at the gap between the adjacent electrodes to provide a detectable change in capacity. The present invention relies upon the establishment of a coupling between the electrodes and the glue, and thus the glue of other material being detected must be conductive. In operation, each of the electrodes 26, 27, 28, 29, and 31 forms a capacitor with the glue strip, and the capacitors thus formed are in turn connected in series with each other

by means of the glue strip. In this respect the electrodes are made wide enough to provide coupling within the limits of tolerated lateral shifting of either the paper or the glue strip. While two energized electrodes have been shown alternately spaced between two grounded electrodes, it should be understood that the sensing element can comprise but a single pair of electrodes, one energized and one grounded. By increasing the length of the electrodes employed, it is possible to increase the sensitivity of the system up to a certain point, beyond which no significant increase in sensitivity is achieved. This is due to the resistance added to circuit by the increase in the path of conduction through the glue strip.

While for the purpose of this disclosure the present invention has been described in connection with an application in which a strip of paper is moved continuously past a sensing element, it should be understood that with appropriate modifications, the present invention is equally adapted for applications in which glued articles move intermittently past a sensing element. It should also be understood that the present invention is adapted to detect the presence of glue or other conductive films on materials other than paper. For example, the present invention is applicable for the detection of glue on such materials such as cardboard, woven fabrics, and the like.

In addition to functioning as a glue detecting apparatus, the circuit of the present invention can be utilized to indicate the amount of glue applied to a given surface. When so utilized a D.C. milliammeter may be connected in series with the relay coil 15 to indicate the magnitude of plate current flowing, and hence the amount of glue. Still further, the circuit of the present invention may be adapted to detect the location of glue applied to an article. For such an application, a plurality of detecting circuits and sensing elements may be utilized with the sensing elements positioned so as to detect the presence of glue on given areas of the material being tested. As for example, two sensing elements may be positioned on either sides of an intended glue path to detect the placing of glue on areas other than the intended path.

Having described the present invention, that which is claimed as new is:

1. An apparatus for detecting the presence or absence of a conductive glue on a portion of a moving strip of paper comprising, in combination, a sensing element adapted to be positioned adjacent to said paper on the reverse side of said paper from said glued portion and opposite to the glued portion, said sensing element comprising at least a pair of electrodes spaced from each other, said electrodes having dimensions large compared with their spacing, each of said electrodes being adapted to form a capacitor with said glued portion, the capacitors thus formed being connected to each other through said glue, oscillator means coupled to said electrodes and relay means connected to said oscillator responsive to the series impedance of said capacitors.

2. An apparatus for indicating the presence or absence of a conductive glue on a portion of a moving strip of paper comprising, in combination, a sensing element adapted to be positioned adjacent to said paper on the reverse side of said paper from said glued portion and opposite to the glued portion, said sensing element comprising at least a pair of electrodes spaced from each other in an in-line relationship, said electrodes having dimensions large compared with their spacing, each of said electrodes being adapted to provide a capacitive coupling with said glued portion, said sensing element being connected to control the tuning of the plate circuit of a vacuum tube oscillator and indicating means connected to said oscillator, the presence or absence of glue on the

portion of said paper opposite to said electrodes controlling the oscillation or non-oscillation of the oscillator.

3. An apparatus for indicating the presence or absence of glue on a moving strip of paper comprising, in combination, a sensing element adapted to be positioned adjacent to the path of movement of said paper opposite the area of said paper upon which said glue is applied, said sensing element comprising at least a pair of electrodes spaced from each other in an in-line relationship in line with said path of paper movement, said electrodes having dimensions large compared with their spacing, one of said electrodes being connected to ground, oscillator means connected between ground and the other of said electrodes to supply to said electrode oscillatory energy of a radio frequency, and relay means connected to said oscillator, said electrodes forming capacitors with said glue strip, said glue strip connecting said capacitors in series to control the oscillation or non-oscillation of said oscillator means.

4. An apparatus for indicating the presence or absence of glue on a moving strip of paper comprising, in combination, a sensing element adapted to be positioned adjacent to the path of movement of said paper on the side of said paper opposite to the side upon which said glue is applied and parallel with the area of said paper upon which said glue is applied, said sensing element presenting a surface over which said moving strip of paper can pass, said sensing element comprising at least a pair of capacitor electrodes spaced from each other in an end to end relationship in line with the path of movement of said paper, said electrodes having dimensions large compared with their spacing, an insulating film covering said electrodes, one of said electrodes being connected to ground, oscillator means connected between ground and the other of said electrodes, said oscillator means being adapted to oscillate when glue on said paper bridges said electrodes, and indicating means connected to said oscillator, the amount of glue on strip controlling the level of oscillation of said oscillator means.

5. An apparatus for indicating the presence or absence of a strip of conductive glue on a moving sheet of paper comprising, in combination, a sensing element adapted to be positioned adjacent to said paper on the reverse side of said paper from said glue strip and opposite to said glued strip, said sensing element comprising a plurality of electrodes spaced from each other in an in-line relationship, said electrodes having dimensions large compared with their spacing, each of said electrodes being adapted to form a capacitor with said glue strip, the capacitors thus formed being connected to each other through said glue, oscillator means coupled to ground and alternate ones of said electrodes to energize said alternate electrodes, the others of said electrodes being connected to ground and indicating means connected to said oscillator, the presence or absence of glue on said paper controlling the oscillation or non-oscillation of said oscillator means.

6. Apparatus as specified in claim 5 wherein said oscillator means comprises a tuned-plate, tuned-grid crystal controlled oscillator and said sensing element is connected to control the tuning of the plate circuit in response to the presence or absence of glue on said moving sheet.

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