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APPARATUS FOR MEASURING MOISTURE IN WEB COATINGS

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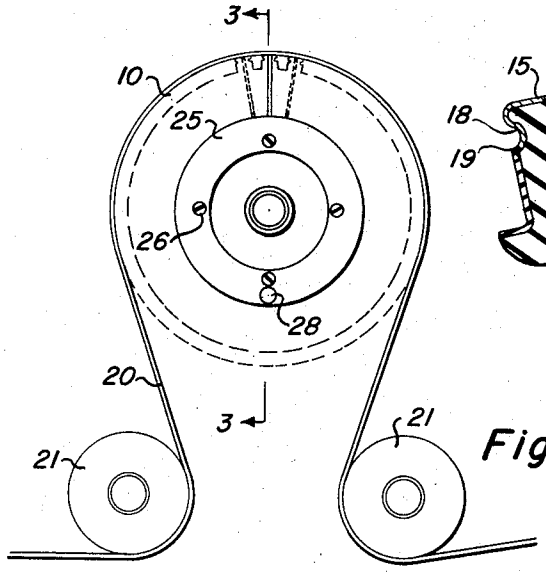


Fig. 1

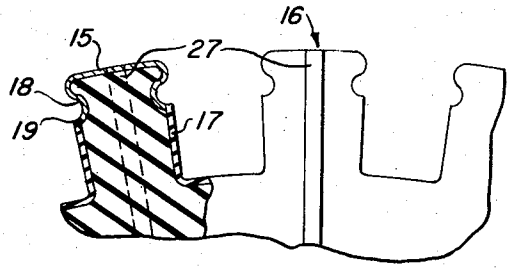


Fig. 2

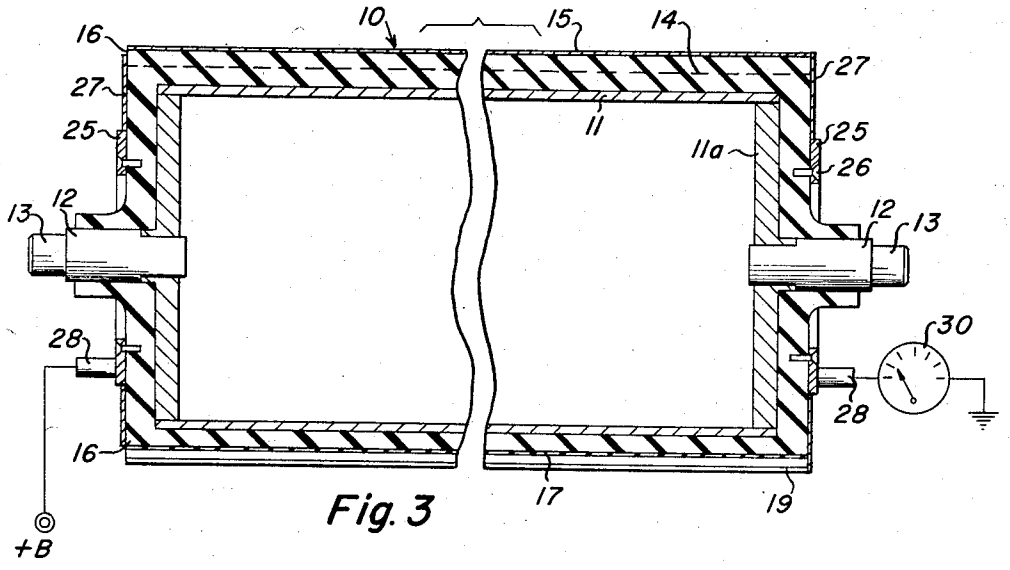


Fig. 3

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APPARATUS FOR MEASURING MOISTURE IN WEB COATINGS

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The present invention concerns apparatus for continuously measuring the moisture content of web materials and more particularly concerns apparatus which measures the conductivity of an easily damaged coating on a moving web where the conductivity of the coating is a known function of the moisture content of the web.

In the production of many web materials it is desirable to control the moisture content of the web or of a coating thereon. The moisture content of a sensitized coating on photographic film base or on a paper base has been found to be a function of the conductivity of the coating. Numerous devices have been proposed for measuring the conductivity to determine the moisture content.

One prior art device comprises two tandem rollers over which the web is moved. The rollers are employed as sensing electrodes to complete a circuit through the web coating and through a current-measuring instrument. This device is quite unsatisfactory for measuring the conductivity of the emulsion coating on moving photographic film where resistivities of the order of 10^8 to 10^{12} ohms are encountered. The electrostatic current discharged to the rollers of such a device from a charged web exceeds the minute conduction current which is to be measured; therefore, the measurements cannot be made while the web is moving.

Another prior art device employs a series of coaxial spaced disks over which the web is rolled. Alternate disks are connected to slip rings on the respective ends of the disk assembly and current is passed through the slip rings, the disks, the web material between the disks and a current-measuring instrument. If a sufficient number of disks are used and if the total area of contact between the disks and the web is large enough, the conduction current can be increased sufficiently relative to the electrostatic current to permit accurate conductivity measurement while the web is in motion. However, the device just described cannot be used in production lines for emulsion-coated webs because tension on the web pulls the web down between the disks where the web is unsupported in a direction parallel to its movement, and the disk edges tend to mark the soft web coating, thereby rendering the film unfit for its intended use. Consequently, such a device can be used only on discardable samples of the film taken from the production line at considerable expense and loss of time.

It is therefore a primary object of the present invention to measure the conductivity of the emulsion coating on a moving film web by apparatus which leaves the coated web surface undamaged.

The embodiment of the invention which is illustrated in the accompanying drawings comprises a large roller having a series of angularly spaced metallic web supporting surfaces, or ribs, extending parallel to the roller axis. The rib surfaces have the same radius of curvature as the roller itself in order to provide a smooth cylindrical support for a film web which moves over the

roller. Alternate rib surfaces are connected to respective slip rings on the ends of the roller to complete a circuit from a grounded power source through one slip ring, one set of rib surfaces, the web coating, the alternate set of ribs surfaces, the second slip ring and a current-measuring instrument to ground. A roller having this configuration distributes the web pressure evenly among the supporting surfaces with practically no tendency for the web to be pulled down between the ribs, and permits the continuous measurement of the conductivity of the moving web without damaging the emulsion coating.

In constructing a roller of the type having a peripheral metallic surface, it is important to minimize its weight, particularly the weight of the outer portions of the roller, to thereby minimize the moment of inertia of the entire roller. It is thereby a further object of the invention to provide a roller of the above type having a minimum moment of inertia.

Other objects of the invention will appear from the following description, reference being made to the accompanying drawings, wherein:

Fig. 1 is an end view of the novel roller showing the web path;

Fig. 2 is a detailed illustration of a portion of Fig. 1, partly in section, showing the rib shape;

Fig. 3 is a sectional side view of the roller taken along the line **3—3** of Fig. 1 and showing a schematic wiring diagram of the conductivity-measuring circuit.

Referring to Fig. 3, the roller, designated generally at **10**, comprises a hollow center drum **11** formed of high-strength material such as extruded aluminum. The drum is welded or otherwise secured to a pair of end plates **11***a* which are mounted on respective end shafts **12** for rotation therewith on respective bearing surfaces **13**. A suitable light-weight insulating material, such as epoxy resin, is molded around drum **11** and plates **11***a* to form a cylindrical shell **14**.

In order to form alternate supporting surfaces on the periphery of the roller, its outer surface is first ground to a smooth cylindrical shape and then grooved parallel to the axis as shown best in the detailed end view of Fig. 2. The first grooving operation extends the grooves toward the axis of the roller to a depth indicated at **19** in Fig. 2 and produces a series of radially spaced ribs, such as **16**, each having a rounded surface for supporting the web. The leading and trailing edges of each rib **16** are preferably rounded by grinding so that no sharp edges are presented to the web surfaces. Also, the rounded edges of ribs **16** are preferably undercut to form an ogee profile, or more specifically, a *cyma reversa* profile.

A thin coating **15** of conductive material, such as nickel, is plated or otherwise attached directly to the outer surface of the insulating shell **14**, including the ogee surfaces previously formed by grooving. The outer, plated surface may then be ground to a smooth, cylindrical shape and provides a conducting surface on each rib for contacting the web material. Next, the grooves between ribs **16** are deepened, such as by square cutting, radially inward from depth **19**, thereby severing the conductive plating between the ribs and electrically insulating the latter from each other. Although the conductive surfaces **15** on ribs **16** are now discontinuous, they extend over the undercut sides **18** of the ribs, thereby tending to clip these plated surfaces to the ribs and hold them in place.

In order to minimize the absorption of moisture by the insulating shell **14**, it may be desirable to coat the unplated outer surface of the roller with a thin layer

17 of a suitable protective material such as "microcircuits" insulating lacquer.

A roller constructed according to the method just described presents a smooth, rounded surface to the web material supported thereby. As shown in Fig. 1, the web 20 may be threaded around a first idler roller 21, the measuring roller 10 and a second idler roller 21. Roller 10 turns as the web moves, and thereby presents successive ribs 16 to the inner, coated web surface. The number of ribs in contact with the web at any given time is determined by the total number of ribs on roller 10 and the spacing of the idler rollers 21.

A respective slip ring 25 (Fig. 3) is mounted on each end of roller 10 by screws 26. Each slip ring is connected to the conductive surfaces 15 of alternate ribs 16 by strips 27 of conductive material which may be painted, stenciled, cemented or otherwise permanently attached to the ends of the roller. A conventional source of regulated D. C. power +B is connected to a first insulated brush 28 which engages one of the slip rings 25. Similarly, a second insulated brush 28 engages the remaining slip ring and is connected through an ammeter 30 to ground.

The amount of current flowing from +B to ground through the roller circuit and ammeter 30 depends upon the geometry of the electrodes, i. e., the geometry of the conducting surfaces of the ribs 16. In turn, the geometry of the electrodes determines the "electrode factor" which, when divided into the measured conductance current, yields a value of conductivity. The electrode factor is directly proportional to the width of the web and to the number of ribs 16 in contact with the web surface, and is inversely proportional to the radial spacing of successive ribs, which is the length of the conducting path on the web. Since the ratio of the conductance current to the electrostatic current must be large in order to accurately measure the minute conductance of photographic film emulsions, the electrode factor should be made large. This is done by proper selection of the diameter of roller 10 and the number of ribs 16 as well as their radial spacing. The measured conductance current of the ribs is a function of conductivity and can be read directly from a properly calibrated meter 30 for a given web width.

We claim:

1. Apparatus for measuring the conductivity of a web including a roller the surface of which is in contact with the web, a power source having a pair of terminals, a first brush connected to one of said terminals, a second brush, and a current meter interconnecting said second brush and the remaining terminal, said roller comprising: a central drum having end plates and mounted for rotation about its own axis; a layer of insulating material surrounding said drum, including said end plates, and having a plurality of ribs extending radially therefrom and parallel to the axis of said drum; a layer of conductive material on the outer surface of each of said ribs; a pair of slip rings attached to the respective portions of said insulating material covering said pair of end plates and in sensing engagement with respective ones of said brushes; and strips of conductive material interconnecting each slip ring with the layers of conductive material on alternate ones of said ribs.

2. The apparatus defined in claim 1, wherein the outer surfaces of said ribs are rounded to form a discontinuous, cylindrical outer surface for said roller.

3. The apparatus defined in claim 1, in combination with a layer of water-resistant material covering at least a portion of the exposed outer surface of said insulating material.

4. The apparatus defined in claim 1, wherein the mutually-facing edges of said ribs are rounded.

5. The apparatus defined in claim 4, wherein said rounded edges are undercut and wherein the layer of conductive material on the outer surface of each rib extends to and covers the undercut portions thereof.

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