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METHOD AND APPARATUS FOR POSITIONING CONTACT ELEMENT OF PENETROMETERS

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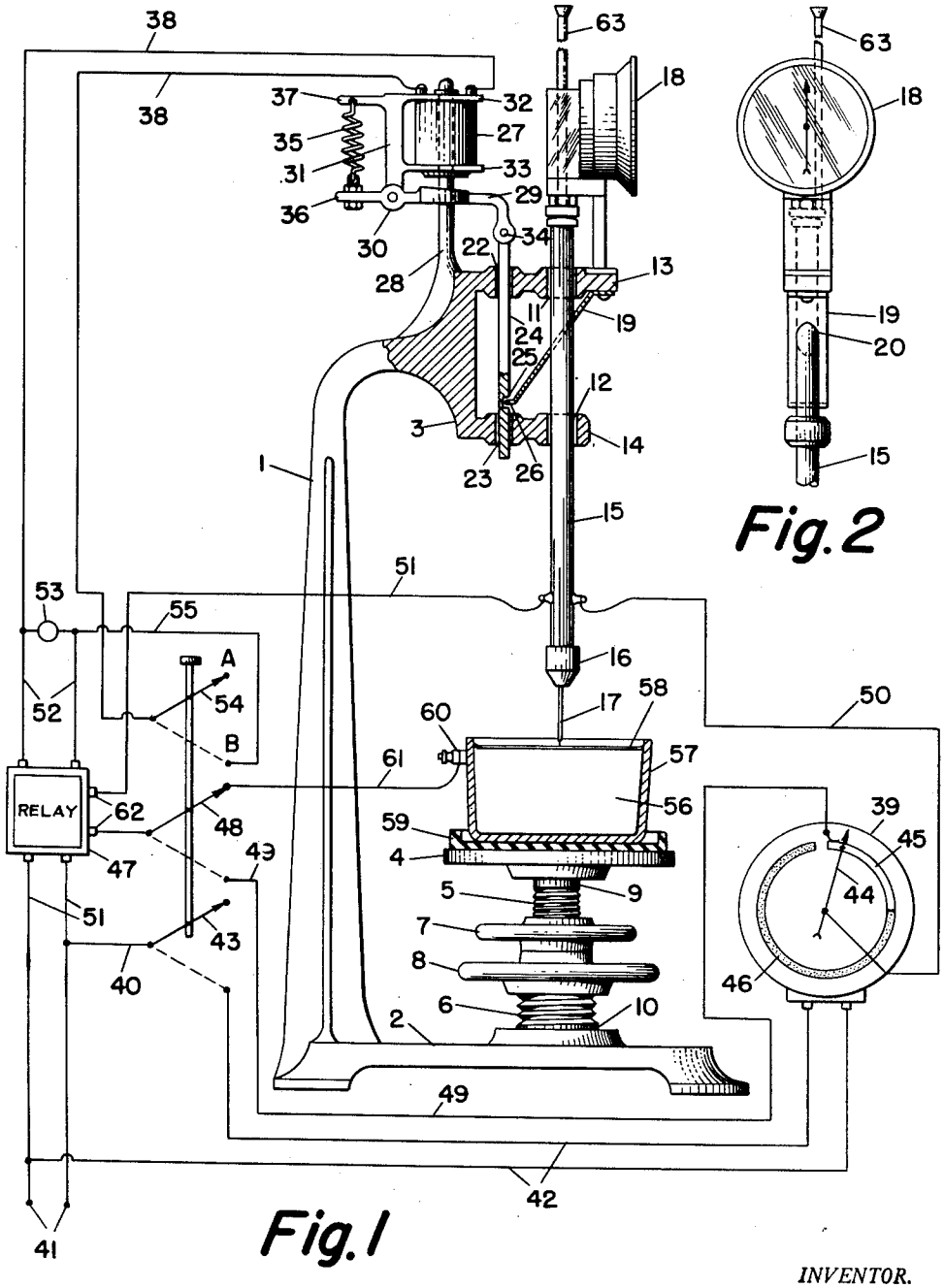


Fig. 1

Fig. 2

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METHOD AND APPARATUS FOR POSITIONING CONTACT ELEMENT OF PENETROMETERS

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This invention relates to improvements in penetrometers for determining the penetrability of asphalt and similar materials, and more particularly relates to a novel process and apparatus for accurately adjusting the penetrometer needle to bring it substantially into contact with the surface of the material preparatory to making the determination and for accurately releasing the needle for a preselected period of time.

In the operation of conventional penetrometers it has been the practice heretofore to move, by means of the adjustment screws or the like provided thereon, either the support for the penetrometer needle or the support for the sample of asphalt, or other material under investigation, relative to the other until the end of the needle is just in contact with the surface of the material. Then the needle is released from its support permitting it to fall freely under the force of gravity for a definite length of time. The distance of fall of the needle within the fixed period of time is indicative of the penetrability of the material. The accuracy and reproducibility of the determinations are to a large degree dependent upon the skill of the operator in bringing the penetrometer needle substantially into contact with the surface of the material prior to release thereof. In the event that the needle is not brought into substantial contact with the surface of the material prior to release thereof, the apparent extent of penetration of the material during free fall of the needle will be greater than the actual penetration, thus introducing error into the determination.

Another source of error in penetrometer determinations, as heretofore made, is the inability of an operator to accurately and consistently release the penetrometer needle clutch manually so as to permit the needle to fall freely for a preselected period of time such, for example, as 5 seconds. In conventional systems the operator is required to manually engage and disengage a needle clutch to effect release of the needle for a prescribed period of time.

It is, therefore, an object of the present invention to provide a process and apparatus for accurately adjusting the position of the needle of any conventional penetrometer so that the needle is substantially in contact with the surface of asphalt or other electrically non-conducting material under investigation, whereby human error in bringing the needle just into contact with the surface of the material is substantially eliminated.

Another object of the invention is to provide a process and apparatus whereby a signal is given automatically when, in the adjustment of a conventional penetrometer preparatory to making a penetration determination, the penetrometer needle is brought substantially into contact with the surface of the material under investigation.

Another object of the invention is to provide a process and apparatus for making penetration determinations whereby the penetrometer needle may be accurately adjusted, prior to release thereof, to bring it substantially into contact with the surface of the material under investigation, and the needle subsequently may be released automatically for a desired period of time.

Other objects and feature of the invention will be apparent from the attached drawing and detailed description which follows.

The figure is an elevation view, partially in section, of a penetrometer provided, in accordance with this invention, with means for accurately adjusting the penetrometer needle relative to the sample preparatory to making a determination and with means for accurately releasing the needle for a preselected period of time.

Broadly, this invention involves a process and apparatus applicable to any conventional penetrometer for providing automatically an indication, during the adjustment of the penetrometer preparatory to making a determination, when the penetrometer needle is "zeroed" or brought substantially into contact with the surface of the asphalt or other electrically non-conducting material under investigation. To this end, a thin continuous and reproducible film, which is electrically conducting, is formed on the surface of the material. This is accomplished preferably by contacting the surface of the material with water containing a water-soluble or water-dispersible wetting agent, and then shaking vigorously the material to remove all excess water. Other means may be used, if desired, to remove excess water, such as directing a blast of air over the surface of the material. Due to the action of the wetting agent, a very thin film of water, reproducible from sample to sample, remains on the material, the film being continuous over the entire surface of the material. An electric circuit including a source of electric energy and an electrically actuatable indicator is connected between the penetrometer needle and the conducting film. As the distance between the needle of the penetrometer and the sample of material is reduced during adjustment of the penetrometer in preparation for making a determination, the needle finally contacts the conducting film, completing the circuit through the electric energy source and indicator, thereby actuating the indicator and thus informing the operator that the needle is at that time properly "zeroed" on the surface of the sample.

In combination with such means for adjustment of the needle relative to the sample surface, is an electric circuit including a timing means and an electrically actuable clutch mechanism for releasing the needle for an accurately controlled time interval such, for example, as 5 seconds.

It is essential to applicant's invention that the aqueous film be very thin, continuous over the entire surface of the sample, and reproducible. If the thickness of the conducting film varies to any appreciable extent anomalies will be introduced into the determinations. Thus the film cannot be formed simply by pouring on the surface of the sample any aqueous solution capable of conducting electricity. However, a suitable film may be formed by contacting the surface of the material with water containing an ionizable water-soluble or water-dispersible wetting agent, that is, any water-soluble or water-dispersible cationic or anionic wetting agent, or with water containing an electrolyte such as a water-soluble chloride, sulfate, nitrate, etc., and a water-soluble or water-dispersible wetting agent, cationic, anionic or non-ionic, and vigorously shaking the material to remove all excess water, as above described.

Water-soluble or water-dispersible wetting agents which may be employed in accordance with this invention include soluble salts of carobxylic acids of fatty acid soaps such as sodium or potassium oleate, stearate, palmitate, laurate, myristate, arachidate, or ricinoleate; soluble salts of amino acids (or alkylated or phenylated amino acids) such as valine, cystine, arginine, hydroxyvaline, glutamic acid, hydroxyglutamic acid, citrulline, phenylalanine, tryptophane; soluble salts of peptides and polypeptides which are either synthetic or are degradation products of proteins such as casein, glue, albumin; esters of higher fatty acids with tertiary amino alcohols such as triethanolamine or alkyl ethers of tertiary amino alcohols; acid phosphates or phosphonates of oleic or ricinoleic acids or their esters, or polyethyleneglycol esters of phosphoric acid; sulfated oils, sulfated fatty alcohols as cetyl sulfate, lauryl sulfate or oleyl alcohol sulfate, sulfated fatty acid monoglycerides, sulfated fish oils, castor oil, tallow, or olive oil; soluble salts of amines as the primary fatty amine acetates and chlorides and their quaternary compounds such as cocoanut fatty alkyl dimethylbenzylammonium chloride; acylated or alkylated alkylene polyamines such as ethylenediamine or diethylenetriamine or polyethylene polyamines; alkane sulfonates such as petroleum sulfonates of the water-soluble

green acid type; products of esterification of a fatty acid with isethionic acid, taurine or methyl taurine, sulfoacetates, sulfoacetamines, sulfopropionates, sulfobutyrates, or sulfosuccinatees of cocoanut fatty oleyl, cetyl, or stearyl alcohols, sulfotricarboxy aliphatic acids; lignin sulfonate; quaternary compounds of fatty alkyl halides with substituted morpholines, benzimidazoles, and hexyl amines; alkyl aromatic sulfonates such as propylated or butylated naphthalene or naphthol sulfonates, di- and trialkyl benzene and alkyl toluene sulfonates in which the alkyl group may be amyl or butyl, alkylated diphenyl ether sulfonates, or alkylated phenyl sulfonates in which the alkyl group contains from 9 to 15 carbons atoms; non-ionic wetting agents such as polyoxyalkylene oxide derivatives of fatty alcohols, mercaptans, ether alcohol, fatty acids, or natural phosphatides as lecithin; fatty acid esters of sugar alcohols; substituted high molecular weight alkanol amines; condensation products of polyhydric alcohols and polybasic water-soluble acids as the stearic acid ester of glycol tartrate; and water-soluble substituted glucosides.

The concentration of the wetting agent obviously is not critical and can be varied over a relatively wide range. It is dependent to some extent on the particular wetting agent employed. A concentration of from 0.01% to 2%, however, has been found satisfactory. It is to be understood that it is necessary only that sufficient wetting agent be present to reduce the surface tension sufficient to cause the water film to completely wet the surface of the sample.

Similarly the concentration of electrolyte in the water when using a non-ionic wetting agent may vary over a wide range, that is, from as low as 0.01% or less by weight up to the saturation concentration of the electrolyte.

Referring now to the drawing, the present invention is exemplified in detail in connection with a penetrometer generally denoted by the numeral **1**, and including base **2** and support **3**. Sample support platform **4** is adjustably mounted for vertical movement on base **2** by means of threaded stud **5** and threaded nipple **6**, and associated adjustment nuts **7** and **8**, respectively. Externally threaded stud **5** is welded or otherwise secured at one end, as at **9**, to the lower surface of platform **4** and its free end is adapted to telescope into a longitudinal bore, not shown, provided in nipple **6** which, in turn, is secured, as at **10**, by welding or other suitable means to base **2**. It will be seen that by proper manipulation of adjustment nuts **7** and **8**, threaded respectively on stud **5** and nipple **6**, sample support platform **4** may be moved a limited distance vertically, nipple **6** being provided with relatively coarse threads for coarse adjustment, and stud **5** being provided with relatively fine threads for fine adjustment of the position of platform **4**.

Aligned openings **11** and **12** provided in arms **13** and **14**, respectively, of C-shaped support **3** provide a guide for needle holder **15** which is adapted for slidable movement therein. One end of needle holder **15** is provided with a gripping device **16** of any suitable type, or with other means for securely mounting penetrometer needle **17** on needle holder **15**, as shown. Dial indicator **18** is mounted on arm **13** of support **3** and functions to measure the amount of vertical movement of needle holder **15** and consequently the penetration of the sample by needle **17**, when the latter is permitted to fall freely for a definite period of time such, for example, as 5 seconds. Indicator **18** includes a rod **63**, disposed immediately above needle holder **15**, which may be lowered into contact with the upper end of the needle holder **15** immediately before and also after release of the needle thereby to determine the amount of penetration of the sample by needle **17**.

A detailed showing and discussion of dial indicator **18** is believed unnecessary since the construction and operation of penetrometers is well known in the art and forms no part of the present invention. Further, while a particular type of penetrometer is shown in the drawing, it is to be understood that such showing is presented for the purpose of describing the operation of the invention only, and the invention is not to be limited to use in connection with such penetrometer but is capable of operating with any conventional penetrometer.

Electrically actuatable means are provided for releasably holding needle holder **15**, and consequently needle **17**, against vertical movement. Such means includes detent **19** secured at one flanged end, as shown, by screws or otherwise to arm **13** of support **3** and provided with a suitable elliptical aperture **20** to receive needle holder **15**. Arms **13** and **14** of support **3** are provided with aligned openings **22** and **23**, respectively, providing a guide for rod **24**. Groove **25** is formed in rod **24** to accommodate the free flanged end **26** of detent **19**. It is to be understood that elliptical aperture **20** is so formed that when rod **24** is moved downwardly, detent **19** will be caused to move into frictional engagement with needle holder **15** thereby securing needle **17** against vertical movement; and when rod **24** is moved upwardly detent **19** and needle holder **15** will become disengaged, permitting needle holder **15** to move freely downward in elliptical aperture **20**.

Movement of rod **24** is controlled by electric coil **27** mounted in any suitable manner on post **28** which is formed, in turn, on support **3**. Lever **29**, formed of iron or other metal, is pivotally connected, as at **30**, to support member **31**, which is connected to support **28** through arms **32** and **33**, and has formed therein a suitable bore, not shown, to receive stud **28** with sufficient freedom of movement to cause rod **24**, pivotally connected to one end of lever **29**, as at **34**, to bring detent **19** into and out of contact with needle holder **15**. Spring **35** is normally distended between the other end of lever **29**, as at **36**, and arm **37** protruding from support member **31**, whereby lever **29** is maintained normally in its furthermost position away from coil **27** and thus needle holder **15** is secured normally against vertical movement by friction contact with detent **19**. When coil **27** is energized by electric energy supplied thereto through leads **38**, lever **29** is caused to move toward coil **27**, resulting in disengagement of needle holder **15** and detent **19**, thereby permitting needle holder **15**, and needle **17**, to fall freely.

By means of electric clock **39** and an associated electric circuit, energization of coil **27** may be accurately controlled so that needle holder **15** and needle **17** may be released and permitted to fall freely for a definite period of time such, for example, as 5 seconds. When ganged switch, generally denoted by numeral **40**, is changed from its normal position A to position B, electric energy from a suitable source, not shown, and applied to terminals **41**, is conducted through leads **42** and contact **43** to clock **39**, causing the latter to operate. Sweep hand **44** of clock **39** is adapted to contact strip **45** and strip **46** provided on the face of clock **39**, strip **45** being electrically conducting and strip **46** being electrically non-conducting. The rate at which hand rotates and the length of strip are so selected or adjusted that the length of time hand **44** is in contact with strip **45** during one revolution of hand **44** is equal to the desired time of free fall of needle **17**. With switch **40** in position B, during the time hand **44** and strip **45** are in contact an electric circuit is completed from across terminals **62** of conventional electronic relay **47** through contact **48** of switch **40**, lead **49**, strip **45**, hand **44**, lead **50**, needle holder **15**, and lead **51**. The electronic relay is so constructed that completion of such circuit across terminals **62** causes relay **47**, which is normally open, to close, thereby permitting electric energy applied to terminals **41** to pass through relay **47**, and leads **52** to indicator **53**, such as a bell, light or other suitable device, which is thus actuated, and through leads **38**, contact **54**, and lead **55** to coil **27** which is thus energized resulting in release of needle holder **15**. Such a situation maintains as long as hand **44** and strip **45** are in contact. When hand **44** passes from strip **45** into contact with strip **46** which is electrically non-conducting the circuit through the clock hand is opened, causing relay **47** to open also, with the result that indicator **53** is no longer actuated and needle holder **15** is again contacted by detent **19** preventing further movement thereof.

The sample **56** of asphalt or other non-conducting material to be investigated is placed preferably in a metallic vessel **57**. The vessel **57** is then submerged in a constant temperature water bath, not shown, to bring the sample up to the temperature such, for example, as 77° F. at which the determination is to be carried out, the water in the bath having dissolved or dispersed therein a small amount of wetting agent. After reaching the desired temperature, vessel **57** is removed from the bath and shaken vigorously to remove excess water. A very thin, continuous film **58** of water, however, will remain

on the surface of the sample due to the presence of the wetting agent. The vessel then is placed on adjustable platform 4 with a dielectric element 59 therebetween.

It is a purpose of this invention to provide means for automatically indicating when needle 17 is "zeroed" or brought substantially into contact with the surface of sample 56, preparatory to making the desired penetration determination. This is accomplished, in accordance with the invention, by means of the conducting film 58 and an electric circuit associated with needle 17 and film 58. To this end, a terminal 60 is formed in the wall of vessel 57, and lead 61 is provided to connect such terminal and vessel 57 with contact 48 of switch 40 when the switch is in its normal position A. With switch in position A, when sample 56 is raised sufficiently, by proper manipulation of adjustment nuts 7 and 8, needle 17 will contact film 58. At that time, it will be noted, an electric circuit is completed across terminals 62 of electronic relay 47 through contact 48, lead 61, terminal 60, vessel 57, film 58, needle 17, needle holder 15, and lead 51, the same as when hand 44 contacts strip 45 with switch 40 in position B. Completion of such circuit, as before, causes relay 47 to close permitting electric energy applied to terminals 41 to pass therethrough, actuating indicator 53 to thereby indicate to the operator that needle 17 substantially is in contact with the surface of the sample and that further adjustment of nuts 7 and 8 is not required. In this case, however, since switch is in position A the circuit to coil 27 through contact 54 will not be completed, and therefore needle 17 will not be released.

In operation, the sample of asphalt is placed in vessel 57 and the thin continuous aqueous film 58 is formed on the surface thereof using a wetting agent, preferably in the manner described hereinbefore. It is to be understood, however, that as an alternative, water containing the dispersing agent may be poured on the sample after the latter has been brought to the desired temperature in the constant temperature bath, without departing from the spirit and scope of the invention. Vessel 57 is then placed on platform 4, as shown, with dielectric element 59 therebetween. With switch 40 in position A, adjustment nuts 7 and 8 are manipulated in a manner to slowly raise platform 4. When needle 17 contacts film 58, electronic relay 47 closes causing indicator 53 to be actuated as described above, thus indicating to the operator that needle 17 is properly adjusted; however, coil 27 remains de-energized since switch 40 is in position A.

Switch 40 is then moved to position B. When this is done, electronic relay 47 is caused to open since the circuit across terminals 62 is broken, it will be noted and at the same time electric energy will be supplied through contact 43 of switch 40 to clock 39, causing it to operate. As hand 44 moves into contact with strip 45, electronic relay 47 again is closed as a result of completion of a circuit across terminals 62, as described above. This time, not only is indicator 53 actuated, but also coil 27 is energized through contact 54 thereby releasing as a unit needle holder 15 and needle 17. The needle will be free to fall for the selected time that hand 44 and strip 45 are in contact. As hand 44 moves out of contact with strip 45 and into contact with strip 46, electronic relay 47 is caused to open with the result that indicator 53 is no longer actuated and needle 17 is prevented from further vertical movement by the action of detent 19. At this point the operator returns switch 40 to position A, thus stopping the clock and preventing subsequent release of needle holder 15 and needle 17.

In the preferred embodiment of the invention, hereinbefore described, the thin film of water is formed on the surface of the sample under investigation through the use of a water-soluble or water-dispersible wetting agent present in the water. If desired, however, the aqueous film may be formed by dissolving or dispersing a wetting agent in the asphalt or other material being tested. When water is applied to the asphalt containing the wetting agent, a similar thin film of water will be retained on the surface thereof. In some cases it may be necessary to add an electrolyte to the water to obtain electric current conduction through the film. A serious disadvantage of this latter method of forming the conducting film is that the wetting agent may have the tendency of modifying the penetration characteristics of the material, thus rendering the determinations unreliable in some cases.

Another method which may be employed for forming a thin, reproducible film, which is electrically conducting, on the surface of the material under investigation involves brushing, or otherwise treating, the surface of the material with an aqueous dispersion of graphite or other metal, and then permitting it to dry, thus forming an extremely thin but conductive film. Once the film has dried, it is stable to the extent that the sample may be placed in a water bath without deterioration of the graphite or metallic film. On removal from the water bath, the sample contained in vessel 57 may be placed under water in a small dish, not shown, on platform 4 whereby the sample may be maintained for a relatively long time, if necessary, at the temperature for carrying out the determination. If the sensitivity of relay 47 is properly adjusted, the sample may be raised so as to "zero" the needle on the sample surface. As the needle enters the water, no signal is produced because of the low electrical conductivity of the water. At the point, however, when needle 17 just touches the graphite or metallic film, the relay closes causing indicator 53 to be actuated, thus indicating that the needle is properly adjusted. A disadvantage of this embodiment of the invention is that the graphite or metallic film in some cases may abnormally resist penetration by the needle and thus introduce error into the determination.

While in the foregoing there has been shown and described the preferred embodiment of this invention, it is to be understood that minor changes in the details of construction, combination, and arrangement of the parts may be resorted to without departing from the spirit and scope of the invention as claimed.

I claim:

1. A process for adjusting a penetrometer, preparatory to making a determination, to bring the penetrometer needle substantially into contact with the surface of an electrically non-conducting material under investigation comprising the steps of forming a thin continuous film, which is electrically conducting, on said surface, said needle and said film forming part of an indicating circuit adapted to close when said needle and said film are brought into contact, and decreasing the distance between said needle and said surface just enough to cause said indicating circuit to close whereby said needle is substantially in contact with said surface of said electrically non-conducting material.

2. A process for adjusting a penetrometer, preparatory to making a determination, to bring the penetrometer needle substantially into contact with the surface of an electrically non-conducting material under investigation comprising the steps of forming a thin continuous aqueous film, which is electrically conducting, on said surface, said needle and said film forming part of an indicating circuit adapted to close when said needle and said film are brought into contact, and decreasing the distance between said needle and said surface just enough to cause said indicating circuit to close whereby said needle is substantially in contact with said surface of said electrically non-conducting material.

3. A process for adjusting a penetrometer, preparatory to making a determination, to bring the penetrometer needle substantially into contact with the surface of an electrically non-conducting material under investigation comprising the steps of forming a thin continuous metallic film, which is electrically conducting, on said surface, said needle and said film forming part of an indicating circuit adapted to close when said needle and said film are brought into contact, and decreasing the distance between said needle and said surface just enough to cause said indicating circuit to close whereby said needle is substantially in contact with said surface of said electrically non-conducting material.

4. A process for adjusting a penetrometer, preparatory to making a determination, to bringing the penetrometer needle substantially into contact with the surface of an electrically non-conducting material under investigation comprising the steps of contacting said surface with water in the presence of a wetting agent, removing excess water from said surface to form a thin continuous electrically conducting film of water covering said surface, and decreasing the distance between said needle and said surface just enough to cause said indicating circuit to close whereby said needle is substantially in contact with said surface of said electrically non-conducting material.

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