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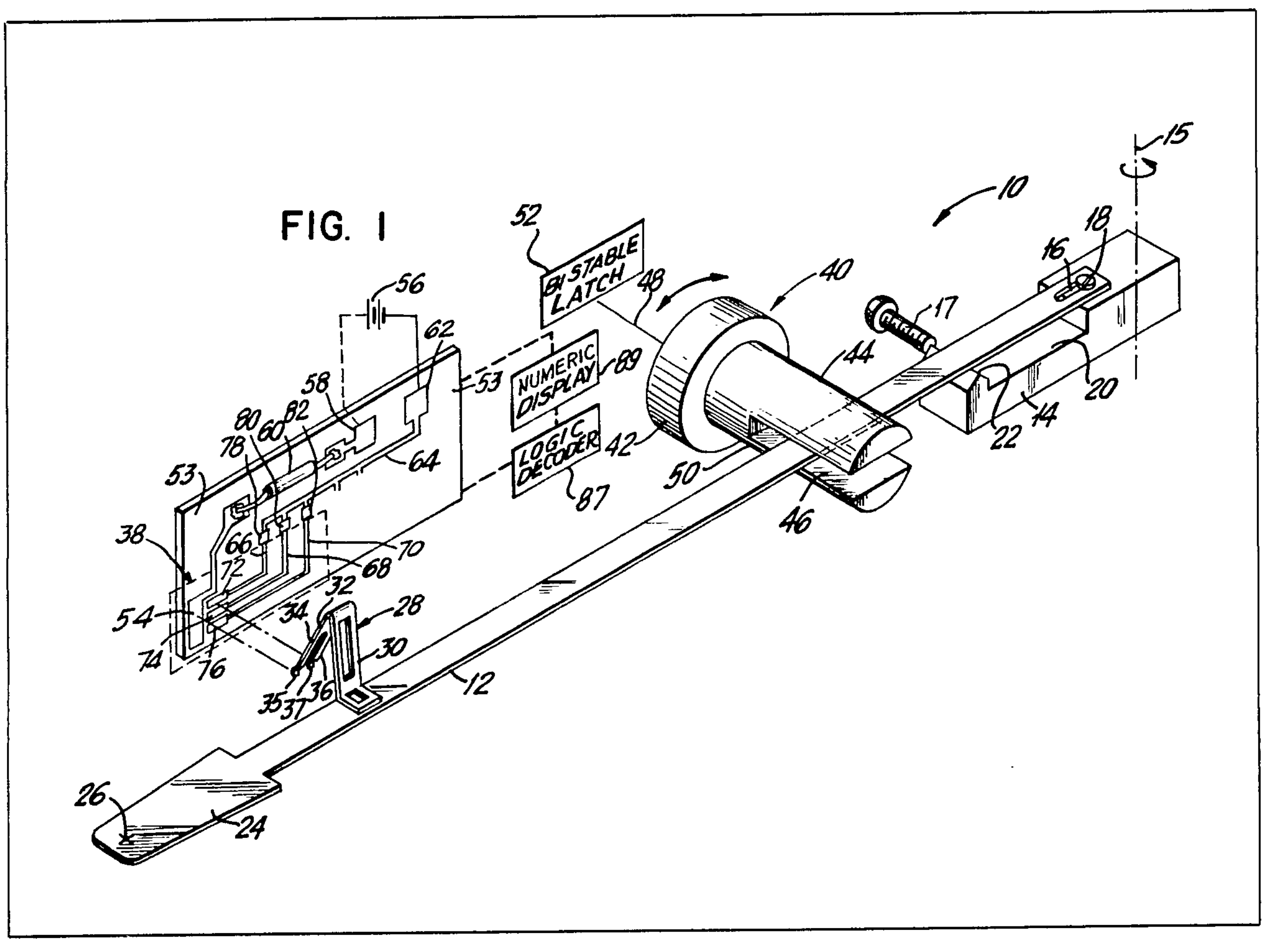
(54) Apparatus for measuring a force applied to a resilient member

(57) Apparatus is described for measuring a force applied to a resilient member (12) by, for example, the stylus of a gramophone cartridge. The apparatus comprises a plurality of spaced electrical contacts (72, 74, 76); an electrically conductive member (28) attached to the resilient member (12) for sequentially engaging the contacts as the resilient member is deflected by a force applied thereto; and display means which may be digital, analogue or numerical actuated as the electrically conductive member engages the contacts to provide an indication of the force applied to the resilient member or alternatively of the displacement of the electrically conductive member. Preferably, two alternative points of support (22 and 50) about which the resilient member may be deflected are provided to allow a greater range of measurement.



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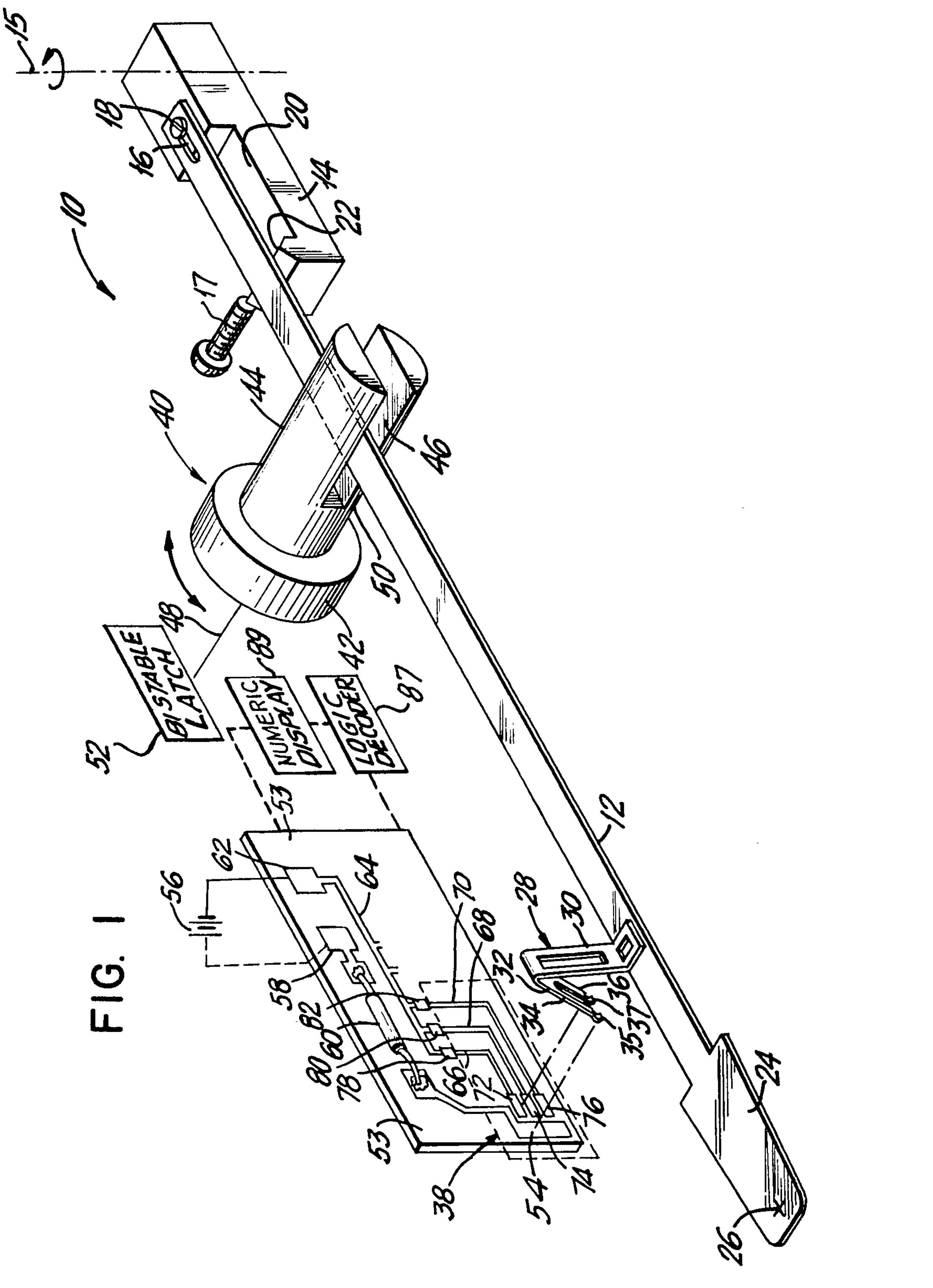

FIG. 1

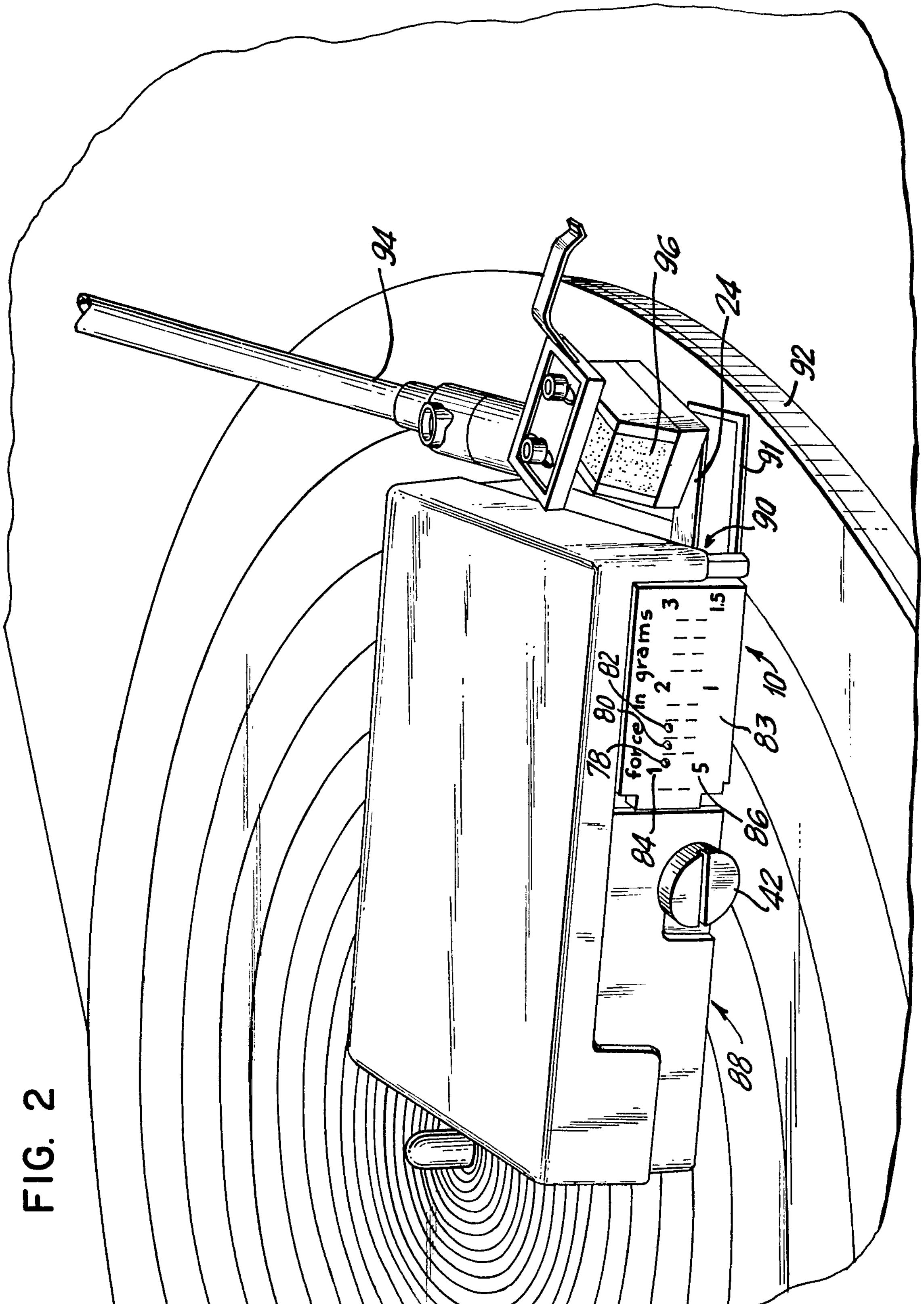

FIG. 2

SPECIFICATION

Apparatus for measuring a force applied to a resilient member

THIS INVENTION relates to apparatus for measuring a force applied to a resilient member, in particular for providing an accurate measurement of the tracking force of the stylus of a gramophone cartridge.

A gramophone cartridge contains a stylus which generally tracks the grooves of a record with a force equivalent to the weight of a mass of approximately 0.5 to 4 grams measured at the stylus tip. It is important that the stylus tracking force be determined and accurately established, since either too high or too low a stylus tracking force may cause damage to the record grooves and result in an audible degradation of the sound produced in the reproduction process. When such damage occurs to the record, it is irreversible.

Over the years a number of different devices have been proposed and used to measure the tracking force of a gramophone stylus. These devices have generally utilized a beam balance arrangement in which the gramophone stylus is placed at one end of a pivotable bar and a sliding weight is moved on a calibrated scale at the other end until the bar is balanced. These devices have suffered from difficulties in use, including difficulties in reading the often small indication of the measured force. Certain of these devices suffer from inaccuracy and a lack of repeatable measurements of the stylus force. Furthermore, the operation of certain of the previously proposed devices may cause the user to damage the stylus by its being dropped during the measurement operation.

According to one aspect of the present invention, there is provided apparatus for measuring a force applied to a resilient member, comprising: a plurality of spaced electrical contacts; an electrically conductive member attached to the resilient member for sequentially engaging the electrical contact as the resilient member is deflected by a force applied thereto; and display means actuated as the electrically conductive member engages the contacts to provide an indication of the force applied to the resilient member.

Conveniently, the apparatus comprises a first support means for providing a first point of support about which the resilient member is deflectable and desirably also has a second support means for providing a second point of support about which the resilient member is deflectable. First and second scales of measurement may thus be provided to cover two, possibly overlapping ranges of force applied to the resilient member.

In a second aspect of the invention, there is provided apparatus for measuring the displacement of an electrically conductive member, comprising: a plurality of spaced contacts; means for displacing the electrically conductive member and causing the electrically conductive member to engage the contacts sequentially, and display means actuated by the electrically conductive member engaging the contacts to provide an indication of the displacement of the electrically conductive member.

Preferably, the display means comprises a plurality of indicators and means are provided for coupling the indicators to different ones of the contacts, so that, as the resilient member is deflected, or the electrically conductive member is displaced, the indicators are actuated sequentially.

Alternatively, decoding means are coupled to the contacts to provide a digital representation of the measured force or displacement on the display means.

In a preferred embodiment, the apparatus comprises a resilient flexure member to which is attached an electrically conductive member for engagement with an encoder. As the flexure member is deflected by an amount proportional to the force being measured, various contacts on the encoder are activated to provide discrete electrical signals. The signals are then used to drive a discrete visual display of the measured force. The display may be analog, numeric or digital and the reading of the display is directly related to the deflection of the flexure member. The apparatus may include a mechanism for providing a second point of deflection for the flexure member and a second visual scale to provide either greater precision or a greater range of measurement. The apparatus is particularly suitable for determining the tracking force of a gramophone stylus.

In order that the invention may be more readily understood, an embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a simplified perspective internal view of a stylus force gauge embodying the present invention; and

Figure 2 is an elevational view of the measuring scale used in conjunction with the gauge of Fig. 1.

Referring now to the drawings, there is shown a stylus force gauge 10 embodying the invention including a flexure member, here shown as a precision leaf spring 12, fixed at one end to a mounting block 14. Other spring arrangements such as a coil spring and a non-flexible arm could be used in place of the planar spring illustrated herein. The flexure member 12 is formed with an elongate slot 16 through which the screw 18 or other fastening member is inserted for mounting to block 14. The slot 16 permits calibration adjustment for the spring rate of flexure member 12. Mounting block 14 includes a recessed portion 20 spaced away from flexure member 12 and a knife edge 22 about which flexure member 12 deflects. Tip 24 of flexure member 12 includes a locating mark 26 or depression for positioning the stylus of a gramophone cartridge for measurement purposes.

Proximate to tip 24 on flexure member 12 is an electrically conductive member in the form of a conductive wiper 28 which includes an upstanding portion 30 and a depending portion 32 presenting contact arms 34 and 36 for engagement with the contacts of an encoder 38. Contact arms 34, 36 include curved ends 35, 37 for positive contact with encoder 38. The conductive material of wiper 28 and encoder 38 are selected so that reliable contact is achieved with minimal friction thereby assuring that the accuracy of measurement is not appreciably affected by contact friction.

In order to assure minimum friction between wiper 28 and encoder 38 it is preferable that the contacts of wiper 28 and the contacts of encoder 38 be formed of dissimilar metals. Suitable metals include noble metals such as gold or platinum for the contacts of encoder 38 and refractory, relatively harder, metals such as rhodium or rhenium for the contacts of wiper 28. Since the gauge is designed to measure forces equivalent to weights of tenths of grams, to prevent appreciable hysteresis errors it is necessary that the friction forces between the contacts of wiper 28 and encoder 38 be kept to the equivalent of weights of a few hundredths of a gram. In order to set the minimal contact force necessary to ensure accurate results, the rear of mounting block 14 is pivotable about an axis 15 and an adjustment screw 17 abuts flexure mounting block 14 to vary the distance of flexure 12 from encoder 38. Screw 17 is adjusted so that curved ends 35, 37 of contact arms 34, 36 just touch the contacts of encoder 38.

In order to provide a second scale of measurement for the device, a second point of support for flexure member 12 is provided. This second point is provided by a selector assembly 40, which includes a selector knob 42 with a cylindrical extension 44 including an elongate slot 46 through which the flexure member 12 extends. Selector assembly 40 is pivotable along its longitudninal axis 48 from a first position, in which flexure member 12 is completely out of contact with an edge 50 of slot 46, to a second position in which edge 50 of slot 46 contacts flexure member 12 to provide an alternative support point. Due to the fact that the effective length of flexure member 12 is shortened when it is in contact with edge 50, a different scale factor is obtained in the measurements. A bistable magnetic latch 52 serves to hold adjustment member 40 in either its first or second position until it is manually turned.

Encoder 38 includes a non-conductive substrate 53 having a number of conductive contacts disposed thereon for engagement with the contact ends 35 and 37 of wiper 28. A first conductive contact 54 is oriented generally vertically in the direction of deflection of flexure member 12 so that end 35 of contact arm 34 will be in engagement with it at all times. A voltage source such as a battery 56 is connected to a terminal 58 on substrate 53 and to contact 54 through an appropriate current limiting resistor 60.

The other pole of battery 56 is coupled to a terminal 62 on substrate 53. A lead 64 is connected to terminal 62, and a plurality of branches, only three of which, namely branches 66, 68, 70, are illustrated for the sake of clarity, extend from lead 64. It is to be understood, however, that as many additional branches as may be required can be added. The larger the number of branches, the greater is the number of discrete forces that may be indicated. Branches 66, 68, 70 respectively, include contacts 72, 74, 76 for contact with the end 37 of contact arm 36 of wiper 28 as flexure member 12 moves.

Visual indicia such as light-emitting diodes (LED's) 78, 80, 82 are respectively connected in series with branches 66, 68, 70. Thus, when arm 36 of wiper 28 is engaged with contact 72 and arm 34 is in contact with contact 54, LED 78 will be illuminated. Similarly the engagement of arm 36 and contact 74 will illuminate LED 80 and the engagement of arm 36 and contact 76 will illuminate LED 82. Thus, as flexure member 12 is displaced, such that the deflection of the wiper is directly converted to the force readout, various ones of the LED's will be illuminated.

LED's 78, 80, 82 are preferably mounted to the rear of substrate 53 and, as shown in Fig. 2, are arranged behind a translucent screen 83 having a first scale 86 and a second scale 84.

Substrate 53 has all the contacts, wiring and indicators mounted to it which greatly facilitates assembly and repair of the device. Furthermore, screen 83 may also be mounted to substrate 53.

Scale 84 is used when selector assembly 40 is in its second position and edge 50 is contacting flexure member 12 to shorten its effective length and thus increase the amount of force required for a given deflection of flexure member 12. Scale 86 is used when selector assembly 40 is in its first position and edge 50 thereof is out of contact with flexure member 12. In place of the "bar graph" type of display illustrated in Fig. 2, a "numeric" display could be obtained by having the LED's read out the force in a series of discrete digits illuminated by LED's. Alternatively the output of encoder 38 may be supplied to a logic decoder 87 and thereafter to a digital display 89 of, for example, conventional 7-segment type. The display may be made up of LED's, LCD's, fluorescent or other well known displays. The plurality of discrete electrical signals provided by encoder 38 corresponding to the force applied to flexure member 12 may thus be used to drive different types of displays, both analog and digital.

A preferred enclosure 88 for force gauge 10, as illustrated in Fig. 2, is generally rectangular and includes an opening 90 through which tip 24 of flexure member 12 extends and an extension 91 which provides flexure member 12 with protection from sideways blows. As illustrated, enclosure 88 is designed to rest on the turntable 92. The user positions the tone arm 94 so that the stylus of cartridge 96 rests on positioning mark 26, and the tracking force may then be read directly from the LED display through screen 83. Turning selector knob 42 permits the selection of either scale 84 or scale 86. These scales have some overlap in their measurement range to permit the user to select the most appropriate scale.

The size and spacing of contacts 72, 74, 76 are arranged so that if end 37 of contact arm 36 is midway between two contacts (i.e., contacts 72, 74 or contacts 74, 76) it will simultaneously engage both of the contacts. The illumination of two LED's will indicate that the force reading is between the points indicated. Thus, the resolvable precision of measurement exceeds the number of discrete contacts in the encoder. The spacing between contacts 72, 74, 76 may be equal or non-equal. If the spacing is equal, the spacing of the LED's in the corresponding bar graph display should preferably be equal; if the spacing is non-equal, the spacing of the LED's should preferably also be non-equal. Thus, the spacing between the LED's 78, 80, 82 should preferably be directly proportional to the spacing between cntacts 72, 74 and 76.

In use of the apparatus, the stylus is placed on the tip 24 of the flexure member 12 and the illuminated discrete, digital or numeric display can thereupon directly read to indicate the tracking force of the stylus. Thereafter the user may adjust the tone arm to achieve the optimum desired tracking force. Preferably, first and second scales of measurements are provided to cover two, possibly overlapping force ranges. No balancing, calibration or other adjustments need be made by the user to employ or read measurement indicated by the apparatus.

Apparatus embodying the invention is particularly suitable for determining the tracking force of a gramophone stylus as described above, is simple to use and provides an indication that can be clearly read and understood by the user. Moreover, the apparatus does not require user adjustment and the possibility of the user damaging the object, for example of a gramophone stylus, applying the force to the resilient member is minimised. Further, in apparatus embodying the invention a relatively small deflection of the resilient member is directly converted to an easily readable output which may be in the form of an analogue, numeric or digital display of the force measured. Also, two separate measurement scales may be provided to cover two possibly overlapping ranges of forces, the arrangement being such that switching between the two scales is easily accomplished.

CLAIMS

1. Apparatus for measuring a force applied to a resilient member, comprising: a plurality of spaced electrical contacts; an electrically conductive member attached to the resilient member for sequentially engaging the electrical contacts as the resilient member is deflected by a force applied thereto; and display means actuated as the electrically conductive member engages the contacts to provide an indication of the force applied to the resilient member.

2. Apparatus according to claim 1, wherein the display means comprises a plurality of indicators and means are provided for coupling the indicators to different ones of the contacts, so that, as the resilient member is deflected, the indicators are actuated sequentially.

3. Apparatus according to claim 2, wherein the indicators are arranged in the same sequence as the contacts.

4. Apparatus according to claim 2 or 3, wherein the spacing of the indicators is a function of the spacing of the contacts.

5. Apparatus according to claim 4, wherein the spacing of the indicators is directly proportional to the spacing of the contacts.

6. Apparatus according to any preceding claim, wherein the contacts are evenly spaced apart.

7. Apparatus according to any one of claims 2 to 6, including means for labelling each of the indicators with a numeral representing the value of the force required to be applied to the resilient member to actuate that indicator.

8. Apparatus according to any one of claims 2 to 7, wherein the contacts and indicators are mounted on a substrate.

9. Apparatus according to claim 1, wherein decoding means are coupled to the contacts to provide a digital representation of the measured force on the display means.

10. Apparatus according to any preceding claim, including a first support means for providing a first point of support about which the resilient member is deflectable.

11. Apparatus according to claim 10, including a second support means for providing

a second point of support about which the resilient member is deflectable.

12. Apparatus according to claim 11, wherein the second support means is displaceable between a first position in which the second support means does not engage the resilient member and a second position in which an edge of the second support means engages the resilient member to provide the second point of support.

13. Apparatus according to claim 11 or 12, including means for locking the first and second point of support.

14. Apparatus according to claim 12, wherein means are provided for locking the second support means into the first or second position until manually displaced therefrom.

15. Apparatus according to claim 13 or 14, wherein the locking means is a bistable magnetic latch.

16. Apparatus according to any preceding claim, wherein the resilient member is a spring.

17. Apparatus according to claim 16, wherein the spring is a cantilever leaf spring.

18. Apparatus according to claim 17, wherein one end of the spring is fixedly mounted to a fixed mounting means.

19. Apparatus according to claim 18, when dependant on claim 10, wherein the mounting means includes the first support means.

20. Apparatus for measuring the displacement of an electrically conductive member, comprising: a plurality of spaced contacts; means for displacing the electrically conductive member and causing the electrically conductive member to engage the contacts sequentially; and display means actuated by the electrically conductive member engaging the contacts to provide an indication of the displacement of the electrically conductive member.

21. Apparatus according to claim 14, wherein the display means comprise a plurality of indicators and means are provided for coupling the indicators to different ones of the contacts so that, as the electrically conductive member is displaced, the indicators are actuated sequentially.

22. Apparatus according to claim 21, wherein the indicators are arranged in the same sequence as the contacts.

23. Apparatus according to claim 21 or 22, wherein the spacing of the indicators is a function of the spacing of the contacts.

24. Apparatus according to claim 23, wherein the spacing of the indicators is directly proportional to the spacing of the contacts.

25. Apparatus according to any one of claims 20 to 24 wherein the contacts are evenly spaced apart.

26. Apparatus according to any one of claims 21 to 25, wherein the contacts and indicators are mounted on a substrate.

27. Apparatus according to any one of claims 21 to 26 including means for labelling each of the indicators with a numeral representing the value of the displacement of the electrically conductive member required to actuate that contact.

28. Apparatus according to claim 20, wherein decoding means are coupled to the contacts for providing a digital representation of the displacement of the electrically conductive member on the display means.

29. Apparatus according to any preceding claim, wherein the electrically conductive member is constructed and arranged so that in any position the electrically conductive member engages at least one but not more than two of the contacts.

30. Apparatus according to any preceding claim, including means for adjusting contact friction between the contacts and the electrically conductive member.

31. Apparatus according to claim 30, wherein the contact friction adjusting means comprise means for displacing the electrically conductive member along a line perpendicular to a plane containing the contacts.

32. Apparatus according to any preceding claim, wherein the electrically conductive member and the contacts are made of dissimilar metals.

33. Apparatus according to claim 32, wherein the electrically conductive member is made of a refractory metal and the contacts are made of a noble metal.

34. Apparatus for measuring a force applied to a resilient member substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

35. Apparatus for measuring the displacement of an electrically conductive member substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

36. Any novel feature or combination of features described herein.

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