A/B is the 'mechanical magnification factor' which is determined by the geometry of stage lever **13**, and will be typically of order **10**.

In the example for the sector shown in FIG. **3**, the piezo sector expansion, ΔZ_3 is positive (upwards), so that the rectangular arm of stage lever **13** rotates in the clockwise direction, and ΔX_3 is positive (to the right). Simultaneously, the corresponding piezo of sector **1** contracts, ΔZ_1 is negative (downwards), but the arm still rotates in the clockwise direction, and ΔX_1 is again positive (to the right), which reinforces the displacement of sector **3** to which sector **1** is coupled.

In this way, linear motion in the z-direction is translated to magnified linear motion in the x-direction. Likewise, coupled voltages applied across sectors **2** and **4** generate displacements in the ±y direction independently of the displacement in the x-direction.

The four horizontal wire springs **15** on the stage levers **13** couple the motions in the ±x and ±y directions to stage **14** (see FIG. **4**). The stage **14** is connected via four vertical wire springs **16** to the rigid housing base **10**. The four vertical springs **16** act like the legs of a table and allow for linear motion in the horizontal plane of stage **14**, which is itself connected to the tip or sensor surface **18** via inner piezo tube **17**.

Inner piezoelectric tube **17**, which is not required to be physically sectored but which may be if desired, allows for fine control of tip displacements in the ±z direction independently of the x and y displacements (which are controlled by the main piezo **12**). These normal displacements will in general be small—much smaller than the lateral displacements, so that the inner piezo tube is always operated within its linear region.

The advantages of the structure and operation of the present invention are as follows:

(1) LINEARITY. The present invention allows for generating linear motion along three orthogonal directions (x, y and z) completely independently of each other, but with motion in all three directions available at the same time. Linearity is achieved by (i) decoupling the piezo elements that give rise to each displacement, and (ii) mechanically amplifying the movement in the x and y directions. By magnifying the linear motion of piezo elements mechanically, via stage lever **13**, rather than increasing the voltage beyond the non-linear range, a much higher displacement is achieved while still remaining in the linear region. The 'mechanical magnification factor' A/B can be chosen to be **10** or more by a suitable choice of dimensions for stage lever **13**.

(2) DECOUPLED DISPLACEMENTS IN X, Y, AND Z DIRECTIONS. The independence of the three motions from each other means that more reliable and stable displacements can be applied than is currently possible with existing piezoelectric tubes (cf. FIG. **1**). It also means that fine movements can be generated by applying relatively low voltages to the inner piezo tube **17**. This reduces the problems of drift and creep which arise when piezos are strained beyond their linear region or when elements are mechanically coupled to each other. The separate fine control in the normal, z-direction is particularly useful in many SPM and related devices where one generally needs to independently fine adjust the normal displacement by angstroms without interfering with the 'coarse' lateral displacement in any way, and vice versa.

(3) ISOLATION AND STABILITY. The piezo-mechanical scanner is completely sealed in its housing, thereby allowing for its installation into almost any SPM, SFA or other positioning chamber whose atmosphere (relative humidity, organic vapor contamination) can be kept clean or fully controlled. Since normal displacements are controlled mainly mechanically (the inner piezo tube **17** for fine distance control having relatively thick, robust walls) the new device will have much less hysteresis and drift than scanner heads employing conventional piezo tubes. In addition, the physically sectored main piezo tube **12** (which will be more sensitive to thermal drifts and creep) is isolated from both walls of the scanner, making it particularly well-shielded from extraneous temperature drift, thereby adding to the stability of the tip position.

(4) SIMULTANEOUS OPTICAL IMAGING. The new scanner may be used with an optical microscope for directly visualizing the surfaces during scanning. In addition, with the proposed design, the microscope objective **24** can be placed very close to the surfaces on either the 'tip' or 'sample' sides.

The above disclosure is not intended as limiting. Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the restrictions of the appended claims.

I claim:

1. A piezo-mechanical scanner comprising:

a main piezoelectric tube to generate motion of a probe tip of said scanner along a first axis and a second axis in a first plane, motion along said first axis being independent from motion along said second axis,

a mechanical advantage means that is not part of said main piezoelectric tube, said mechanical advantage means translates vertical expansion and contraction of said main piezoelectric tube generated by voltage differentials within a linear operating range of said main piezoelectric tube into resultant motion of said probe tip; wherein

said resultant motion of said probe tip is also linear, and is non-hysteretic and creep-free.

2. The piezo-mechanical scanner of claim **1** wherein:

said main piezoelectric tube comprises a plurality of sectors, each one of said sectors being physically separated from each of the other sectors so that motion generated by a first pair of opposing sectors along said first axis is not affected by motion simultaneously generated by a second pair of opposing sectors along a second axis.

3. The piezo-mechanical scanner of claim **2** wherein:

said main piezoelectric tube is substantially cylindrical in shape, and said sectors are created by longitudinal slots in walls of said main piezoelectric tube, a lower connecting portion of said walls having conducting material removed in a region corresponding to said longitudinal slots to ensure electrical isolation of said sectors.

4. The piezo-mechanical scanner of claim **1** wherein:

said scanner comprises a second piezoelectric tube that generates motion in a second plane orthogonal to said first plane.

5. A piezo-mechanical scanner comprising:

a main piezoelectric tube to generate motion of a probe tip of said scanner along a first axis and a second axis in a first plane, motion along said first axis being independent from motion along said second axis,