spaced-apart optical fibers **202** can convey light received at the distal end of the optical fibers from the ROI to light detectors (not shown) at a proximal end of the optical fibers (e.g., outside the body of a patient). Piezoceramic tube actuator **206** concentrically surrounds a clad optical fiber **208** that is tapered to a distal end **210**. This tube actuator produces a driving force corresponding to a harmonic of a natural resonant frequency of optical fiber **208** so that the distal end of the optical fiber produces an orbit **212** having an actuation controlled radius. At the distal end of the scanning optical fiber is the optical point source, which can be focused out to an illumination plane (not shown) by adding an imaging lens (not shown). The major advantages of this embodiment over the other embodiments discussed hereinabove are that this embodiment employs a single actuator and a tapered waveguide that provide high resolution, directed illumination, and imaging within a relatively small diameter enclosure.

[**0090**] A series of variable radii circles are produced in a circular scan mode, while in a spiral scan mode, the optical fiber produces a spiral scan in which the radius alternately increases and decreases. In either the circular or spiral scan modes, the distal end of optical fiber **208** scans an ROI to image the region and also renders therapy and/or diagnostic functions over the ROI. The whirling motion of the cantilevered optical fiber is controllably driven larger or smaller in diameter by increasing or decreasing the voltage applied to the four individual quadrants of piezoceramic tube actuator **206**. A "propeller" scan mode **216** is illustrated in **FIG. 5E**. In this scanning mode, the scanning optical fiber moves back and forth along different diameters of a circle, scanning the ROI. The rotation of the linear scan can be generated from the two axis piezoceramic tube actuator or by simply rotating a single-axis actuator about the longitudinal axis of the optical fiber.

[**0091**] To achieve a maximum numbers of pixels across the widest FOV, for imaging, diagnosis, and therapy, a diffraction-limited spot of illumination must be formed by the lens system. Assuming an ideal scanning optical fiber, the spatial resolution of the delivered illumination is limited by the projected optical point source size and the diffraction-limited or aberration-limited performance of the lens system. When an optical system is aberration-limited, the main purpose of a secondary imaging lens or a small lens **228** at the fiber tip in **FIG. 5F** is to reduce optical aberrations and thus to reduce the illumination spot size. In a diffraction-limited optical system, a smaller spot size is achieved with larger lenses or beams of scanned optical illumination. Thus, high-resolution optional designs will use an oversized collimating lens or a ball lens **245** for increasing pixels within a fixed FOV, as shown in **FIG. 5H**. Assuming a diffraction-limited collimation and scan lenses, a maximum number of pixels or display resolution is theoretically possible for an optical fiber scan system that is within about a 1.0 mm diameter enclosure. Note that the lateral vibratory resonance mode depicted in **FIGS. 5F and 5H** satisfies the requirement of high angular deflection at the distal tip without large lateral displacements of the moving waveguide. By scanning in a whirling or propeller motion, this embodiment can provide both high resolution and a wide FOV in an ultrathin single fiber system.

[**0092**] **FIG. 5F** thus illustrates details of a beam scanning embodiment **220**, which is perhaps the most preferred of the embodiments thus far discussed. It will be recalled from **FIG. 5**C, which was discussed above, that use of the ball lens on the distal end of the optical fiber produces a PSF that is consistently small across a wider FOV than the other forms of scanning optical fibers, and thus, has a relatively small spot size **240**, as indicated in **FIG. 5G**. Beam scanning embodiment **220** includes a cylindrical supporting housing **222** in which is disposed a cylindrical actuator **224** of the piezoelectric or piezoceramic type that drives an optical fiber **226** to vibrate in a resonant 2D scanning mode so that the optical fiber bends to form nodes on opposite sides of the nominal longitudinal axis of the device (as discuss further below in regard to the example shown in **FIG. 5H**). A ball lens **228** is affixed to the distal end of optical fiber **226**. Light conveyed through the optical fiber is focused forming a beam **230** by the ball lens and by a lens **238**. Beam **230** describes an angle that is preferably greater than or equal to at least 40° relative to the longitudinal axis of the optical fiber and of cylindrical housing **222**. When scanning, the center of the cantilevered portion of the optical fiber moves back and forth about this axis, as illustrated, while a center of ball lens **228** remains generally stationary due to its inertial mass and the fact that the vibratory node is near the tip at the second node of resonance (see **FIG. 5C**). The length of optical fiber **226** extending distally beyond actuator **224** and the mass of ball lens **228** are selected to ensure that the scanning occurs with this form of motion. Light detectors **232** are disposed around cylindrical actuator **224**, which may be coated with high reflective material (e.g., aluminum) **237** to help channel the backscattered light to the detectors at high efficiencies.

[**0093**] Theoretically, only a single light detector is required to collect the backscattered scanned light, to generate a monochrome or black and white image. A simple method for generating a full-color image is to use three light detectors (as noted above), each covered with a different filter selected for blue, green, or red light transmission. Silicon-based semiconductor photodiodes (such as Si-PIN type) are preferred for visible and near IR light detection because of their high sensitivity, low cost, small size, high speed, and ruggedness. Photodiodes used routinely in the telecommunications industry, such as InGaAs material photodiodes, are preferred for embodiment of the present invention that use IR optical detection. Since the resolution of the integrated optical scanning technique does not depend on size and number of light detectors, all available space at the distal end of the optical fiber assembly can be covered with light detectors for the purpose of increasing and discriminating between signal levels. As will be more apparent from the discussion that follows, the light detectors are preferably provided in stereo-pairs about the optic axis so that topographical features (e.g., shadows) of the ROI can be enhanced and glare from spectral reflections can be diminished. If IR radiation is used in conjunction with visible light, then light detectors of different light-sensitive materials can be used without filters (not shown). An alternative method for separating the spectral response of a light detector that is not filtered requires synchronizing the detector signal in time with an appropriate illumination source having a pulsed output. For example, the same visible light detector can be used without any filters if the RGB laser or other light sources are individually pulsed in rapid time series and in synchronicity with the processing of signals received from the light detectors.