[0094] Leads **234** extend from each of the light detectors to the proximal end of the optical fiber, which is external to the patient's body, to convey the electrical signals from the light detectors to the external instrumentation, as discussed above. Actuator **224** is driven with an electrical signal supplied through leads **236**.

[0095] Further details helping to explain the motion of an optical fiber **244** that is driven into vibration by an actuator such as actuator **224** are shown in **FIG. 5H** for an oversized collimation lens, which provides higher resolution in a relatively small package. Optical fiber **244** is surrounded by cladding **242** and at its distal end, is coupled to ball lens **245** that collimates the light traveling through optical fiber **244**. As noted above, due to its relatively larger mass, ball lens **245** remains substantially stationary, while the center of the cantilevered portion of optical fiber **244** deflects upwardly and then downwardly. Light traveling through optical fiber **244** passes through a center **246** of ball lens **245** as the optical fiber moves between the upper and lower range of the scan as illustrated. Light passing through ball lens **245** exits a scan lens **248** with a collimation diameter of approximately 0.5 mm. At its maximum amplitude of vibration, optical fiber **244** describes an included angle that is approximately 60° around center **246** in ball lens **245**. Thus, the light emitted that travels through scan lens **248** has a relatively small PSF or spot size as it scans an ROI. This oversized ball lens embodiment is described in "Single Fiber Flexible Endoscope: General Design for Small Size, High Resolution, and Wide Field of View," Eric J. Seibel Quinn, Y. J. Smithwick, Chris M. Brown, and Per G. Reinhall, Biomonitoring and Endoscopy Technologies, Proceedings of SPIE, Vol. 4158 (January 2001), the disclosure of which is hereby specifically incorporated herein by reference. The embodiment with a lens at the distal end of the optical fiber can use a gradient index lens, diffractive or optical element, or combination of diffractive and refractive lenses.

[0096] Optical Fiber Systems for Imaging and Spectral or Polarized Light Analysis

[0097] **FIG. 6A** illustrates a system **266** that is used for providing both a pseudo-stereo image of an ROI and for acquiring a spectral image that can be analyzed with a spectrophotometer, in accord with the present invention. In this system, an optical fiber assembly **250** includes an optical fiber **256** that is tapered at its distal end and is surrounded by a piezoelectric actuator **254**. Actuator **254** causes optical fiber **256** to vibrate and scan an ROI, emitting light that passes through lenses **258***a* and **258***b*. Light reflected from the ROI or light otherwise received therefrom (such as phosphorescent or fluorescent emissions) is collected by twelve optical fibers **252** that are arranged in a circumferential array around optical fiber **256**. As illustrated in this exemplary figure, optical fibers **1**, **2**, and **3**, which are collectively referred to by a reference number **260**, are respectively coupled to external RGB imaging detectors corresponding to a left side of the circumferential array. Similarly, optical fibers **7**, **8**, and **9**, which are collectively identified by a reference number **262**, are respectively coupled to a RGB imaging detectors for the right side of the circumferential array. Another set of optical fibers **264** corresponding to optical fibers **4**, **5**, **6**, **10**, **11**, and **12** are coupled to a spectrophotometer **270**. The spectrophotometer is employed for spectral analyses and spectral image acquisition using UV, visible, and/or IR light. Since the RGB detectors for the left and right side of the circumferential array receive light from the ROI at two spaced-apart portions of the array (i.e., the left and right sides), they produce a pseudo-stereo full color image that is readily viewed using an HMD display (not shown).

[0098] Another system **271** in accord with the present invention is illustrated in **FIG. 6B**. In system **271**, an optical fiber bundle **250** is arrayed concentrically around optical fiber **256** and is coupled to a spectrophotometer **272** that uses a prism/grating and an array of spectral detectors to measure the spectra of light received from the ROI. The output signals from spectrophotometer **272** are input to a computer workstation and spectrum analyzer **274**, which produces a full color image on an RGB video display **276**. Also, computer workstation and spectrum analyzer **274** is connected to a spectral display **278** that can be employed for spectral analysis and diagnoses of the ROI. An integrated display of both a standard endoscopic image and spectral mapping, and any additional diagnostic/screening information can be shown together in a multitude of modalities **279**, such as text, pseudo-color overlays, audio enhancement, stereoscopic viewing, etc. As in system **266**, a portion of the optical fiber system that is disposed within a patient's body is indicated within a dash line rectangle.

[0099] To control optical fiber scanning, additional light detectors and emitters can be employed adjacent (along or adjacent) to the scanning optical fiber to detect the motion and position (or frequency and speed) of the optical fiber distal tip over time. As shown in **FIG. 6**A, the increase in light leakage incurred when the optical fiber makes a sharper bend can be detected using passive photon sensors **255**.

[0100] In **FIG. 6**B, an IR emitter **281** and an IR detector **283** are located on opposite sides of the optical fiber scanner and use the change in optical light transmission caused by the changing position of the vibrating tapered distal end or tip of the optical fiber **256** to control the tip position. In **FIG. 6**C, emitter **281** and detector **283** are disposed adjacent (alongside) each other and are used to detect a change of reflected light. These methods are routinely used in the optical fiber sensing industry (although not for controlling scanning), and emitters and detectors of separate, non-imaging wavelengths are especially useful in controlling scanning probe microscopes. The signals from these sensors, which can also be piezo-electrically, magnetically, or electrostatically based, are used in feedback controllers that increase scanning rates, while reducing scanner distortion.

[0101] Spatial resolution of the scanning optical fiber system that produces directed illumination for therapy depends on the number of distinguishable spots of light that can be projected onto the illumination image plane. The resolution depends on the minimum spot size while FOV depends on the maximum scan angle (total number of distinguishable spots). When acquiring images, spatial resolution also depends on the bandwidth of the photon detectors, (assuming sufficient signal-to-noise ratio), and the total number of pixels available in the display system. By operating within bandwidth limitations of the scanning system components, the resolution and FOV can be changed dynamically, enabling features such as zooming or dynamic magnification of the ROI. In many applications, both the ROI and the single optical fiber system are stationary (other than the scanning distal end of the optical fiber), reducing