as discussed above. In addition to the structures of arthropods being susceptible to the effects of acoustic and/or acousto-EM energy, they may also function as piezoelectric structures.

The present invention takes advantage of composing parts of the structures or the entire organism of arthropods for the purpose of identification and/or physical disruption of the arthropod structure using acoustic and/or acousto-EM energy at specific resonant frequencies and patterns, and using them as piezoelectric, intrinsic dissipation, acoustoelectric, and or magnetoacoustic structures, either alone or in combination with a resonant acoustic field.

The methods of the present invention allow the resonant acoustic frequencies of arthropods to be determined and utilized, with devices of appropriate frequency similar to those previously described. For example, researchers capturing and cataloging thousands of insects and other arthropods in an effort to identify the source of an infectious agent such as Ebola, a hemorrhagic fever, or encephalitis, could use an apparatus such as that shown in Figure 27. The portion of the acoustic spectrum containing the resonant frequencies of the infectious agent in question is scanned. Known resonant frequencies of arthropod materials are fed into the negative lead of the spectrum analyzer and cancel out their component resonant frequencies in the positive lead sample scan. The remaining frequencies are analyzed for the resonant acoustic signature of the offending microorganism. This provides a means to readily identify the host reservoir of an infectious agent without the need for expensive and time-consuming studies.

The present invention also provides a means to kill infecting arthropods on a large organism, for example fleas on a dog or human, as shown in Figure 28. High kHz to very low MHz transducers are fitted onto a bathtub-type apparatus. The resonant acoustic frequencies for fleas are delivered through the water to the surface of the animal. High power outputs for deep tissue penetration are not required, as the infectious arthropods are restricted to the surface or outer-most layers of the dog or human. The same method can also be used, for example, to de-flea or de-louse bedding and linens in a washing machine.

Example 4

Augmentation of Bone Growth

Bone demineralization in humans is a significant health care problem. Thousands of elderly people sustain fractures of the hip, leg, or arm due to this bone demineralization (osteoporosis). These injuries cost the American health care system billions of dollars a year, for treatment, surgery, and rehabilitation after the injury. In addition, the overall health status of the victims is impaired, and they suffer loss of time and quality of life due to these fractures. Other conditions which contribute to bone matrix loss include weightlessness (i.e., in outer space) and prolonged confinement to bed. People in certain occupations may benefit from an increase in the normal bone density. Examples include professional athletes, military personnel, and jobs requiring exposure to increased atmospheric pressures (i.e., undersea diving).

Living bone is organized in a calcium based crystalline structure of hydroxyapatite, doped with copper, and embedded in collagen fibers. The application of force to the collagen fibers in the bony matrix, through mechanical pressure or gravitational fields, stimulates the piezoelectric effect and flow of ions via fluid channels in bone. This small electrical charge, in turn, acts as a signal to the body's osteoblasts to deposit more hydroxyapatite. As the hydroxyapatite density increases, the bone becomes stronger. Thus, bones maintain their normal structure and density in response to pressures and forces encountered in normal daily activities, via a piezoelectric effect.

With aging, normal copper doping is lost, and the piezoelectric effect diminished. The result is that hydroxyapatite density is not maintained, and the elderly suffer from osteoporosis and bone fractures. The same thing occurs in the absence of normal activity (weightlessness and confinement to bed), with subsequent absence of the normal piezoelectric effect and ionic current flows.

Bone is a crystalline piezoelectric structure and as such is subject to the vibratory effects of acoustic energy. The operative process behind normal physiologic bone density maintenance is the generation of hydroxyapatite molecular movement within collagen fibers, compressed by macro-pressures. These occur from daily activities, and stimulate the piezoelectric and subsequent bone building osteoblastic effects.

This molecular movement and the collagen fiber compression can also be generated from micro-pressures within the semiconductor matrix of bone. Thus understood, micro-pressures can be produced by acoustic energy waves.

In addition to the piezoelectric effect, since bone is a piezoelectric and semiconductor structure, it will exhibit the acoustoelectric, intrinsic dissipation and magnetoacoustic effects. Conditions with diminished bone semiconductor function (osteoporosis) and/or decreased macro-pressures(weightlessness and bed confinement) can be effectively treated through application of acoustic micro-pressures which generate a biological piezoelectric effect, and/or also via acoustic resonance, intrinsic dissipation, acoustoelectric and magnetoacoustic effects.

Prior literature describes the use of non-resonant ultrasound to speed the rate of healing of bone fractures, however, the mechanism causes gross disruption of the bone tissues, which in turn damages the microscopic capillary bed in bone, with leakage of serum and cells into the bony matrix, and with subsequent bone mineralization. The literature also describes attempts to use ultrasound to detect resonant frequencies of the structure of entire bones (femur and ulna) to diagnose a bone as normal or defective. However, the use of acoustics and/or acousto-EM resonant frequencies to activate the piezoelectric effect is not described. No consideration is given in the prior art to using bone as a living transducer for the piezoelectric, intrinsic dissipation, acoustoelectric, and magnetoacoustic effects, either alone or in combination with a resonant acoustic field.

The present invention takes advantage of the crystalline, piezoelectric structure of bone for the purpose of augmenting bone growth and calcification. The invention has the potential to significantly reduce the number and severity of bone fractures suffered by victims of osteoporosis. The invention has the potential to speed the healing process of fractures. Other conditions which contribute to bone matrix loss, such as weightlessness (i.e., in outer space), or prolonged confinement to bed, would also benefit from the invention. The invention has the potential to aid people in occupations which would benefit from an increase in their bone density (athletes, military personnel, and jobs requiring exposure to increased atmospheric pressures such as undersea diving.) The invention also has potential veterinary applications. Unlike prior treatment using ultrasound, the present invention uses resonant acoustic and/or acousto-EM frequencies of bone to stimulate at least the piezoelectric effect for augmentation of bone growth without affecting neighboring tissue.

The methods of the present invention provide a means to augment the growth and maintenance of bone using resonant acoustic and/or resonant acousto-EM energy. For example, as shown in Figure 29, a sheet of piezoelectric material is fitted into a shower mat device. When an elderly person, prone to osteoporosis, showers the mat is activated. Water in the shower acts as a conductive medium and primary or harmonic resonant frequencies are delivered through the soles of the feet, along the lines of force, up into the legs and hips. The piezoelectric effect in bone is activated and bone density is increased.

The present invention provides a method to augment the growth and maintenance of bone using resonant acoustic and/or acousto-EM energy, for example, as also shown in Figure 30. The sleeping/tether bags used by astronauts during conditions of weightlessness are fitted with EM radiation transmitters in the foot of the bags. The bags are made of EM absorptive materials. The tethers that anchor the sleeping bags to the space vessel include the cables to connect the antennas to signal generators in the space craft. While sleeping, the bone maintenance devices in the sleeping bag are activated, delivering EM radiation to the astronauts at a resonant frequency that activates the piezoelectric effect in bone, and thus, maintains their normal body density. Extraneous EM radiation which might interfere with other equipment on board is blocked by the EM absorptive materials in the sleeping bags.

Example 5

Disruption and Detection of Benign or Malignant Tissues or Masses

There are a wide variety of tissue masses, both benign and malignant, which afflict humans and animals. Many tissue masses are encapsulated or are contained within a restricted area in the body. Nearly all benign tumors grow and expand slowly, developing a fibrous capsule, and producing a discrete, readily palpable and easily movable mass. Examples of benign tumors include fibroma, lipoma, chondroma, osteoma, hemangioma, lymphangioma, meningioma, leiomyoma, adenoma, papilloma, polyps, condyloma, fibroadenoma, and rhabdomyoma. Most malignant tumors are invasive and metastasize, however, notable exceptions are gliomas and basal cell carcinomas. Other tissue masses causing disease include emboli, thrombi, abscesses, stones, and foreign bodies.

By virtue of having a defined, discrete structure, many tissue masses are susceptible to the disrupting effects of acoustic energy at resonant frequencies matched to their size and shape. Prior art contains many applications for the use of acoustics at non-resonant frequencies to detect and even disrupt tissue masses, but to date detection of tissue masses via resonant acoustic energy and disruption of tissue masses via acoustic energy at resonant frequencies has not been disclosed.

In addition to tissue masses being susceptible to detection and disruption by resonant acoustic frequencies matched to their shape and size, the components comprising the tissue mass itself (cell types, crystalline proteins, etc.) also have unique resonant frequencies susceptible to detection and disruption. At lower power inputs, certain tissues or masses can be augmented in growth or metabolism, providing a supplemental technique for tissue culturing, regeneration, and growth.

Depending on their structure, certain tissue masses or types may also exhibit resonant acousto-EM effects as well as functioning as piezoelectric, intrinsic dissipation, acoustoelectric, and/or magnetoacoustic structures.

The present invention takes advantage of the discrete shape, size, and composition of numerous benign and malignant tissues and masses to cause the identification, augmentation, detection, and/or disruption of those structures using acoustic and/or electromagnetic energy at specific resonant frequencies. Unlike prior treatments using ultrasound, the present invention uses specific resonant acoustic and/or electromagnetic frequencies, which can be used to treat a multilayer organism by targeting a specific structure therein. It combines the known tumor/mass detection abilities of acoustic energy (diagnostic ultrasound) with the disruptive characteristics of acoustic and/or electromagnetic energy at resonant frequencies. The invention also has the potential to augment the growth and function of various tissues and masses, where desirable.

The present invention provides a means to detect and disrupt benign or malignant tissues and/or tissue masses using resonant acoustic and/or acousto-EM energy. For example, as shown in Figure 31, an acoustic transducer designed with standard echo-reflective capabilities is used to determine the size and dimensions of a tissue mass. Based on the calculated resonant frequencies, a range is scanned to determine the precise resonant frequencies. Then one or more of those frequencies are delivered to the mass, disrupting its