A security system is described wherein radio frequency or microwave radiation of high intensity is used to disable or trigger detonation of explosive devices in a controlled environment. The electromagnetic radiation transmitted from a generator is imposed on a circuit creating a voltage spike in the circuit of greater magnitude than the components in the circuit are capable of handling, resulting in damage to active or passive circuit components, or to cause the circuit to fire in a controlled environment. The invention acts to disable or cause premature detonation of concealed devices.
ELECTROMAGNETIC SECURITY SYSTEM

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to security devices used to check baggage or shipping containers. Presently used devices used for inspection include x-ray imaging devices used to screen baggage in airports. The invention provides a security function by using electromagnetic radiation to disrupt the performance of electronic devices or to make them detonate prematurely in a controlled area.

[0002] In providing air travel security, it is desirable to screen baggage, cargo, and any other items that are carried in aircraft. Current x-ray screening techniques are based on irradiation of cargo and baggage with x-rays, which pass through materials of low density and are absorbed by materials of high density, creating an image of the cargo that reflects density and atomic number differences. Operators are trained to read x-ray images which indicate high density objects, metals, and suspicious shapes, but, with the wide range of explosive devices available today, error in interpreting the x-ray can result in failure to detect an explosive device, which has disastrous safety consequences. In addition, x-ray scanning is slow and tedious, as only a thin beam of x-rays is used to scan the cargo in creation of the x-ray image. As a consequence, at present, air cargo is only checked at random; explosive devices can be easily concealed within a closed container to destroy a plane in flight. Since methods for explosive screening are time consuming, labor intensive, and not specific to explosives, only a small fraction of the total volume of cargo that is shipped on airplanes is actually screened for explosive devices, which constitutes a serious deficiency in airplane security. There are other applications of the invention where a recipient of cargo, baggage, or other items desires that such items be screened for the presence of explosive devices; this can include virtually any industry that handles or receives packaged items such as the postal service, Federal Express, secure areas, military bases, or government entities that may be targets.

[0003] Electromagnetic radiation (EM) of high intensity is capable of destroying electronic and electrical components. An example of an application of intense EM waves pertinent to the present invention is the use of high power microwave and radio frequency (RF) electronic warfare weaponry employed by the U.S. Department of Defense to destroy enemy communications, weapons systems, and command centers. Such weapons use various methods of generating high powered EM waves, such as explosively pumped flux compression generators, in order to damage or destroy targeted electronic equipment. Typically, such munitions can only be used once, generating high powered EM waves, usually microwaves, which induce voltage spikes in targeted electronics similar to a lightning strike. The magnitudes of the induced voltages are far greater than the maximum rated voltages of the electronics resulting in failure or damage to individual transistors, capacitors, or other components integral to the operation of the device. With reference to experiments with high power EM waves, analytical analysis and harmonic balanced nonlinear simulations suggest that device destruction be due to large drain-gate voltage swing that exceeded the breakdown voltage under high RF drives. Results of high powered microwave damage to specific electronic components have been observed and recorded in other experiments.

[0004] Aside from the operation of electromagnetic weapons systems, high power continuous or pulsed RF or microwave radiation from devices that are not weapons systems can cause damage to electronics. The action of such a RF or microwave generator is to produce a traveling EM wave that induces a voltage on any conductor that intercepts the wave. Any conductor acts as a receiving antenna converting the EM wave into a voltage.

[0005] An antenna, in its simplest form, that generates microwaves coupled to an axial virctor high power microwave source would be comprised of a cylindrical waveguide tapered outward into a conical horn structure, a cathode, and an anode. High velocity electrons emitted from the cathode and not flowing to the anode create and area known as a virtual cathode. The electrons in the virtual cathode area oscillate at microwave frequencies through the conical waveguide, which can be tuned to a resonant frequency yielding high power microwaves. Power levels achieved in virctor experiments range from 170 kiloWatts to 40 GigaWatts. Furthermore, the directivity of high power microwaves has been studied and the output from an axially extracted virctor has been found to be within 20° of 0° vertical and horizontal reference planes, which indicates applications to directional scanning, pertinent to the invention at hand.

[0006] The voltage spikes from the EM waves may disable electronic components in several ways. First, active semiconductor devices, including bipolar and field effect transistors, diodes, and silicon controlled rectifiers, have maximum voltage ratings which cannot be exceeded without destroying or impairing the function of the device. The failure of a semiconductor device through this mechanism is sometimes referred to as "junction breakdown". Transistors and other active semiconductors are sensitive to excessive reverse biasing, which is also capable of destroying the device. The imposition of a large voltage transient by an EM wave can easily destroy active devices through the mechanism of exceeding the voltage specifications of the device. A second mechanism of disabling electronic circuits is destruction of passive electronic devices such as capacitors, resistors, and inductors through inducing a voltage larger than the breakdown voltage of the device, which can create a permanent conductive channel, defeating the purpose of the device. The breakdown of dielectrics along the surface of an insulator is referred to as "flash-over". Melting and shorting out of components can take place as a result of imposition of high intensity EM waves as well, both of which result in the malfunction of the electronic device as a whole. Microwaves can enter a shielded electronic device in what is referred to here as, the "front door" or the "back door". Entering through the front door means that the EM waves induce voltage spikes in the circuit by means of an antenna, cable, port, or power supply main originally designed for communication, transmission of signals, or electrical contact with components outside the shielding. The action of the high power EM waves in the case of front door operation can take place through destruction of the function of the first stages of amplification of the device or with any component of the device that is wired to the antenna, cable, port or power supply main capable of
generating an electromotive potential in response to irradia-
tion with EM waves. Entering through the “back door” means that the EM waves induce voltage spikes by entering the enclosure through cracks, screws, fittings, loose wires, etc., not specifically intended for communication, signal transmission, conveyance of power to elements outside the enclosure. Even when a device is shielded, any imperfections in the shielding can render the device susceptible to the action of EM waves.

BRIEF SUMMARY OF THE INVENTION

[0007] In this regard, the present invention provides an apparatus designed to disable, destroy, or detonate any electronically or electrically activated explosive device inside cargo, containers, or baggage intended for shipment, opening or inspection. An EM wave generator such as a magnetron, klystron, gyrotron, vircator, pasotron or similar high intensity EM wave generator is placed in proximity of the items to be inspected. Details of vircator (virtual cathode oscillator) and pasotron operation have been documented [3, 4]. It is anticipated that the items to be scanned would be moved on a conveyor to facilitate the inspection process. Since the mechanism of action of the apparatus is either to disable, destroy, or to activate the explosive device, the generator, a portion of the conveyor, and any activation devices used in conjunction with the apparatus would ordinarily be enclosed within protective shielding to prevent damage to the expensive components of the EM wave generator or nearby personnel in the event that the induced voltages spike sets off the explosive device. An embodiment of the device that is automated would have the EM wave generator activated whenever a cargo or baggage item passed the transmitter.

[0008] The operation of the invention is straightforward. Baggage and cargo or any item to be inspected is placed on the conveyor belt of the invention at some point before it is handled, opened, or loaded for shipment. The cargo or baggage passes into proximity to the transmitter and triggers the sensor, which, in turn, activates the RF or microwave generator irradiating the cargo for a pre-selected time. The RF or microwaves act to either destroy the electronics or wiring of the device so that it becomes inoperable and therefore safe to ship or handle, or they act to detonate the device on the conveyor belt, eliminating the possibility of an explosion during transportation. Microwaves and RF are typically transmitted by a number of materials such as plastics, cloth, wood, leather, resulting in little or no heating so that the only interaction is with metallic objects that act as receiving antennas. Many metal objects will pick up the radiation and have voltages induced in them, but no significant damage is expected. It is the electronic components that are uniquely sensitive to imposition of voltage spikes.

[0009] It is an object of the invention to provide a means of protection for human life and property through either destruction of the electronics or electrical components of an explosive device, or through deliberate detonation of the explosive device in a safe area instead where it was intended for detonation.

[0010] It is anticipated that cargo would have to be specially marked if it contained electronics, so that it could be searched by alternate methods, manually, or by the current x-ray methods. The invention, to a first approximation, is safe to humans, as human flesh is non-conductive; however, the heating effects of some frequencies is well-known so that the device would normally be expected to be shielded to prevent exposure to personnel. The device provides a much faster and lower cost method of scanning cargo and baggage than present methods of scanning, as a human operator is not required as an integral part of the operation of the invention. The invention provides a dramatic reduction in searching time relative to existing screening methods, and permits a significant increase in the total volume of cargo scanned for malicious devices.

[0011] Other objects, features and advantages of the invention shall become apparent as the description thereof proceeds when considered in connection with the accompanying illustrative drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the drawings which illustrate the best mode presently contemplated for carrying out the present invention:

[0013] FIG. 1 is a schematic diagram of the electromagnetic security apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Referring now to the drawing, the elements comprising a preferred embodiment of the electromagnetic security system of the present invention are shown schematically in FIG. 1. In reference to FIG. 1, in a preferred embodiment of the invention, the apparatus consists of a unit to generate high power RF or microwave radiation 1, a conveyor belt 2 for moving the objects to be inspected into the proximity of the EM wave generator, a protective enclosure 3 made of metal or metal screen, to confine the EM waves to the interior of the enclosure and shield personnel from the EM waves. A sensor 4 indicates when the position of the baggage or shipping container is within range of the transmitted radiation so that the radiation can be switched on. The sensor can be any of a mechanical switch, a light source and detector, acoustic source and detector or even an operator activated switch that senses the correct position of the bag, cargo, or item to be inspected 5 relative to the transmitter of the EM radiation. On receipt of a signal from the sensor, the EM wave generator is actuated to irradiate the object on the conveyor belt. It is anticipated that since one outcome of the use of the invention is to detonate the explosive device, that appropriate barriers would be built around the area of the transmitter to provide safety for nearby personnel in the event of an explosion.

[0015] In one embodiment of the invention a portable RF or microwave generator is used in environments where a permanent installation is not warranted, or where a spot
inspection is desired. The principle of operation of the portable invention is that same irrespective of whether it is fixed or portable. The shielding and method of transfer of the item to be searched is configured according to operator preference.

[0016] While there is shown and described herein certain specific structure embodying the invention, it will be manifest to those skilled in the art that various modifications and rearrangements of the parts may be made without departing from the spirit and scope of the underlying inventive concept and that the same is not limited to the particular forms herein shown and described except insofar as indicated by the scope of the appended claims.

What is claimed:
1. A method for destroying or detonating electrical explosive devices hidden in objects being shipped or inspected, the method comprising:
   placing said objects onto a transport device;
   operating said transport device to move said object into a contained environment; and
   applying high levels of electromagnetic energy to said objects, wherein said electromagnetic energy interrupts circuitry within said electrical explosive device to destroy or detonate said device.
2. The method of claim 1, wherein said electromagnetic energy is high power radio frequency radiation.
3. The method of claim 1, wherein said electromagnetic energy is microwave radiation.
4. The method of claim 1, wherein, said transport device is a conveyor belt.
5. The method of claim 1, further comprising:
   detecting the position of said object within said contained environment before applying said electromagnetic energy.
6. The method of claim 1, wherein said step of applying electromagnetic energy includes applying said electromagnetic energy using a portable electromagnetic energy generator.
7. A device for destroying or detonating electrical explosive devices hidden in objects being shipped or inspected, the device comprising:
   a containment area;
   a transport device extending through said containment area, said transport device for transporting said objects into said containment area; and
   means for applying high levels of electromagnetic energy to said objects when said objects are within said containment area, wherein said electromagnetic energy interrupts circuitry within said electrical explosive device to destroy or detonate said device.
8. The device of claim 7, wherein said electromagnetic energy is high power radio frequency radiation.
9. The device of claim 7, wherein said electromagnetic energy is microwave radiation.
10. The device of claim 7, wherein said transport device is a conveyor belt.
11. The device of claim 7, further comprising:
   means for detecting the position of said object within said contained environment before applying said electromagnetic energy.
12. The device of claim 7, wherein said means for applying electromagnetic energy is a portable electromagnetic energy generator.