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United
Amlung

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[54] FIELD DISTURBANCE TYPE MOTION DETECTION SYSTEM

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[52] **U.S. Cl.** ..... **340/258 A;** 325/19; 325/119; 343/795; 343/908

[51] **Int. Cl.²** **G08B 13/18**

[58] **Field of Search** ..... 340/258 A, 258 B; 343/5 PD, 7.7, 100 AM, 818, 908, 702, 795; 325/19, 119, 352

[56] **References Cited**

UNITED STATES PATENTS

2,650,304	8/1953	Schlesinger	343/795
2,989,745	6/1961	Carroll	325/19
3,691,556	9/1972	Bloice	340/258 A
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Primary Examiner—Glen R. Swann, III
Attorney, Agent, or Firm—Brady, O'Boyle & Gates

[57] **ABSTRACT**

A field disturbance proximity motion sensor apparatus includes a printed circuit board mounted in a plastic housing one-quarter wavelength from a metal backplate which serves as a reflector as well as providing antenna gain for a printed circuit half-wave dipole antenna fabricated on the printed circuit board. A single transistor oscillator/detector circuit is fabricated on the printed circuit board and forms a transceiver which is located adjacent to and coupled to the dipole antenna. Collector current change of the oscillator/detector transistor is sensed in response to any field disturbance whereupon an audio signal is produced which is amplified, filtered and fed to a comparator whose output activates an instrusion alarm device. All of the circuitry is mounted on the printed circuit board containing the antenna.

10 Claims, 5 Drawing Figures

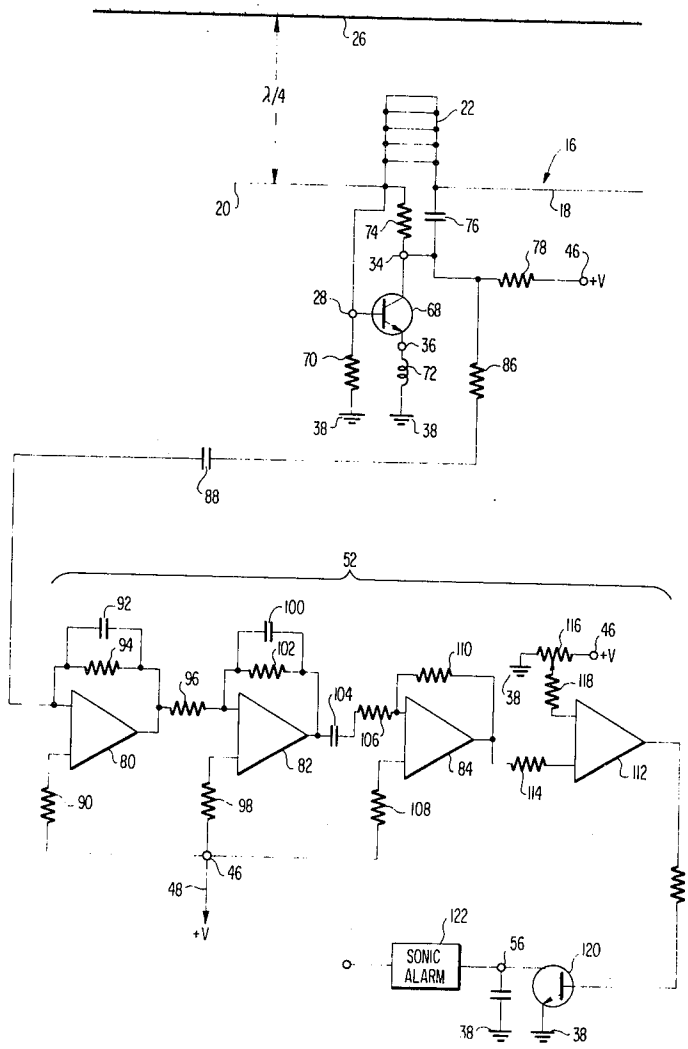


FIG. 1

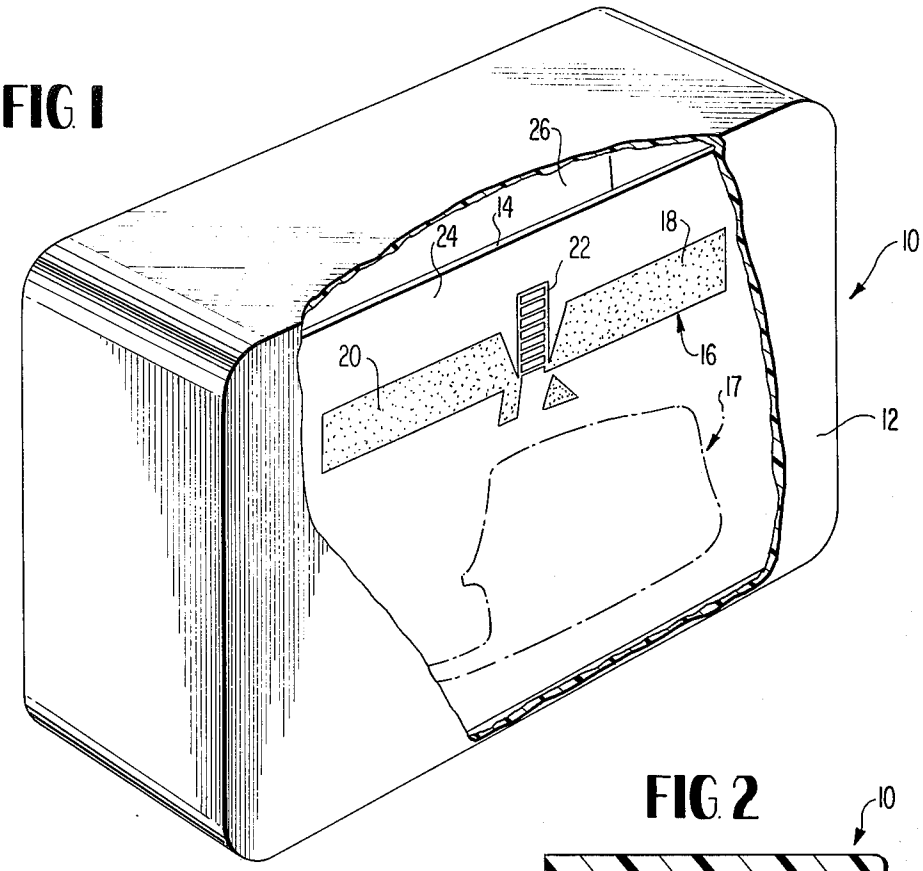


FIG. 2

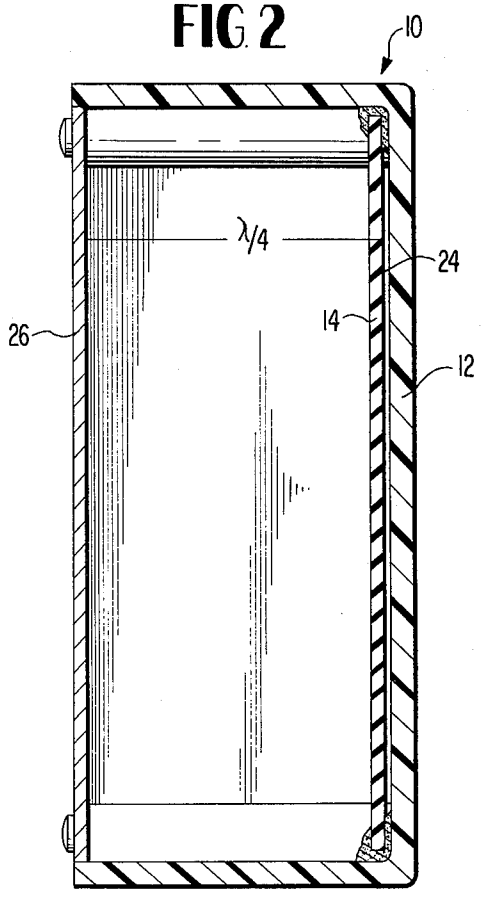
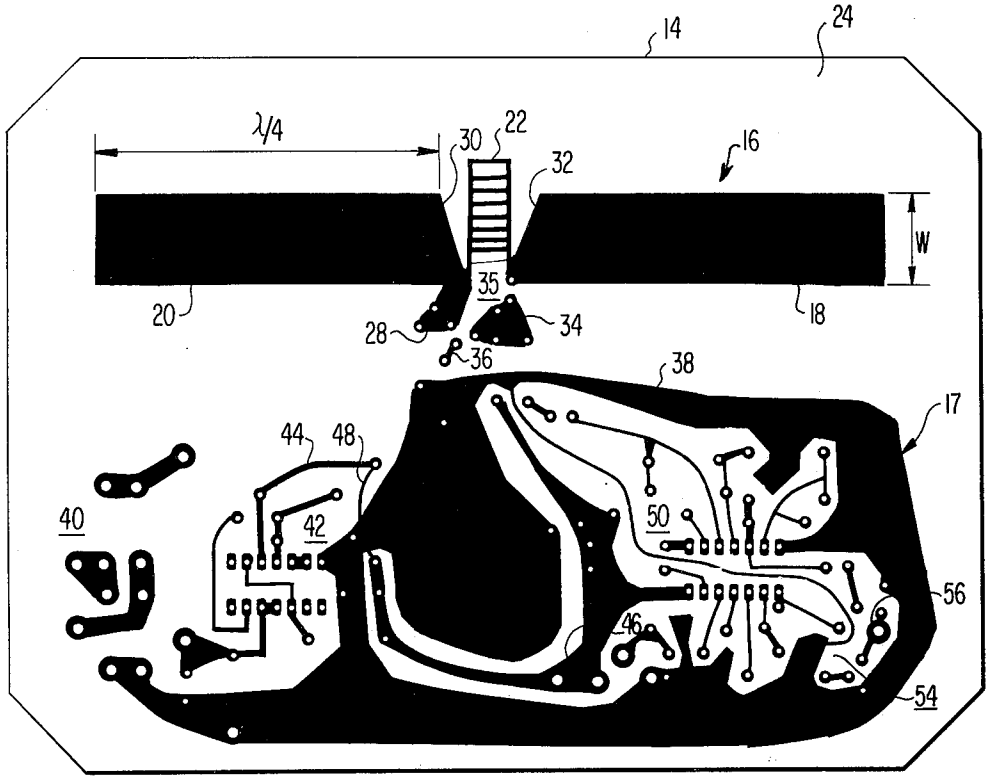


FIG. 3


14
24
λ/4
30
22
32
16
W
35
20
28
34
36
18
38
17
44
48
40
42
50
56
46
54

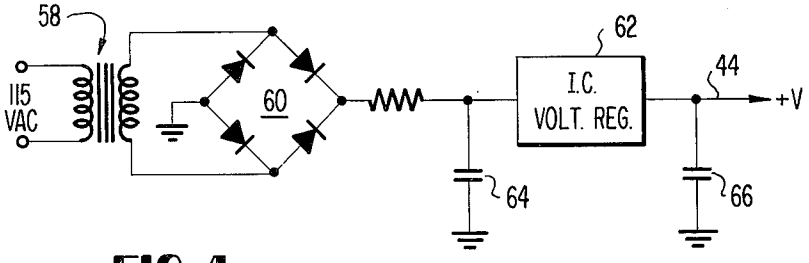

58
115
VAC
60
62
I.C.
VOLT. REG.
44
+V
64
66

FIG. 4

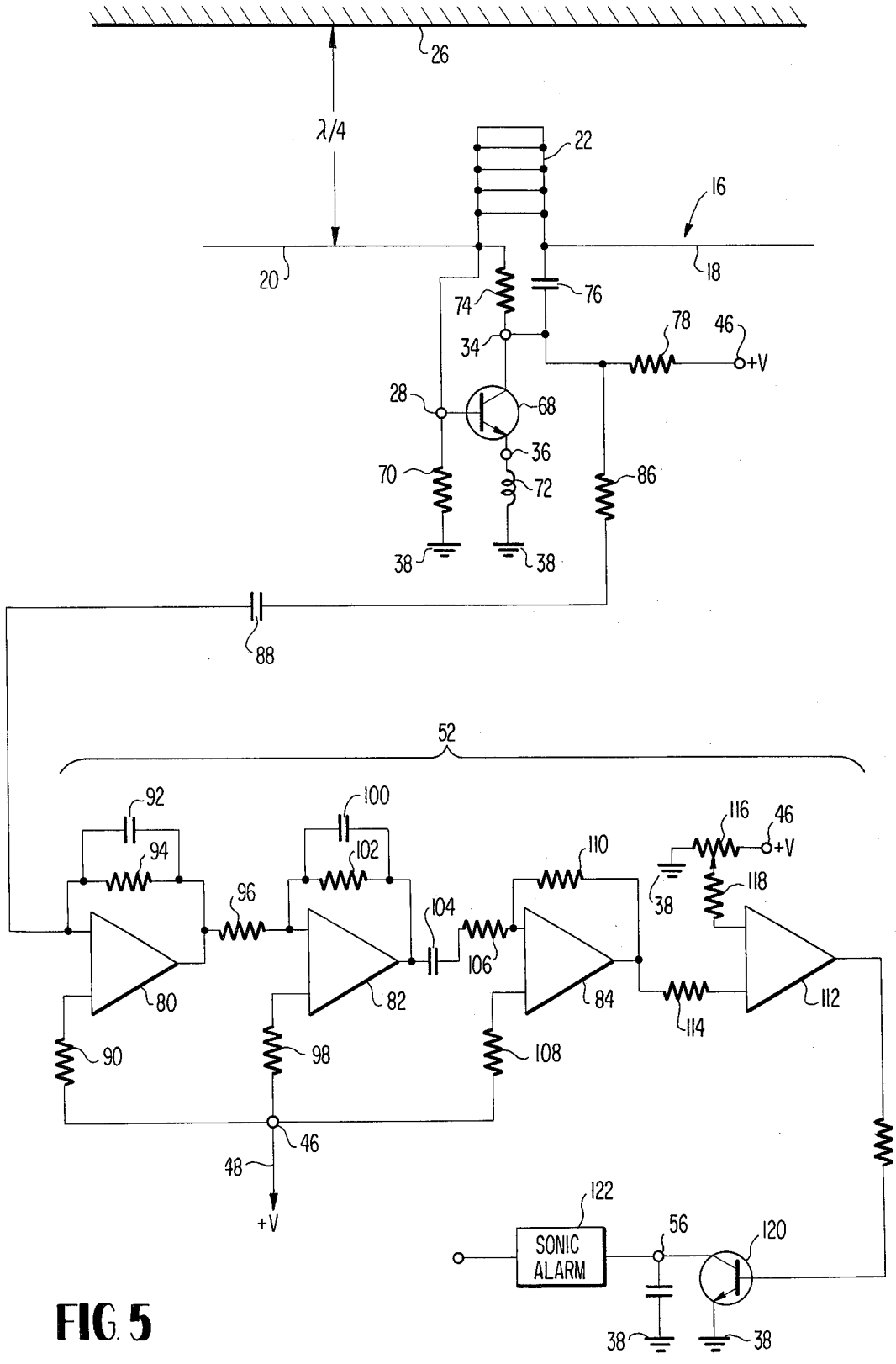

26
λ/4
22
16
20
18
74
76
78
46
34
+V
28
68
36
70
72
86
38
38
88
52
92
100
116
46
94
102
110
+V
96
104
118
38
106
80
82
84
112
90
98
108
114
46
48
+V
122
SONIC ALARM
56
120
38
38

FIG. 5

FIELD DISTURBANCE TYPE MOTION DETECTION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed generally to proximity or motion detection systems and more particularly to the class including field disturbance devices which generate a directional antenna pattern around an area to be monitored and accordingly generate a signal in response to any change in the field due to motion of an object or person in the area.

2. Description of the Prior Art

Motion detection or intruder alarm systems are well known in the art. Generally these systems may be classified into two classes, one of which includes means which operate on the principle of the Doppler effect and the other includes means which operate on the disturbed field principle.

Examples of Doppler type systems of which the applicant is aware are disclosed in: U.S. Pat. 3,813,699, L. T. Saunders, May 28, 1974; U.S. Pat. 3,665,448, H. A. McGlinchey, et al., May 23, 1972; and U.S. Pat. 3,376,507, A. H. McEuen, et al., Apr. 2, 1968. Examples of field disturbance type systems of which the applicant is aware is shown in: U.S. Pat. 3,839,709, K. Sugiura, Oct. 1, 1974; U.S. Pat. 3,747,012, R. Buck, July 17, 1973; and U.S. Pat. 3,483,437, J. J. Coyne, Dec. 9, 1969.

Additionally, such systems require some type of antenna as utilized in combination with electronic circuitry for radiating waves of radio frequency energy through the space under surveillance. One such antenna which is adapted to be utilized with electronic detection systems is disclosed in U.S. Pat. 3,239,838, K. S. Kelleher, Mar. 8, 1966. Other known antenna structures are disclosed, for example, in U.S. Pat. 2,990,574, J. R. McDougal, June 27, 1961; U.S. Pat. 2,724,772, D. E. Bridges et al., Nov. 22, 1955; U.S. Pat. 2,492,358, T. H. Clark, Dec. 27, 1949; and finally U.S. Pat. 2,418,084, B. E. Montgomery, Mar. 25, 1947.

SUMMARY

Briefly, the subject invention is directed to an improved field disturbance type of proximity sensing system comprised of a printed circuit half-wave dipole antenna coupled across the base-collector junction of a single transistor oscillator/detector which operates as a transceiver. Both the antenna and transceiver circuitry as well as a bandpass filter-amplifier and comparator circuit are incorporated on a printed circuit board which is mounted immediately behind the front face of a plastic housing which has a metal backplate secured thereto a quarter wavelength away from the printed circuit board including the antenna. The base-collector connection of the transistor to the antenna results in feedback through the antenna such that any change in the radiated field is detected as a change in the transistor's collector current. A signal of audio frequency is thus provided and is fed to the bandpass filter-amplifier which provides a gain in the order of 2×10^4. The output of the amplifier is fed to one input of a comparator circuit having a reference level signal applied to the other input. The output of the comparator is coupled to an output transistor which operates as a DC switch to control the operation of a sonic alarm device or relay which is adapted to control other external circuitry.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspectivve view of the plastic housing for the subject invention, being partially cut away to illustrate the physical relationship of a printed circuit board located immediately behind the front face thereof;

FIG. 2 is a central vertical cross-section of the arrangement shown in FIG. 1;

FIG. 3 is illustrative of the metallization layout fabricated on the printed circuit board shown in FIGS. 1 and 2;

FIG. 4 is an electrical schematic diagram illustrative of the electrical power supply circuitry and voltage regulator located on the printed circuit board for powering the subject invention; and

FIG. 5 is an electrical schematic diagram illustrative of the preferred embodiment of the subject invention also located on the printed circuit board.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and more particularly to FIGS. 1 and 2, reference numeral 10 denotes a generally rectangular box-like housing made of plastic or the like, so that radio frequency electromagnetic waves pass therethrough without appreciable attenuation. Immediately behind the front face **12** of the housing **10**, is affixed a substantially flat printed circuit board **14** well known in the art, upon which is mounted the required electrical circuit components, forming the subject invention. One of the components comprises a printed circuit half-wave dipole antenna **16** adapted for operation in the UHF range and more particularly at a frequency of 915± 5MHz (megaHertz). The antenna **16** is comprised of two generally trapezoidal printed circuit elements (FIG. 1) **18** and **20** having a small spacing therebetween. A printed circuit ladderlike structure **22** bridges the elements in the spacing for providing tuning i.e. feedback control. The printed circuit elements **18, 20** and **22** are fabricated in a common plane on the front face **24** of the printed circuit board **14.** A metal backplate **26** is adapted to be fastened to the housing **10** such that it is substantially parallel to the printed circuit board **14** containing the antenna **16,** being separated therefrom by one-fourth wavelength. The metal backplate **26** serves as a reflector for the antenna **16** for providing a directional radiated antenna pattern as well as providing an antenna gain of 3db (decibels) when utilized in combination with the circuitry to be described.

The antenna **16** is shown in greater detail in FIG. **3.** The elements **18** and **20** each have the same mean length ($\frac{1}{4}\lambda$) and width W (for providing a predetermined antenna impedance) and are substantially identical with the exception that element **20** additionally includes an appendage or tab **28,** at the lower edge which is closer to element **18** and which includes the junction of the tuning structure **22.** The element **20** also includes an inclined inner side portion **30** which diverges away from a like opposing side portion **32** of the element **18.** Adjacent the tab **28** is a triangular shaped printed circuit land portion **34** which has an apex directed to the lower corner of the element **18** to which the tuning structure **22** is attached. The tab **28** and the land **34** are adapted to accommodate the connection of the base and collector leads, respectively, of a transistor, not shown, at location **35** whose emitter is

connected to the printed circuit line element **36** so as to be positioned as closely as possible to the antenna **16** for operation as a single transistor oscillator/detector circuit of a transceiver.

Adjacent the land **34** and the printed circuit element **36** is a relatively large encircling printed circuit area of metallization **38,** which is adapted to act as a point of common reference potential, commonly referred to as "ground". The location **40** of the printed circuit board **14** is adapted to accommodate circuit means shown in FIG. **4** for providing a suitable DC power supply potential from a 115 volt AC line source. The location **42,** adjacent location **40,** is adapted to accommodate solid state voltage regulator means also shown in FIG. **4** for providing a regulated DC supply potential +V at the metallization element **44** which element is coupled to the inner metallization region **46** by means of a jumper lead **48.** The location **50** of the printed circuit board **14** is adapted to accommodate solid state circuitry shown in FIG. **5** by reference numeral **52** for providing an active bandpass filter-amplifier combination and a differential amplifier comparator circuit configured from an integrated circuit module package having a plurality of operational amplifiers included therein. A typical example is identified as a 34-10E manufactured by RCA. The location **54** of the printed circuit board **14** is also designed to accommodate a transistor switch, not shown, which is adapted to be coupled to an external sonic alarm device or other alarm circuitry via a terminal land **56.**

Referring now to the electrical circuitry embodying the subject invention, attention is directed to FIG. **4** which discloses the means for supplying power for operating the circuitry shown in FIG. **5.** A power transformer **58** has its primary winding coupled to a 115 VAC power line while the secondary winding is connected to full-wave diode rectifier **60,** whose output is coupled to a voltage regulator **62.** The voltage regulator typcially comprises an integrated circuit configuration such as a CA 723 CE manufactured by RCA. The capacitors **64** and **66** act as filter capacitors and a regulated DC power supply potential appears on printed circuit lead **44** shown in FIG. **3.** Such circuits are well known to those skilled in the art.

Turning attention now to FIG. **5,** it discloses, inter alia, a single N-P-N transistor **68** which has its base, collector, and emitter respectively connected to the metallization tab **28,** metallization land portion **34** and printed circuit element **36.** Since the base is connected to the tab **28,** it is directly connected to the $\lambda/4$ antenna element **20** and one side of the ladder tuning structure **22** which bridges elements **18** and **20.** The base is also connected to a resistor **70** which is returned to ground **38.** The emitter is returned to ground **38** through an inductance coil **72.** The collector of transistor **68** is commonly connected to a resistor **74** and a capacitor **76** whose opposite ends are respectively connected to the antenna elements **18** and **20** at the location of the connection of the tuning structure **22** thereacross. Physically, the resistor **74** is connected between the metallization land portion **34** and the tab **28,** while the capacitor **76** is connected between the apex of the land portion **34** and the lower corner of the side portion **32** (FIG. **3**) common to the tuning structure **22.** A collector load resistor **78** having the +V supply potential applied via metallization region **46** is connected to the collector of transistor **68** by means of the metallization land **34.**

A bandpass filter/amplifier comprised of three operational amplifier portions **80, 82** and **84** of the integrated circuit module **52** is connected to the collector of transistor **68.** This is provided by means of resistor **86** and capacitor **88** connected in series to the input of operational amplifier **80.** The positive power supply potential V+ on metallization portion **46** (FIG. **3**) is applied to the operational amplifier **80** by means of a resistor **90.** A parallel combination of a capacitor **92** and resistor **94** is coupled between the output and input of the operational amplifier **80** to provide feedback required to partially implement a bandpass filter characteristic. The output of operational amplifier **80** is coupled to the input of operational amplifier **82** by means of a resistor **96.** The positive supply potential V+ is also applied to the operational amplifier **82** by means of resistor **98.** As in the case for the first operational amplifier **80,** operational amplifier **82** also includes a feedback network comprised of the parallel combination of capacitor **100** and resistor **102.** The output of operational amplifier **82** is capacitively coupled to the third operational amplifier **84** by means of the series combination of capacitor **104** and resistor **106.** The positive power supply potential V+ is adapted to be coupled to the operational amplifier **84** by means of resistor **108.** A single feedback element comprising resistor **110,** however, is connected between the input and output of operational amplifier **84.**

It is to be noted that the capacitance values of capacitors **92** and **100** of the feedback networks for operational amplifiers **80** and **82** determine the high frequency cut-off of the desired filter characteristic whereas the capacitance values of the series coupling capacitors **88** and **104** at the input of operational amplifier **80** and the input of operational amplifier **84,** determine the low frequency cut-off. The high frequency cut-off is selected to be in the order of 15Hz to prevent the 60Hz AC line frequency from affecting the operation of the subject invention whereas the low frequency cut-off is selected to be in the order of 1.8Hz or lower and thus provides a bandpass for audio frequencies appearing at the collector of transistor **68.** The output of the operational amplifier **84** is fed to one input of a fourth operational amplifier portion **112** of the integrated circuit module **52** and is configured to operate as a comparator and more particularly a differential amplifier. Accordingly, one input of operational amplifier **112** is coupled to the output of operational amplifier **84** by means of the resistor **114.** The other input of the operational amplifier **112** is connected to a selectable DC reference voltage which is provided by a potentiometer **116** coupled between the positive supply potential V+ and ground **38** and a fixed resistor **118** connected to the potentiometer's slider element. The output of the differential amplifier comprised of operational amplifier **112** is connected to the base of a second N-P-N transistor **120** by means of a resistor which transistor comprises the switch transistor referred to above located at location **54** on the printed circuit board shown in FIG. **2.** As shown in FIG. **5,** the emitter is directly connected to the ground metallization **38,** while the collector is connected to the terminal **56** shown in FIG. **3.** A sonic alarm device **122** or other desired device or circuitry is adapted to be connected to terminal **56.**

In operation, the transceiver circuit including the single transistor **68** coupled to the antenna **16** is adapted to operate as an oscillator having a frequency of opera-

tion in the UHF range and more particularly at a frequency of 915± 5MHz. These oscillations are coupled to the dipole elements **18** and **20** which in combination with the tuning structure **22** and the metal backplate **26** positioned a one-fourth wavelength away from the antenna **16** generates a highly directional localized radiation pattern which is transmitted to the area under surveillance. The coupling of the base-collector junction of the transistor **68** across the antenna elements **18** and **20,** as shown in FIG. **5,** provides a unique feedback through the antenna system under the control of the ladder structure **22** whereby any change of the localized field results in a change in collector current of the transistor **68,** thus operating as the detector as well as the oscillator. Accordingly, any movement within the radiated field will be detected as an audio signal of very low level at the collector of transistor **68.** The combination of the operational amplifier **80, 82,** and **84,** and the circuitry associated therewith provides a bandpass filter-amplifier having a gain in the order of 2×10^4 which when compared against a reference voltage set by potentiometer **116** for controlling system sensitivity, causes a DC output voltage from the comparator amplifier **112** to turn the transistor **120** "on" if the reference level is exceeded and thereby drive any type of an appropriate alarm device.

In summation then, what has been shown and described is a single transistor oscillator/detector forming a transceiver which is coupled to a single printed circuit half-wave dipole antenna mounted a quarter wavelength in front of a reflector formed of the back mounting plate of the plastic housing. The collector current change occurring as a result of field disturbance of the highly directional antenna pattern is sensed, amplified, filtered and fed to a comparator whose output is adapted to initiate an alarm.

Having thus described what is at present considered to be the preferred embodiment of the subject invention, I claim:

1. A field disturbance motion detection system generating an electromagnetic wave pattern which is radiated to a selected location and being responsive to a predetermined disturbance of said wave pattern thereat to activate an alarm device, comprising in combination:

a housing having a front portion adapted to pass electromagnetic waves therethrough without substantial attenuation;

a printed circuit board in said housing adjacently behind said front portion;

said printed circuit board including thereon a single transceiver antenna comprised of a pair of opposing quarter wave antenna elements including a spacing therebetween forming a half-wave dipole antenna, and tuning control means located in said spacing coupled between said opposing elements;

an electromagnetic wave reflecting plate attached to said housing substantially one quarter wavelength behind said printed circuit board thereby providing a predetermined antenna gain and directional sensitivity;

a transceiver oscillator/detector circuit located immediately adjacent and coupled to said pair of antenna elements on said printed circuit board and including a single transistor having an emitter, base and collector, and additionally including a direct circuit connection of said base to one of said pair of antenna elements, first circuit means coupling said base to a point of reference potential, second circuit means coupling said emitter to said point of reference potential, third circuit means coupling said collector to said one antenna element, fourth circuit means coupling said collector to the other of said pair of antenna elements, and fifth circuit means coupling said collector to a supply potential, whereby said circuit is energized to provide oscillations which are coupled to said antenna whereupon electromagnetic signals of a predetermined frequency are radiated to a localized area which when a field disturbance occurs a change in collector current of said transistor results providing a relatively low level output signal of another predetermined frequency across said fifth circuit means;

bandpass filter-amplifier means coupled to said collector and being responsive to said output signal occurring across said fifth circuit means and being adapted to increase the amplitude of said output signal by a predetermined gain;

comparator circuit means having first and second input means respectively coupled to the output of said bandpass filter-amplifier means and a reference potential whereby a control signal is generated in response to a field disturbance for initiating an alarm when the amplitude of said output signal from said bandpass amplifier exceeds said reference potential.

2. The system as defined by claim **1** wherein said first, third and fifth circuit means comprises means of a first type electrical impedance, said fourth circuit means comprises means of a second type electrical impedance and said second circuit means comprises means of a third type electrical impedance.

3. The system as defined by claim **2** wherein said first type of electrical impedance comprises resistive impedance means, said second type electrical impedance comprises capacitive type impedance means and said third type electrical impedance comprises inductance means.

4. The system as defined by claim **3** wherein said pair of opposing quarter wave antenna elements comprise printed circuit elements of a generally trapezoidal configuration each having a pair of relatively longer parallel sides of unequal length greater than a pair of associated non-parallel sides, and wherein the mutually opposing shorter non-parallel sides of said pair of elements diverge with respect to the location of said single transistor and wherein said tuning control means is coupled between said mutually opposing shorter non-parallel sides.

5. The system as defined by claim **4** wherein said tuning control means comprises feedback control means in the form of a ladder type structure of printed circuit material.

6. The system as defined by claim **5** wherein said ladder type structure is comprised of a pair of parallely disposed printed circuit line elements adjacent said mutually opposing non-parallel sides and a plurality of spaced apart printed circuit line elments interconnecting said pair of parallely disposed line elments.

7. The system as defined by claim **4** wherein the other non-parallel shorter side of said trapezoidal configuration is substantially at right angles to the pair of parallel sides.

8. The system as defined by claim **7** wherein each of said pair of antenna elements have a predetermined width substantially less than the length of either of said parallel sides, said width providing a predetermined an-

tenna impedance.

9. The system as defined by claim **1** wherein said comparator circuit means comprises a differential amplifier.

10. The system as defined by claim **9** and additionally including an output circuit adapted to activate said alarm device coupled to the output of said differential amplifier, said output circuit including a transistor having an emitter, base and collector and wherein said base is coupled to the output of said differential amplifier, said emitter is coupled to said point of reference potential, and the collector is adapted to be coupled to said alarm device.

* * * * *