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(54) Omnidirectional antenna array.

(57) An antenna device for receipt and onward transmission of an electromagnetically transmitted signal, said device comprising:

at least three signal detecting means;

means for determining the absolute value of the output of each signal detecting means; and

means for summing the absolute value of said coil outputs.

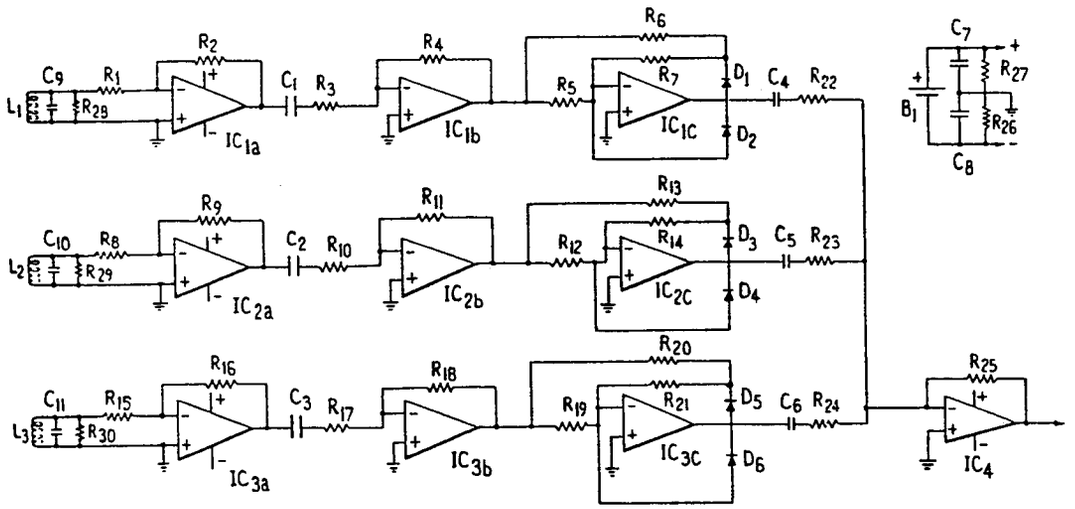

FIG.6

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DEVICE

The present invention relates to a device for detection and onward transmission of a remotely transmitted signal. More particularly the present invention relates to a device for signal detection and transmission with reduced anisotropy.

Signal receivers such as inductive pick-up coils have an anisotropic reception characteristic and null conditions exist in any communication system in which the spatial orientation of the coil cannot be pre-determined.

Schemes have been produced to reduce the anisotropic properties in communications systems. Many such arrangements have relied on mechanical switching networks, but these have the disadvantage of using moving parts.

It is an object of the present invention to eliminate null relationships of the type discussed, allowing a remote signal detection device to be used in any orientation to the signal source.

The null relationships of the transmitter and receiving means may be reduced by using three or more signal detection means (such as coils) in combination,

however, even in such cases the incidence of null orientations is not eliminated.

We have now found that the null orientations of the signal receiver may be eliminated using three or more signal detection means and in combination therewith means for determining and summing the absolute value of the signals produced by said coils.

Accordingly we provide an antenna device for the receipt and onward transmission of an electromagnetically transmitted signal, said device comprising:

at least three signal detection means;

means for determining the absolute value of the output of each signal detection means; and

means for summing the absolute value of said signal detection means.

Generally, the signal detection means will be arranged such that the axes of said signal detecting means are disposed in three dimensions. For example, where there are three signal detection means it is preferred that the axes of the signal detection means do not lie in the same plane and that no two axes are parallel.

It may be preferred in some circumstances to have the axes of said signal detection means disposed with maximum separation. A particularly convenient and useful arrangement consists of three signal detection means arranged so that their axes are orthogonal. However other arrangements, such as four signal detection means with axes in tetrahedral arrangement, may be used.

The nature of the signal detection means is not

narrowly critical, and such components as coils and Hall effect devices may be used. In general, the nature of the signal detection means may be selected by those skilled in the art in accordance with the desired nature and frequency of the signal to be detected Preferred signal detecting means are inductive pick-up coils.

Said means for determining the absolute value of a signal received by a signal detection means include rectifiers. Such rectifiers may include, for example, diode bridges and full wave rectifiers which may, for example, be constructed using operational amplifiers.

Said summing means may provide means for summing signals in one or more stages. The arrangment of summing stages may be chosen as a matter of convenience in order to achieve summing of said signals. The summing stages may comprise a means for summing groups of two or more outputs of the signal detection means.

It will be known to those skilled in the art that a range of additional components may be incorporated into the said antenna device as a matter of convenience. For example, it may be advantageous in some circumstances to use one or more additional components selected from signal amplification means and signal filtering means. Means for signal amplification and means for signal filtering may be chosen from a wide range of components known in the art in accordance with desired nature and frequency range of the output signal.

In one embodiment of the invention there is provided an antenna device as hereinbefore described which additionally comprises means for amplification of the output of each signal detection means and means for filtering each amplified signal prior to

absolute value determination.

The present invention further provides a process of communication using a remote receiving means which process comprises:

generating an electromagnetic signal;

transmitting and receiving said signal in at least one of at least three signal detection means;
determining the absolute value of each output of said signal detection means; and

summing the absolute values of the outputs of said signal detection means using a signal summing means.

The device of the present invention provides significant advantage over prior art receiving means by ensuring reliable pick-up and onward transmission of an appropriate signal in any orientation of the antenna to the incoming signal.

It will be understood by to those skilled in the art that the device of the present invention may be used in a wide range of applications. For example the device may be used as an antenna device in communication systems, security systems and remote switching or triggering systems.

The device is of particular use where it is required to receive and onwardly transmit a signal when the device is in a random orientation.

Reliable detection and onward transmission of a signal by a stationary antenna is particularly critical in the case of remote control firing systems used in blasting. Such systems have been developed recently to obviate the need to use fixed signal transmission lines such as wire or

explosive fuse cord to initiate firing of ignition devices in blasting detonators.

The use of the present invention as a means of receiving and onwardly transmitting an initiation signal for an explosive device provides increased safety and reliability in such remote firing systems.

Remote firing systems generally operate by transmission of an electromagnetic signal to an antenna at the site of the blasting detonator. Usually the detonator is placed in places which are difficult to reach and it is difficult to ensure a suitable orientation for signal transmission to a conventional antenna. Hence a blasting assembly for remote initiation comprising an antenna device according to the present invention for receipt and onward transmission of a signal to a blasting detonator has the advantage of allowing random orientation of the antenna device and detonator while ensuring reliable response to the appropriate detonation signal.

Hence in one embodiment there is provided a blasting assembly for remote explosive initiation comprising an antenna device as hereinbefore described which is in communication with a detonator.

In a further embodiment, there is provided a method of firing a detonator which method comprises generating an electromagnetic signal, receiving and onwardly transmitting said signal to a detonator by means of an antenna device as hereinbefore described.

Various examples of devices in accordance with this invention will now be described with the aid of the accompanying drawings.

In the accompanying drawings:

Fig 1 is a block diagram of a first example of a device according to the present invention.

Fig 2 is a block diagram of a second example of a device according to the present invention.

Fig 3 is a block diagram of a third example of a device according to the present invention.

Fig 4 is a block diagram of a fourth example of a device according to the present invention.

Fig 5 is a block diagram of a fifth example of a device according to the present invention.

Fig 6 is a circuit diagram of a specific example according to an embodiment of the present invention.

Referring to the diagrams:

"L" is used to designate said signal detection means, "M" is used to designate said absolute value determining means and "S" is used to designate said summing means.

In Fig 1 there is shown one embodiment of said antenna device which comprises:

three input coils (L_1,L_2,L_3) which are arranged in an approximately mutually orthogonal orientation;

amplification means for amplifying the output of each coil (A_1,A_2,A_3);

filtering means for modifying the output of each said

coil (F_1,F_2,F_3);

absolute magnitude determining means of the filtered output of each input coil (M_1,M_2,M_3);

means for summing the absolute values of said coil output (S_1).

Fig 2 shows a block diagram in which the coil signal passes through a filter prior (F_1,F_2,F_3) prior to amplification and absolute value determination.

Fig 3 shows a block diagram of a device of an embodiment of the present invention in which the signals are received (L_1,L_2,L_3) and are passed through a filter before (F_1,F_2,F_3) and after (F_1',F_2',F_3') amplification stages (A_1,A_2,A_3).

Fig 4 shows a block diagram of a device of an embodiment of the present invention in which the amplified signals are summed by a summing means comprising two summing stages (S_1,S_2).

Fig 5 shows a block diagram of a device according to the invention in which there are four signal detecting means (L_1,L_2,L_3,L_4).

Fig 6 shows one possible implementation of the embodiment of the invention shown in Figure 2.

The receiving coils L_1, L_2 and L_3 consist of approximately 3000 turns of copper wire on soft iron cores, having a resistance of 240 ohms and an inductance of 150 mH. The component values of the device are as follows:

R_1,R_3,R_8,R_{10},R_{15},R_{17},R_{22}, R_{23},R_{24},R_{26},R_{27}	10	K Ohm resistors
R_2,R_9,R_{16}	220	K Ohm "
R_4,R_{11},R_{18}	1	M Ohm "
R_5,R_{12},R_{19}	22	K Ohm "
R_6,R_7,R_{13},R_{14},R_{20},R_{21}	12	K Ohm "

R_{25}	470 K Ohm "
R_{28}, R_{29}, R_{30}	1 K Ohm "
$C_1, C_2, C_3, C_4, C_5, C_6$	0.01 uF capacitor
C_7, C_8	0.1 uF "
C_9, C_{10}, C_{11}	0.0047 uF "
L_1, L_2, L_3	Pickup coils
B_1	9 volt Battery
$D_1, D_2, C_3, D_4, D_5, D_6$	IN914 diodes
IC_1, IC_2, IC_3	LM324 Integrated circuit
IC_4	LM741 " "

Components C_9, R_{28}, C_{10}, R_{29}, C_{11} and R_{30} act in conjunctionn with the inductance of the coils as input filtering networks denoted F_1, F_2 and F_3 in the preferred block schematic diagram shown in Figure 2. The filtering stages increase the sensitivity of the coils at the desired transmission frequency. The filtering stages are followed by operational amplifiers IC_{1a}, IC_{1b}, IC_{2a}, IC_{2b}, IC_{3a}, IC_{3b}, and components R_1, R_2, C_1, R_3, R_4, C_2, R_{10}, R_{11}, R_{15}, R_{16}, C_3, R_{17}, and R_{18}. These components act as three independent ac amplifiers which increase the input signals from coils L_1, L_2 and L_3 to an appropriate level for the full-wave rectification stages. Three full-wave rectifiers denoted M_1, M_2 and M_3 in the block diagram (Fig 2) are constructed from components IC_{1c}, IC_{2c}, IC_{3c}, D_1s D_2, D_3, D_4, D_5, D_6, R_5, R_7, R_{12}, R_{13}, R_{14}, R_{19}, R_{20} and R_{21}. The action of these components is to rectify each half cycle of the input signal so as to produce an output signal equal to the absolute magnitude of the input signal. The final stage of the circuit comprises components C_4, C_5, C_6, R_{22}, R_{23}, R_{24}, R_{25}, and IC_4 is an ac summing amplifier, the output of which could, for example, be connected to the command decoding circuitry of the remote control device such as a blasting detonator. Components C_7, C_8, R_{26} 25 and R_{27} produce split supply voltages and a zero voltage level from a single battery B_1.

CLAIMS

1. An antenna device for receipt and onward transmission of an electromagnetically transmitted signal, said device comprising:

at least three signal detection means (L1,L2,L3,L4);and characterized by having

means (M1,M2,M3,M4) for determining the absolute value of the output of each signal detection means; and

means (S1,S2) for summing the absolute value of said signal detection means;

the signal detection means being arranged such that the axes of said signal detection means are disposed in three dimensions.

2. An antenna device according to claim 1, characterized by having three signal detection means (L1,L2,L3) arranged so that their axes are orthogonal.

3. An antenna device according to claim 1, characterized by having four signal detecting means (L1,L2,L3,L4) with axes in tetrahedral arrangement.

4. An antenna device according to any one of claims 1 to 3 inclusive characterized in that the signal detection means are selected from coils and Hall effect devices.

5. An antenna device according to any one of claims 1 to 4 inclusive characterized in that the device additionally comprises at least one component selected from the group of amplification means (A1,A2,A3) and

signal filtering means (F1,F2,F3).

6. An antenna device according to claim 5 characterized in that the device comprises means (A1,A2,A3) for amplification of the output of each signal detecting means and means (F1,F2,F3) for filtering each amplified signal prior to absolute value determination.

7. A blasting assembly for remote explosive initiation comprising an antenna device according to any one of claims 1 to 6 inclusive which is connected to a detonator.

8. A process of communication using a remote receiving means which process comprises

generating an electromagnetic signal;
transmitting and receiving said signal in at least one of at least three signal detection means (L1,L2,L3,L4);characterized in that the absolute value of each output of said signal detection means is determined
and
the absolute values of the outputs of said signal detection means are summed using a signal summing means (S1,S2).

9. A method of firing a detonator which method comprises generating an electromagnetic signal, receiving and onwarding transmitting said signal to a detonator by means of an antenna device according to any one of claims 1 to 6 inclusive.

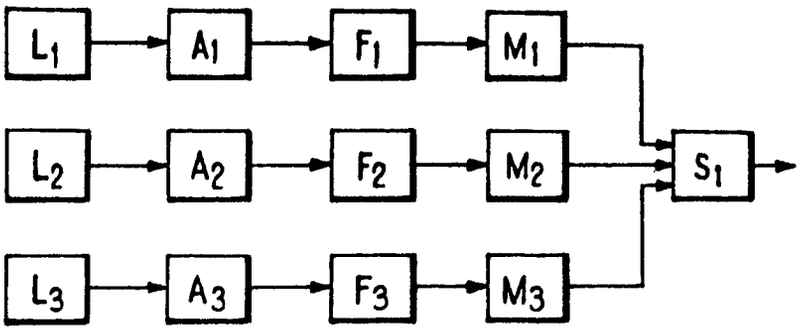

FIG.1

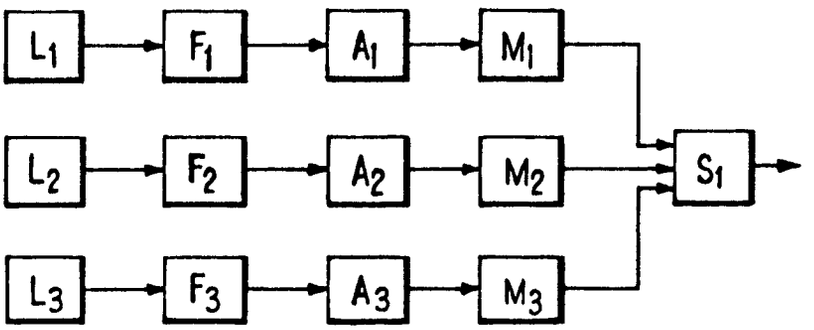

FIG. 2

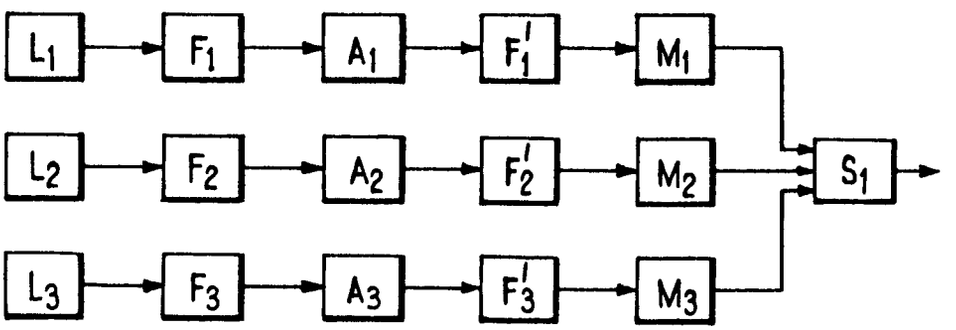

FIG.3

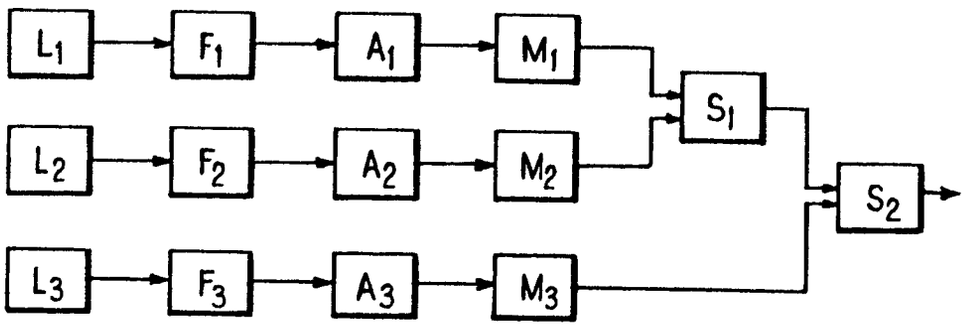

FIG.4

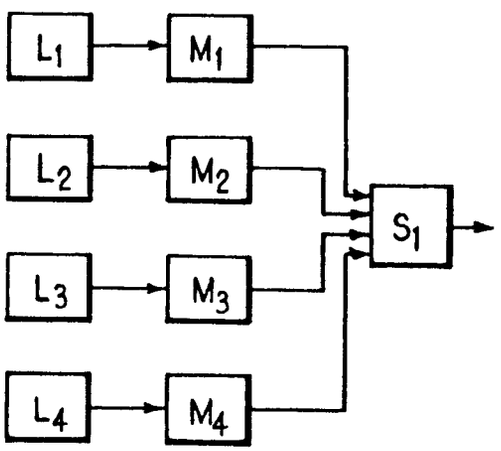

FIG.5

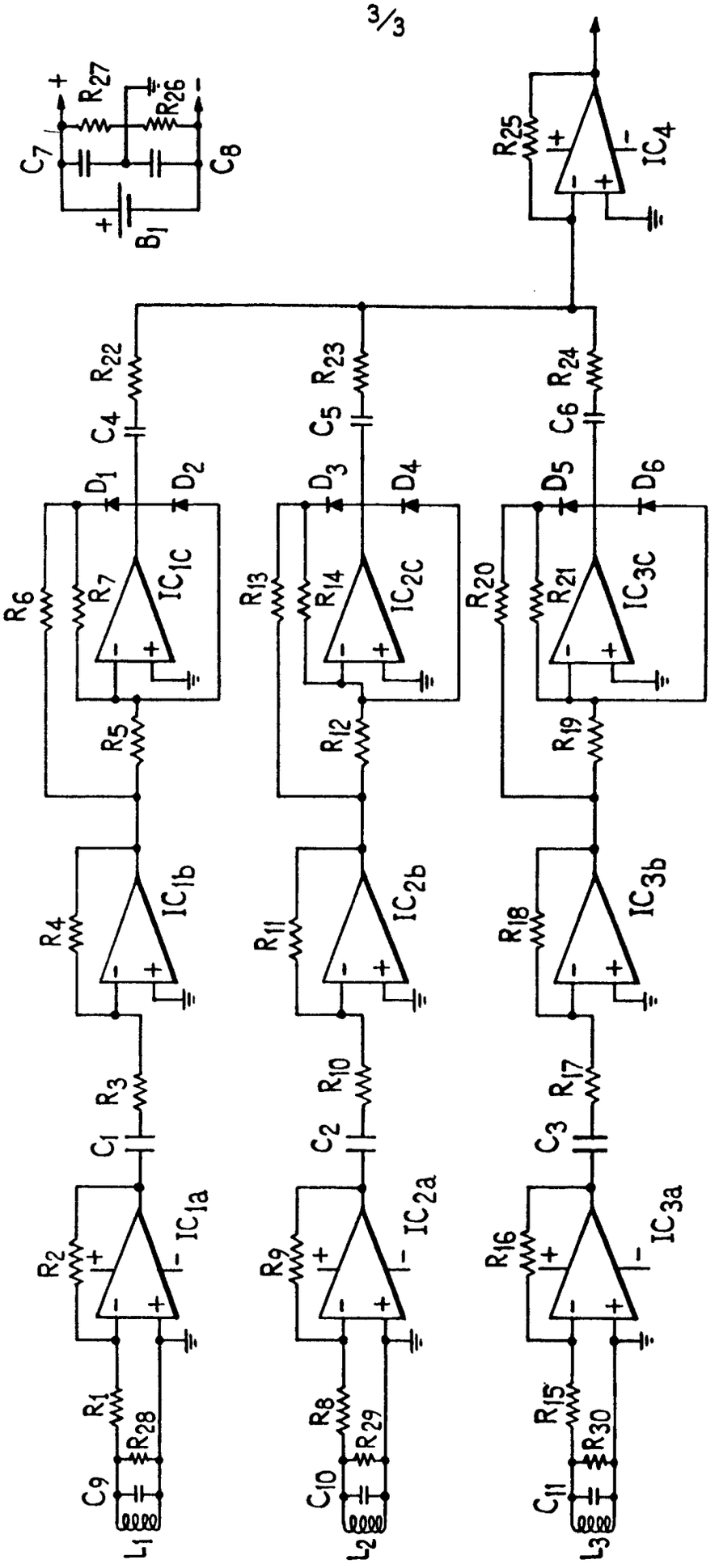
C7
R27
R26
C8
B1
R25
IC4
R22
C4
R23
C5
R24
C6
D1
D2
D3
D4
D5
D6
R6
R7
IC1C
R13
R14
IC2C
R20
R21
IC3C
R5
R12
R19
R4
IC1b
R11
IC2b
R18
IC3b
R3
C1
R10
C2
R17
C3
R2
IC1a
R9
IC2a
R16
IC3a
R1
R28
R8
R29
R15
R30
C9
C10
C11
L1
L2
L3

FIG.6