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BROADBAND ANTENNA ARRAY

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Fig. 1

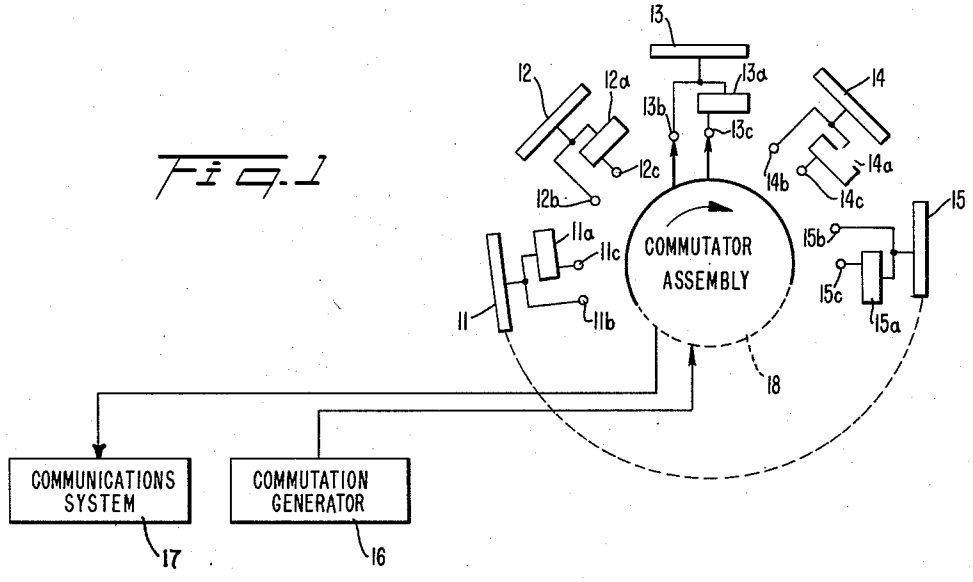
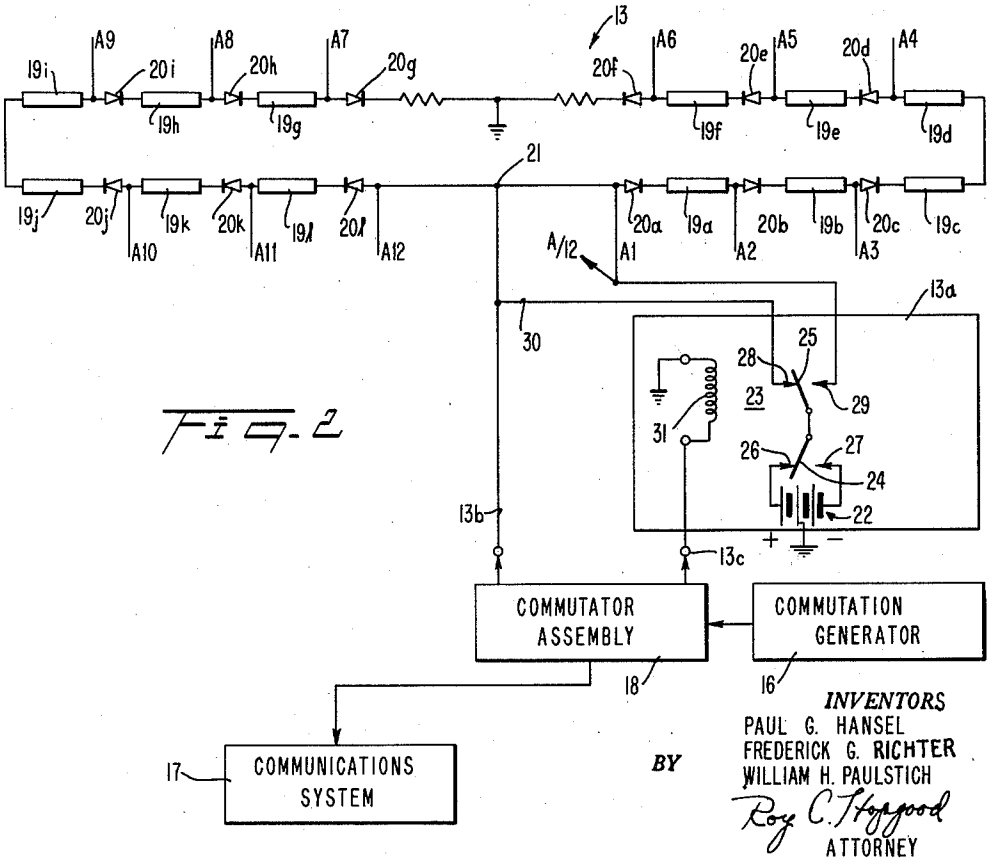


Fig. 2



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BROADBAND ANTENNA ARRAY

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This invention relates to direction finding antennas and, more particularly, to a broadband antenna array for utilization in quasi-Doppler direction finding equipment.

A Doppler direction finding system generally employs a rotating antenna, as contrasted to a quasi-Doppler direction finding system which utilizes a plurality of antenna elements fixed in a predetermined array to simulate the effects of revolving a single receiving antenna around a circle. This is accomplished by commutation of a large number of fixed elements in such a manner, that only one or at most two elements are active at any one instant. The remaining momentarily inactive elements should be as non-receptive to the incoming radiation as possible.

In the operation of conventional direction finders, the system accuracy and sensitivity is severely affected if operation is attempted through the antenna resonance frequency, because the inactive elements act as parasitic reradiators causing a material alteration in the received field configuration from that which is postulated for successful operation of the direction finder. Consequently, in the operation of such systems, parasitic reradiation has been avoided by utilizing antenna configurations that are resonant above the highest frequency encountered in operation. However, by using this type of configuration a material reduction in the utility of the direction finder is suffered because the configuration is inefficient at some frequency levels in a broad band of operation.

Accordingly, it is an object of the invention to provide an antenna array for a quasi-Doppler direction finding system which is operable with accuracy and sensitivity in a broad frequency range including antenna resonant frequencies.

Another object of the invention is to provide a direction finding antenna array in which parasitic reradiation is suppressed in the inactive antenna elements whereby the operable frequency range of the array is broadened.

A further object is to provide a dynamic impedance arrangement in a direction finding antenna array for suppressing parasitic reradiation of energy from the inactive antenna elements.

In accordance with an aspect of the invention, there is provided a circular array of antenna elements. Each of the elements includes a plurality of antenna segments and impedance elements for coupling each adjacent pair of segments. Commutating means are provided for coupling in succession a communication system to the antenna elements. The invention is characterized by means for reducing or substantially eliminating the impedance between segments of only the antenna coupled to the communication system, whereby parasitic reradiation by the idle antenna elements is substantially suppressed.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawing, wherein:

FIG. 1 is a schematic diagram of an antenna array and communication system; and

FIG. 2 is a schematic diagram of an antenna element of an array and the commutating and control circuitry for it.

Referring now to FIG. 1, a plurality of antenna elements 11–15 are arranged in a circular or other suitably configurated array to form a conventional quasi-Doppler antenna. Antenna impedance control circuits 11*a*–15*a* and commutator contacts 11*b*–15*b* are connected to the elements 11–15, respectively. Each control circuit 11*a*–15*a* is also provided with a commutator contact 11*c*–15*c*, respectively. In practice, the impedance control circuit and contacts (which are suggested only by way of example) are closely located with the other electronic equipment remote from the actual antenna elements.

A commutator assembly 18, which, for example, may be a conventional type having brush contacts, is driven by a synchronous motor, shown as commutation generator 16 to couple sequentially the communication system 17 to each antenna element 11–15 through its respective contact 11*b*–15*b*, thereby activating the antenna element for the reception of radiant energy. Simultaneously, each control circuit 11*a*–15*a* is sequentially activated through the elements 11*c*–15*c* when its associated antenna element 11–15 is activated. The elements 11*c*–15*c* are designated as being contacts for illustrative purposes only; it being understood that they may be any suitable type of wiper arm or electronic switch for use with an appropriate commutator assembly.

Each antenna element 11–15, for example, element 13 (FIG. 2) comprises a plurality of segments 19*a*–19*l* which are preferably arranged as a folded dipole by coupling each adjacent pair of segments together by a dynamic impedance, such as diodes 20*a*–20*l*. The coupling diodes are connected to conduct from a common terminal 21 through the opposite dipole branches of the antenna element to ground. A connection 13*b* extends from the common terminal 21 for intermittent contact with the commutator wiper arm.

The dynamic impedance elements, while described as being conventional diodes 20*a*–20*l*, may also be inductive or capacitive elements, such as voltage sensitive barium titanate capacitors or capacity diodes. It is only essential that the impedance elements utilized to couple the antenna segments vary in impedance from substantially a short-circuit condition to substantially an open-circuited condition, dependent on the control voltages that are applied. When an antenna element is inactive, the impedance elements are open-circuited by the impedances to effectively segment the antenna element and thereby practically eliminate any parasitic reradiation from this element. However, when an antenna element is activated, the impedance elements are short-circuited to remove the loading from the antenna; i.e. substantially to return the antenna to a condition free of interposed impedances.

By way of illustration, the antenna control circuit 13*a*, which provides the voltages for controlling the operating condition of the impedance elements, may comprise a source of energy, such as a battery 22, and a conventional double armature relay 23. Each relay armature 24–25 operates as a switch with a pair of fixed contacts 26–27, 28–29, respectively. The contacts 26–27 are connected to the positive and negative terminals, respectively, of the battery 22. The contact 28 is connected to the terminal 21 of the antenna element by the line 30, while the contact 29 is multipled to the anode terminal A1–A12 of each of the diodes 20*a*–20*l*, respectively.

The energizing coil 31 for relay 23 is connected to ground at one end and to commutator contact 13*c* at the other end. Under normal conditions, the relay winding 31 is not energized and the armatures 24–25 are in contact with the contacts 27 and 29, respectively, to complete the circuit from the negative terminal of the battery 22 through the armatures to the anode elements of each of the diodes 20*a*–20*l*, so that these diodes are non-conductive.

However, as the commutator assembly 18 sweeps a cir-

cular path, the contacts **13***b* and **13***c*, are brushed by the assembly **18** to activate the antenna element by commutation with the communication system **17**. When this occurs, the relay winding **31** is energized by a pulse from the commutation generator **16** to attract armatures **24–25** to the contacts **26–28**, respectively. In this position, voltage of positive polarity is coupled over line **30** to the common terminal **21** of the antenna element. The application of positive voltage to the antenna element renders the diodes **20***a*–**20***l* conducting thereby effectively removing the impedance loading of the antenna element, and permitting it to receive radiant energy from a remote source (not shown).

While the communication system is coupled to one antenna element, the remaining elements are inactive. During this period, the relay armatures **24–25** of the antenna control circuit are in a normal position, that is, in contact with contacts **27–29** coupling energy of negative polarity to each of the diode anodes. The diodes are back-biased by the applied voltage thereby rendering them non-conductive. When the diodes are non-conducting their impedance is practically infinite, thereby effectively loading the antenna element into non-radiating segments; thus, the flow of current in the antenna is insignificant and parasitic reradiation is effectively suppressed.

Since the parasitic reradiation of energy from momentarily inactive antenna elements is suppressed, the sensitivity of a direction finding system, utilizing this type of antenna arrangement, is materially increased. Furthermore, the frequency range may be extended, permitting operation through resonant frequencies.

While the foregoing description sets forth the principles of the invention in connection with specific apparatus, it is to be understood that this description is made only by way of example and not as a limitation of the scope of the invention as set forth in the objects thereof and in the accompanying claims. For example, while the system has been described in conjunction with the reception of energy by a communications system coupled to a direction finding antenna array, it is to be understood that the invention is equally applicable to a transmitting antenna array where a signal source is sequentially coupled to each of a plurality of circumferentially disposed antenna elements.

What is claimed is:

1. In combination, an antenna array comprising a plurality of antenna elements, a communication system, commutating means coupled to said communication system for connecting each of said elements in succession with said communication system, each of said antenna elements including a plurality of antenna segments, dynamic impedance means coupling each adjacent pair of segments and having a normally high impedance for inhibiting parasitic reradiation from the element, and means coupled to said commutating means for reducing the dynamic impedances in an antenna element while said element is coupled to said communication system.

2. The combination according to claim 1, wherein said dynamic impedance means comprises a plurality of unidirectional conducting devices, each device coupling an adjacent pair of segments, and said devices being responsive to the impedance reducing means to conduct while said element is coupled to said communication system.

3. The combination according to claim 2, and also comprising means for normally biasing each of said devices to prevent conduction thereof and suppress parasitic reradiation from the inactive antenna elements.

4. The combination according to claim 3, wherein said antenna array comprises a quasi-Doppler direction finding array for receiving directional signals at said communication system.

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