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(54) **An active antenna array.**

(57) An active antenna array (58) for use in a radar seeker has a preselected number antenna elements (60) which are individually connected to an identical plurality of transmitting and receiving modules (64) backed up by a cold plate (66) for removing heat produced during use. In a preferred embodiment each module has a rectangular prism housing (84) within each of which there are individually modifiable phase and gain circuits (76,78). In a further embodiment, the transmitting and receiving modules are constructed of a number of wafers, each wafer having the same number of separate identical circuit function blocks as there are antenna elements.

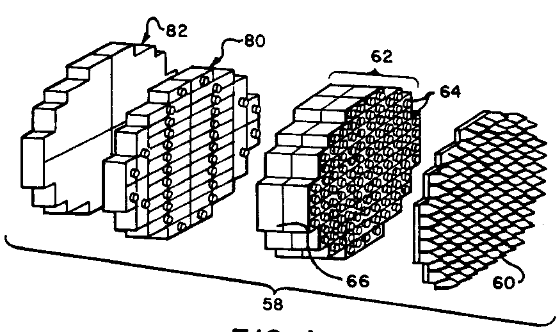

FIG. 4

EP 0 621 654 A2

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BACKGROUND

1. Field of the Invention

The present invention relates to an antenna array, and, more particularly, to an active antenna array for use with a radar guided missile, for example.

2. Description of Related Art

In certain kinds of missile systems, frequently referred to as guided missiles or missile seekers, an on-board radar system directs a radar beam towards the target and reflected energy received and processed maintains the missile on the desired intercept course. The sophistication of avoidance and jamming techniques, which can be employed for the benefit of the target in order to avoid a guided missile seeker or redirect it along a non-intercept course, have made it necessary to improve the missile seeker in order to overcome these defensive measures and enhance the probability of successful target intercept. Typical defensive measures produce false radar return signals, having the purpose of confusing the missile guidance system as to the actual target.

Approaches employed in advanced missile seekers to defeat guided missile defenses, in a major part, recognize that RF signals will be received over a relatively broad angular field and electronic processing of these signals is required to enable the seeker to separate "false" signals from real target radar returns. In addition, in multiple target engagements (multiple real targets and/or multiple radar emitting decoys) the seeker must be capable of selecting a particular target located within the target cluster.

A well-known guidance system, typically referred to as a gimballed seeker, mounts a high gain antenna on a gimbal assembly to allow the seeker to be pointed over a relatively large solid angle or scan volume. A servo system drives the gimbal which allows positioning of the antenna for both transmission and receipt of radar energy in a desired direction within the scan volume. The weight, cost, excessive volume and mechanical complexity of such systems make replacement desirable. Additionally, gimballed systems have traditionally had to be custom designed and fabricated for each new application.

Another form of missile seeker utilizes electronically scanned antenna (ESA) technology which includes a large number of individual antenna elements, each of which has the capability to program the phase of the transmitted and received signals. In one version of an ESA, known as a passive ESA, the high RF power is developed in a separate transmitter unit and then partitioned among the numerous phase shifting elements. Since the phase shifting function is performed at relatively high power, the phase shifters tend to have high losses. In addition, since all the elements of the array are being driven by a single transmitter and the signals received by the individual array elements are combined prior to being routed to the receiver, this ESA approach lacks the flexibility required to fully utilize modern signal processing techniques that require access to multiple sub-arrays of the full aperture.

A second ESA approach, called a hybrid ESA, uses high power amplifiers and low noise amplifiers to develop the transmit and receive signals, respectively, for groups of antenna radiating and receive elements. This latter approach has many of the same difficulties as the passive ESA and still does not provide fully independent radiating/receive elements in the array.

In addition to accurately guiding to intercept the target, a guided missile typically carries a warhead payload that is designed to maximize damage to the target under attack. To increase the probability of taking out the target, accurate data is needed at intercept to determine the optimum burst point for the warhead. Existing missile seekers used for guidance are not capable of collecting the precise data required to compute the optimum burst point for the missile warhead. In known systems, a second highly specialized sensor is included in the missile design to gather this required data. It would be desirable to be able to accomplish this function with the missile seeker, thus eliminating the need for a separate radar system, both because of additional cost and weight of such a system as well as the taking up of additional space on-board the missile.

SUMMARY OF THE DISCLOSURE

It is a primary aim and objective of the present invention to incorporate an active electronically scanned array (AESA) into a radar guidance system for a missile to provide numerous advantages that are not attainable with the present art. These advantages include: (1) a modular and cost effective approach to achieving seeker power-aperture product, (2) wide bandwidth enabling integrated active/passive (ARH) guidance, (3) adaptive beam formation to enhance seeker guidance in the presence of stand-off jammers (SOJs), (4) enhanced guidance against clustered targets, (5) seeker-based fuzing, i.e., integrating guidance and fuzing functions into a single seeker, and (6) improved reliability and graceful performance degradation through functional redundancy and real-time adaptive compensation for failed elements in the array.

1. Modular construction

The AESA is constructed of individual active transmit/receive modules. Each module consists of a transmitter element and a radar receive element which are individually adjustable as to phase and gain. These basic building blocks may be combined together to form an array of any size without having to incur a large design cost. By use of modular construction, it is possible to provide active antenna arrays of any desired size by merely assembling the appropriate number of modules.

2. Wide bandwidth, integrated active/passive (ARH) guidance

Wide bandwidth is inherent in the basic design of the active transmit/receive (T/R) modules, and they are capable of operating over bands that are tens of percent wide. Their ability to operate over such wide bandwidths allows the missile seeker to derive passive guidance information against various emitters operating on-board the target. In addition, the wide bandwidth supports active operation over a wider bandwidth, which provides enhanced performance in scenarios with multiple missiles in flight simultaneously or in high RFI (i.e., radio frequency interference) environments. A wider operating bandwidth may also provide performance advantages against some electronic counter measures (ECM) techniques. Forcing an ECM device to operate over a wider bandwidth may dilute the jamming power received by the missile seeker receiver.

3. Adaptive beam formation to enhance seeker guidance in the present of stand-off jammers (SOJs)

The AESA is capable of adjusting the gain and phase of the individual elements of the active array to steer antenna nulls in real-time to eliminate the interference from off-axis stand-off jammers. With reduced interference, the probability of successful guidance to the desired target is enhanced.

4. Enhanced guidance aaainst clustered targets

With an AESA, the array may be partitioned into multiple sub-arrays which by the use of appropriate signal processing can achieve improved guidance to a specific target located within a cluster of targets. With separate transmission and receiving capabilities as well as individual phase and gain control for each antenna element, the seeker can resolve signals received from a large number of independent targets. Furthermore, the resolution capability is not dependent upon the returns coming from comparably sized targets.

5. Seeker-based fuzing--integrating guidance and fuzing functions into a single seeker

With an AESA, the same missile radar system used to detect and track targets can be used to collect the data requisite for computing the optimum burst point for the missile payload warhead. The inherent features of the active T/R module design which allow the fuzing function to be combined with the radar seeker are the small blind range (fast recovery time after transmit), the wide bandwidth of the T/R modules which supports waveforms that are capable of making precision measurements of target dimensions, and the agility of pointing the seeker beam to interrogate the target dimensions.

6. Improved reliability and graceful performance degradation through functional redundancy and real-time adaptive compensation for failed elements in the array

The AESA is typically composed of 100 or more active elements. Each element has inherently high reliability, but in addition, the failure of a single element may be compensated for by adjusting the parameters of gain and phase of the "nearest neighbors". This feature provides graceful performance degradation as individual elements fail. In addition, high power seekers that use travelling-wave tube (TWT) technology typically require that the seeker be pressurized in order to preclude transmitter arcing and subsequent failure. Any failure of the pressure seal will result in catastrophic failure of the missile seeker. Because each T/R module has a lower peak power, the requirement for pressurization to preclude arcing is eliminated. The active T/R modules use much lower voltages than the TWT transmitter which commonly requires voltages on the order of ten thousand (10,000) volts to operate. Such high voltages require extremely sophisticated manufacturing approaches to ensure that power supply related failures do not occur. Many of these issues are completely eliminated by the use of the active T/R modules which utilize voltages on the order of tens of volts. Finally, an AESA eliminates the moving parts that are part of a conventional gimballed antenna. The elimination of the gimbal assembly with the accompanying torquer motors and high-powered servo electronics will provide a marked enhancement in reliability.

DESCRIPTION OF THE DRAWING

In the accompanying drawing:

FIG. 1 is an exploded view of a prior art antenna assembly with conventional array and servo sweep apparatus;

FIG. 2 is a graph of antenna gain received along boresight and spaced to each side of boresight;

FIGS. 3A, 3B, 3C and 3D are schematic, function block depictions of the various apparatus required in the prior art missile radar seekers for a conventional slotted array antenna, for a passive

ESA, and for a hybrid ESA, respectively;

FIG. 4 shows an exploded view of various parts of an active array seeker of the present invention;

FIGS. 5A and 5E are function block diagrams of the active array of this invention; and

FIG. 6 is a further schematic of a seeker apparatus system in accordance with this invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

There are three known alternative approaches to mechanizing the missile seeker: (1) the conventional gimballed slotted array antenna, (2) a passive electronically scanned antenna, and (3) a hybrid electronically scanned antenna.

FIG. 1 shows in an exploded view the various parts of a typical prior art gimballed radar seeker system for guiding a missile enumerated generally as 10. The system includes, at the forward end, an antenna array 12 consisting of individual antenna elements (or slots) 14 in a general matrix arrangement, and various interconnection and electronic circuit means collectively identified as 16. The antenna assembly 18, consisting of the antenna array 12 with interconnections and electronics 16, fixedly secured to a gimbal mounted pedestal 20 which, in a conventional known manner, provides the ability for moving the antenna array 12 to face in any desired direction over a relatively wide solid angle. A servomechanism drive 22, with associated control and drive electronics 24, is typically combined with an RF processor 26. In use, the seeker assembly 10 can be operated to scan over a given solid angle and thereby enlarge the angular coverage that would be accorded to an antenna array 12 fixed in position. Such a gimballed antenna array system typically has from two to four reception channels, and is highly tuned in frequency with a relatively narrow operating frequency range.

As shown in the graph of radar responses of FIG. 2, the radar echo or response 28 received directly along antenna boresight (often called the mainlobe response) is the largest, but for angles away from the mainlobe, the signal return for high powered off-boresight signals may still be significant (e.g., 30,32). These responses away from the mainlobe peak are usually referred as antenna sidelobes or just sidelobes. Also, it is to be noted that between adjacent lobes there are points of zero reception 34, or "nulls". In practice, a signal located at the same angle or position as a null would not be sensed. There are two potentially adverse impacts of these off boresight responses: (1) In the presence of strong jamming signals located at an off boresight angle with a sidelobe peak, jamming power received may be of such magnitude that will impair acquiring a radar signal returning from the target, and (2) if the main beam of the antenna is not positioned directly toward the target and the target return falls in an antenna null, it may not be possible to acquire the desired target return at all. In the case of a gimballed antenna, the nulls are fixed and present a continuing possibility for error in detection.

Not only have gimballed antenna systems been found unable to overcome many standard defensive techniques, they also are relatively heavy and bulky in requiring servo motors and a gimbal/pedestal which are relatively heavy items. In addition to weight, the size requirements for a gimballed antenna system exceeds desirable limits.

Turning now to FIG. 3B, an electronically scanned antenna (ESA) in the so-called passive form is seen to consist of a large number of antenna elements 36 arranged in a matrix 38 with phase control apparatus 40 which enables collectively changing the phase of the signals received or transmitted from the antenna elements. This approach offers a limited amount of control and processing. Since the phase shift function is performed at high power, a substantial amount of loss typically occurs across the phase shifter elements of apparatus 40.

In a hybrid ESA 42 (FIG. 3C), a phase control 44 again provides phase change across an antenna array 46, with a low noise amplifier 48 (LNA) provided for the return signals and additional separate amplifying means 50 provided for the transmitting signal from the exciter (FIG. 3B). Each low noise amplifier 48 is seen to include a limiter 52, an amplifier 54 and a control 56 for the amplifier (FIG. 3D). Hybrid ESAs have problems similar to passive ESAs in that the phase shift function is implemented at high RF power.

For the ensuing description of the present invention, reference is now made to FIGS. 4 and 5 where an active array to be described is enumerated generally as 58. At the forward facing end of the active array seeker is a wideband antenna array composed of a plurality of individual antenna elements 60 which, for exemplary purposes only, will be considered to number one hundred (100). They are depicted as flared-notch type elements but may assume a variety of different known forms and be suitable for present purposes. It is important to note that the individual antenna elements are not secured to a single background, however, they are arranged in a modular form with each module including an antenna element. In this way, an antenna array can be made up of any desired size by merely utilizing the necessary number of antenna elements for the desired array.

Just behind the array of antenna elements, there is a module array and cold plate assembly 62 consisting of individual modules 64, one for each antenna element. Each module 64 includes at its forward facing surface can be mated with a corresponding element 60 from the broadband antenna array, serving both to physically and electrically interconnect the module array and cold plate assembly modules to the antenna array modules. The cold plate assembly, identified separately as 65, can be constructed in a number of different well known ways, e.g., circulating coolant, change of phases material, or heat pipes.

With reference now particularly to both FIGS. 5A and 5B, it is seen that the individual antenna elements are connected through separate modules 64, identified generally as T/R (transmit/receive) modules, which individually contain the circuits shown in FIG. 5B. More particularly, interconnection with the antenna element is initially via a duplexer 70 which, in a way well known in the art, interconnects outgoing radar signals from a high-power amplifier 72 (HPA) to the associated antenna element 60 for transmit and interconnects reflected radar signals from the same antenna element 60 to a low noise amplifier 74 (LNA) for receive. These signals interconnect through the duplexing switch 75 to a common line consisting of a serially arranged variable phase control 76 and a variable gain control 78. Accordingly, both the amplitude and phase of each signal as applied to or received from each antenna element can be separately controlled as to phase and amplification. For transmit, since the phase and gain control is performed prior to the high power amplifier, phase and gain control are implemented at lower power and can be accomplished with low loss.

The rear face of each of the modules in the module array and cold plate assembly 62 receives necessary RF and logic control signals from the RF and logic distribution network 80.

Finally, adaptive processing and monopulse network circuits 82 are incorporated with four major blocks or modules similarly mounted to and electrically connected with the RF and logic control distribution network 80 from the rear side. The cold plate assembly 60, in addition to effecting desired electrical connections, also provides cooling to the rearward parts of the modular radar missile seeker of this invention, i.e., the RF and logic distribution network 80 and the monopulse network circuit 82.

Turning once again to FIG. 4 and simultaneously to FIGS. 5A and 5B, according to a preferred embodiment each T/R module 64 is built into a complete, stand-alone assembly incorporating all of the required functions and which assembly has the overall form of a generally rectangular prism. The various functional blocks (FIG. 5B), i.e., limiter, high power amplifier, low noise amplifier, phase and gain adjustment, interface circuits, for example, are included within each module and are laid out over the depth of the assembly housing 84 (i.e., extending along the direction from the antenna to the circuits 82). The rigid cold plate 66 is secured to the rear surface of each module 64.

An alternative embodiment of modular construction is obtained where a plurality of wafer modules are sandwiched together, each wafer having a given number of identical and separate function block elements (e.g., limiter, low noise amplifiers) arranged in a matrix pattern. A necessary number of interconnection means are provided on one major surface of each wafer to enable interconnection of the wafers to each other. The cold plate can be identical to cold plate 66 described in connection with the first embodiment.

It is important to note that in either embodiment of modular construction the lateral dimensions of each module as well as the spacing between modules in the first embodiment and between adjacent identical function blocks in the second embodiment, is determined essentially by the spacing of the antenna elements 60. Correlating the module sizes to the antenna element spacing enables direct assembly of the modular array to the antenna array on a one to one basis.

DIRECT COMPARISON OF PRIOR ART AND PRESENT INVENTION

The present invention provides numerous advantages that are not attainable with the known systems, including: (1) a modular and cost effective approach to achieving seeker power-aperture product, (2) wide bandwidth providing integrated active/passive (ARH) guidance, (3) adaptive beam formation to enhance seeker guidance in the presence of, say, stand-off jammers (SOJs), (4) enhanced guidance against clustered targets, (5) seeker-based fuzing, i.e., integrating guidance and fuzing functions into a single seeker, and (6) improved reliability and graceful performance degradation through functional redundancy and real-time adaptive compensation for failed elements in the array.

1. Modular construction

For a conventional radar seeker, the design of the antenna must be custom designed to the specific application taking into account such factors as the center frequency, frequency bandwidth, and aperture size. The present invention is constructed of individual active transmit/receive modules with each module consisting of a transmitter element and a sensitive radar receive element. These basic building blocks may be combined together to form an array of any size without having to incur a large design cost. Since the basic parts are made in modular form, the cost of any given radar missile seeker is substantially reduced in that it merely requires the assembly of a given number of modules to produce the system and does not require a completely customized design. As a further result of the modular construction, both the non-recurring and recurring cost of new seeker development is reduced.

Still further, the use of T/R modules as building blocks provides a modular approach to achieving increased power-aperture product. For the AESA, increasing the size of the array increases both the transmitter power and the antenna gain simultaneously. With existing technology, significant increase in the power-aperture product involve design efforts directed toward developing high powered transmitters and/or larger antennas.

2. Wide bandwidth, integrated active/passive (ARH) guidance

Existing planar array antennas and traveling wave tube (TWT) transmitters are highly tuned to a specific frequency. Even over relatively modest bandwidths of a few percent, these existing systems experience significant performance degradation at the edges of the system operating band frequency. On the other hand, wide bandwidth is inherent in the basic design of the present active transmit/receive (T/R) modules and they are capable of operating over bands that are tens of percent wide. The preferred embodiment benefits from this inherently wide bandwidth. Ability to operate over these relatively wide bandwidths allow a missile to derive passive guidance information against emitters being used for defensive purposes which typically operate over a corresponding wide frequency range.

In addition, the wide bandwidth of the preferred embodiment provides enhanced performance in scenarios with multiple missiles in flight simultaneously or in high radio frequency interference RFI environments. A wider operating bandwidth may also provide performance advantages against some electronic countermeasures (ECM) techniques. Forcing an ECM device to operate over a wider bandwidth tends to dilute the jamming power in the missile seeker receiver.

3. Adaptive beam formation to enhance seeker guidance in the present of stand-off jammers (SOJs)

The conventional gimballed seeker has a fixed antenna sidelobe response that is not capable of being modified in real-time to counter various defensive techniques that may be employed. One method available in the prior art to overcome this problem is to modify the flight path of the missile in an attempt to adjust the geometry with respect to interfering sources and place them in an antenna null. In the process of doing this, however, overall missile performance is frequently degraded. On the other hand, the preferred embodiment enables adjusting both the gain and phase of the individual elements of the active array to steer antenna nulls in real-time and in that way eliminate the interference from off-axis stand-off jammers, and this is all accomplished without modifying the missile flight path. With reduced interference, the probability of successful guidance to the desired target is enhanced.

4. Enhanced guidance against clustered targets

A conventional gimballed seeker has limited performance against target clusters in that the antenna array is typically divided into four quadrants which are either combined and then processed or processed separately. Only a maximum of three targets can be successfully resolved by this method. With the preferred embodiment, on the other hand, the array may be partitioned into multiple sub-arrays which by the use of appropriate signal processing can achieve improved guidance to a specific target located within a cluster of targets. The number of sub-arrays is determined by the size of the array and the complexity of the feed network, but theoretically can be made arbitrarily large within the packaging constraints required for signal processing. With separate transmission and receiving capabilities as well as individual phase and gain control for each antenna element, the seeker can resolve signals received from a large number of independent targets. Further, by utilizing modern signal processing techniques, the resolution capability is not dependent upon the returns coming from comparably sized targets.

5. Seeker-based fuzing -- integrating guidance and fuzing functions into a single seeker

With a conventional gimballed array, it is not practicable to combine the fuzing and guidance functions into a single seeker. The limiting factors include the blind range of the high power seeker, the limited bandwidth of operation, and the difficulty in positioning the beam at rates consistent with attempting to scan the target to determine optimum burst point. In the present invention, the same missile radar system used to detect and track targets can be used to collect the data requisite for computing the optimum burst point for the missile payload warhead. The inherent features of the active T/R design which allow the fuzing function to be combined with the radar seeker are the small blind range (fast recovery time after transmit), the wide bandwidth of the T/R modules which supports waveforms that are capable of making precision measurements of target dimensions, and the agility of pointing the seeker beam to interrogate the target dimensions.

6. Improved reliability and graceful performance degradation

Comparing FIGS. 1 and 4, it can be seen that a substantial reduction in hardware complexity is obtained by use of the present invention over the prior art gimballed pedestal system. More particularly, as seen in FIG. 3A, the equipment specifically required for a conventional missile seeker with a gimballed antenna are those items located in the shaded functional block diagram enumerated 86. Comparing with FIG. 6, the gimbal torquer motors, servo electronics and other mechanical appurtenances necessary for operation of this prior art system have been eliminated and, in their place, there are predominantly lightweight and relatively inexpensive electronic components and circuits shown enclosed in the dotted line part of the circuit enumerated as 88. The remainder of the circuit equipment in both cases (i.e., outside 86 and 88) is very much the same for both the gimballed and present invention.

In the conventional gimballed array, failure of any one of a number of critical components will result in failure of the guided missile to be able to complete its mission. The AESA, because it typically is composed of 100 or more identical active modular elements, will display graceful degradation upon the failure of any single element. Each element has inherently high reliability, and seeker system reliability is further enhanced since the failure of a single element may be compensated for by adjusting the parameters of gain and phase of its "nearest neighbors". This feature provides the highly advantageous graceful performance degradation.

In addition, conventional high power gimballed seekers that use travelling-wave tube (TWT) technology typically require that the seeker be pressurized in order to preclude transmitter arcing and subsequent catastrophic failure. In this case, any failure of the pressure seal will result in failure of the missile seeker and, accordingly, failure of the missile to complete its mission. In the described modular system, because each T/R module has a lower peak power, the requirement for pressurization to preclude arcing is eliminated. The active T/R modular technology uses much lower voltages than a TWT transmitter which commonly requires voltages on the order of ten thousand (10,000) volts to operate. Such high voltages require extremely sophisticated manufacturing techniques to ensure that power supply related failures do not occur.

Although the invention has been described in connection with a preferred embodiment, it is to be understood that one skilled in the appertaining arts may make modifications that come within the scope of the invention as described and within the ambit of the appended claims.

Claims

1. An active antenna array, comprising:

   a plurality of antenna elements unitarily arranged in a general plane facing in a common receiving and transmitting direction; and

   modular transmitting and receiving circuit means, one for each antenna element, interconnected with the antenna element plane.

2. An active antenna array as in claim 1, in which each modular circuit means includes separate apparatus for accomplishing transmission and receipt of radar signals handled by a given antenna element.

3. An active antenna array as in claim 2, in which each module circuit means includes a plurality of wafers, each wafer including a plurality of identical function block circuits arranged in a matrix and function block circuits for the different wafers being selectively different, said wafers being unitarily interconnected together with a function block circuit of each wafer being aligned with a function block circuit of an adjacent wafer.

4. An active antenna array as in claim 1, in which heat absorption means are positioned in heat transferring relation to each modular transmitting and receiving circuit means.

5. An active antenna array of variable transmitter power and antenna gain, comprising:

   a given plurality of modular antenna elements arranged in a uniform spaced apart relation forming a planar array of given areal extent for achieving a predetermined power and antenna gain;

   an identical plurality of transmitting and receiving circuit modules, each module individually physically and electrically interconnected to a single antenna element; and

   cold plate means physically interconnected with the circuit modules forming a unitary arrangement of the circuit modules and antenna elements.

6. An active antenna array as in claim 5, in which each circuit module includes a generally rectangular prism housing enclosing individual transmitting and receiving circuits for the said interconnected antenna element.

7. An active antenna array as in claim 6, in which the circuit modules are identical to each other.

8. An active antenna array as in claim 5, in which each circuit module is individually adjustable as to phase and gain.

9. An active antenna array as in claim 8, in which each circuit module is secured to individually different antenna elements.

10. An active antenna array as in claim 5, in which each circuit module includes a duplexer connected to an antenna element for effecting alternate connection through a high power amplifier and a low noise amplifier, both of which are serially arranged with a variable phase control followed by a variable gain control.

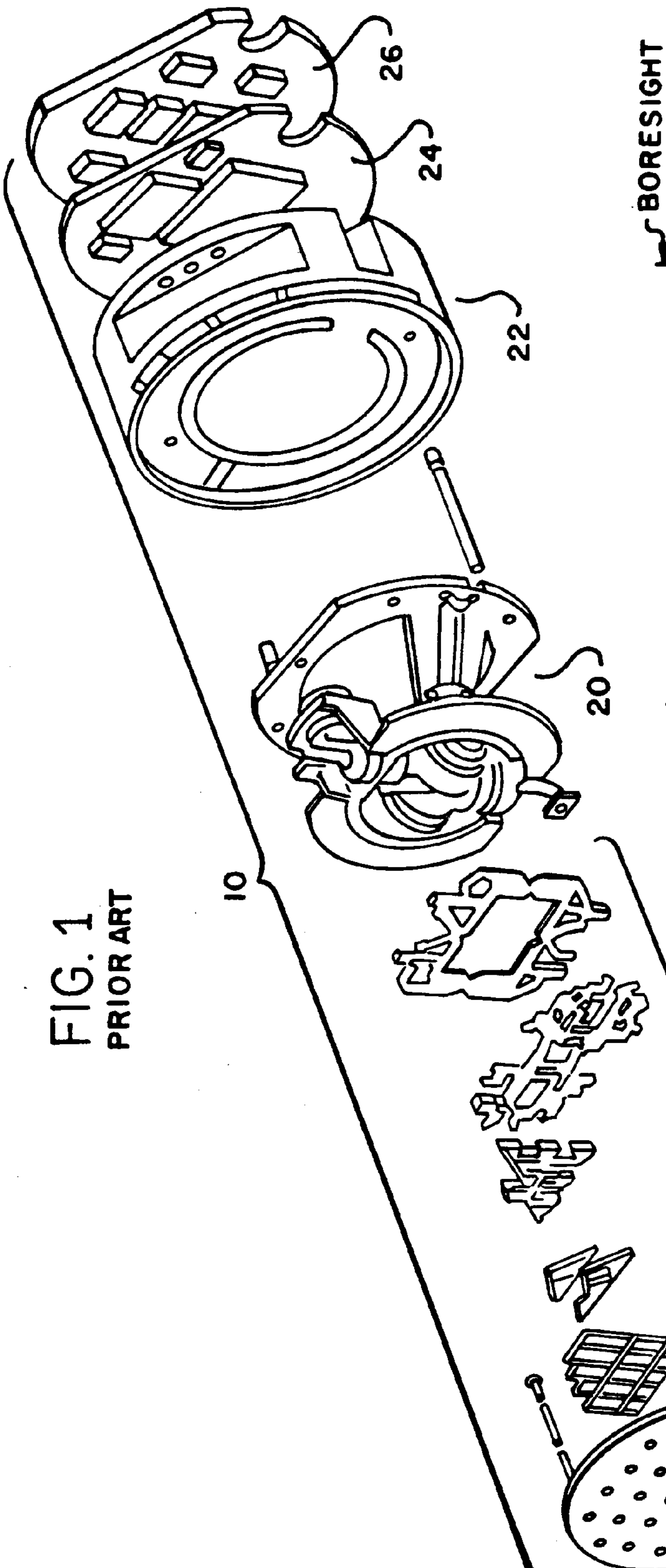


FIG. 1
PRIOR ART

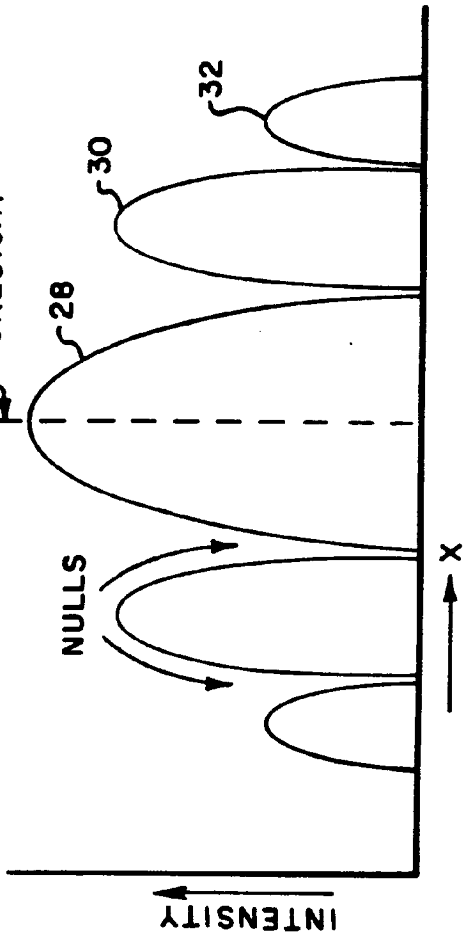
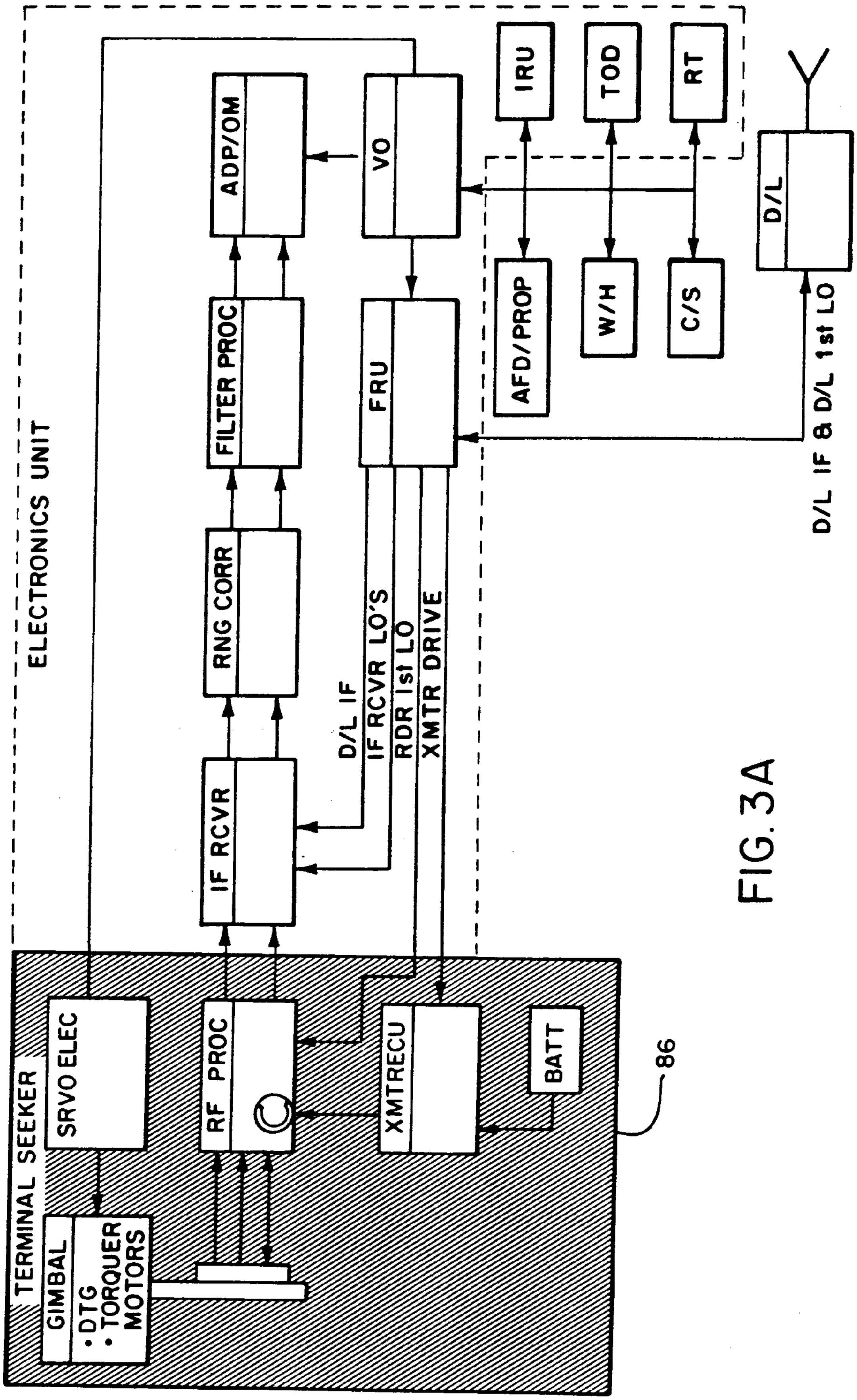


FIG. 2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ADP/OM
VO
IRU
TOD
RT
FILTER PROC
FRU
AFD/PROP
W/H
C/S
D/L
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IF RCVR
D/L IF
IF RCVR LO'S
RDR 1st LO
XMTR DRIVE
D/L IF & D/L 1st LO
TERMINAL SEEKER
SRVO ELEC
RF PROC
XMTRECU
BATT
GIMBAL
• DTG
• TORQUER MOTORS
86

FIG. 3A

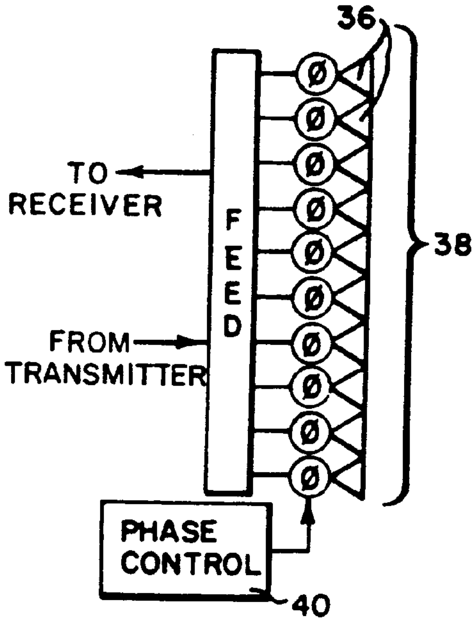

FIG. 3B

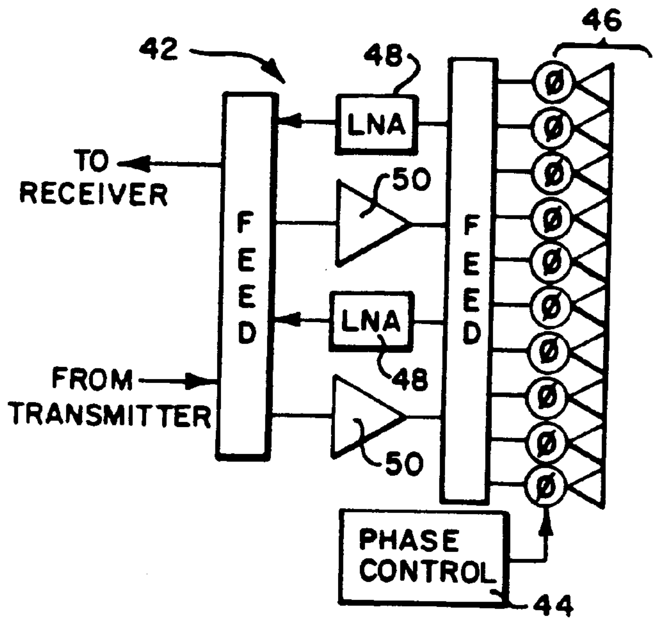

FIG. 3C

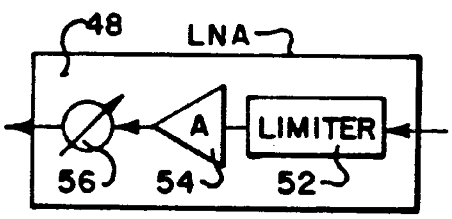

FIG. 3D

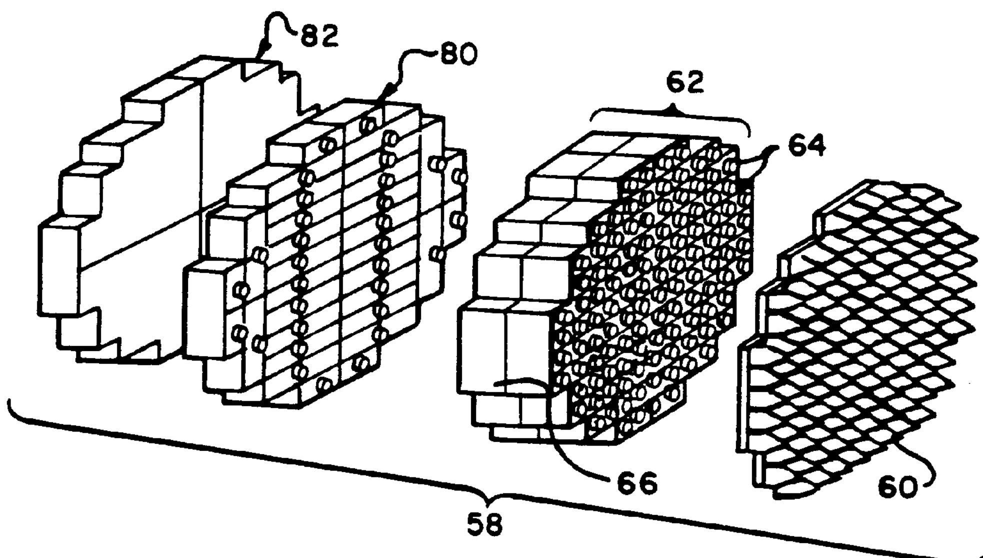

FIG. 4

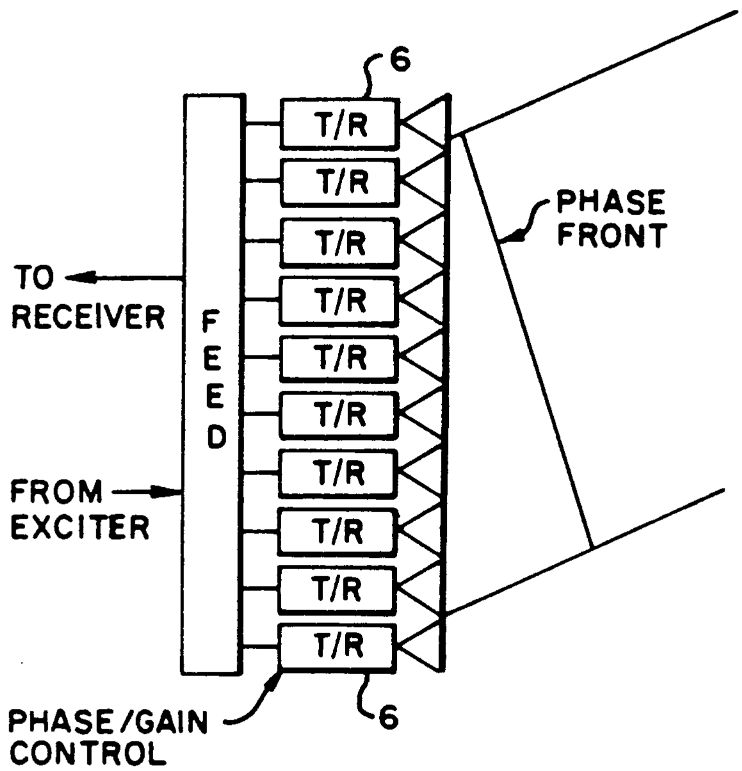
6
T/R
PHASE
FRONT
TO
RECEIVER
FEED
FROM
EXCITER
PHASE/GAIN
CONTROL
6

FIG.5A

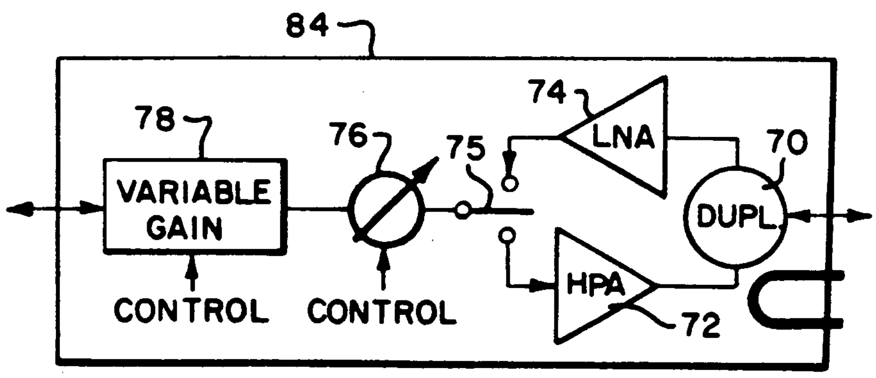
84
78
VARIABLE
GAIN
CONTROL
76
75
CONTROL
74
LNA
70
DUPL.
HPA
72

FIG.5B

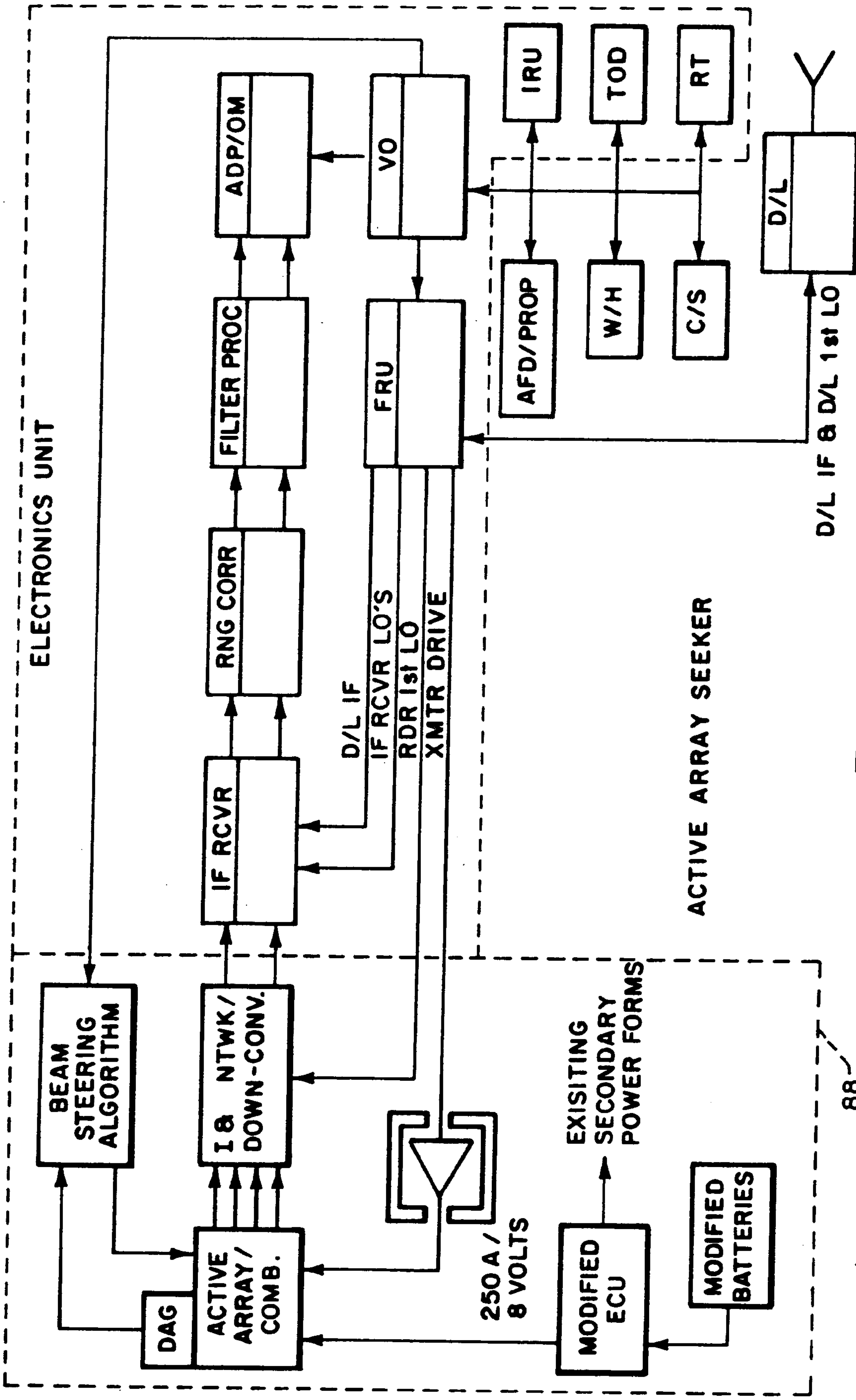
ELECTRONICS UNIT
ADP/OM
VO
FILTER PROC
FRU
RNG CORR
IF RCVR
D/L IF
IF RCVR LO'S
RDR 1st LO
XMTR DRIVE
IRU
TOD
RT
AFD/PROP
W/H
C/S
D/L
D/L IF & D/L 1st LO
ACTIVE ARRAY SEEKER
BEAM STEERING ALGORITHM
I & NTWK/ DOWN-CONV.
EXISITING SECONDARY POWER FORMS
MODIFIED BATTERIES
MODIFIED ECU
250 A / 8 VOLTS
ACTIVE ARRAY/ COMB.
DAG
88

FIG.6