

[54] AUTOMATIC ACTIVE/PASSIVE FUZE SYSTEM 3,732,564 5/1973 Kuck et al..... 343/7 PF
 3,747,531 7/1973 Powell..... 102/70.2 P

[75] Inventors: **Carlton H. Cash**, Norco; **Robert A. Boot**, Riverside; **Ralph L. Bauer**, Riverside; **Benjamin F. Husten**, Riverside, all of Calif.

Primary Examiner—Malcolm F. Hubler
 Attorney, Agent, or Firm—Richard S. Sciascia; Joseph M. St. Amand; T. M. Phillips

[73] Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, D.C.

EXEMPLARY CLAIM

1. A radio fuze system comprising means for transmitting a radio frequency signal in the direction of a target, first antenna means for receiving only the reflected signals transmitted by said transmitting means, a firing circuit, circuit means coupling said first antenna means to said firing circuit for providing an initiating signal thereto when said received signal has a magnitude of a predetermined value, second antenna means for receiving countermeasures signals, and means coupled to said second antenna means for causing said fuze system to respond to said countermeasures signals to prevent dudding past the target.

[22] Filed: **Dec. 27, 1960**

[21] Appl. No.: **78,767**

[52] U.S. Cl..... **343/7 PF; 102/70.2 P; 343/18 E**

[51] Int. Cl.².. **F42C 13/04; G01S 7/36; G01S 9/02; H04K 3/00**

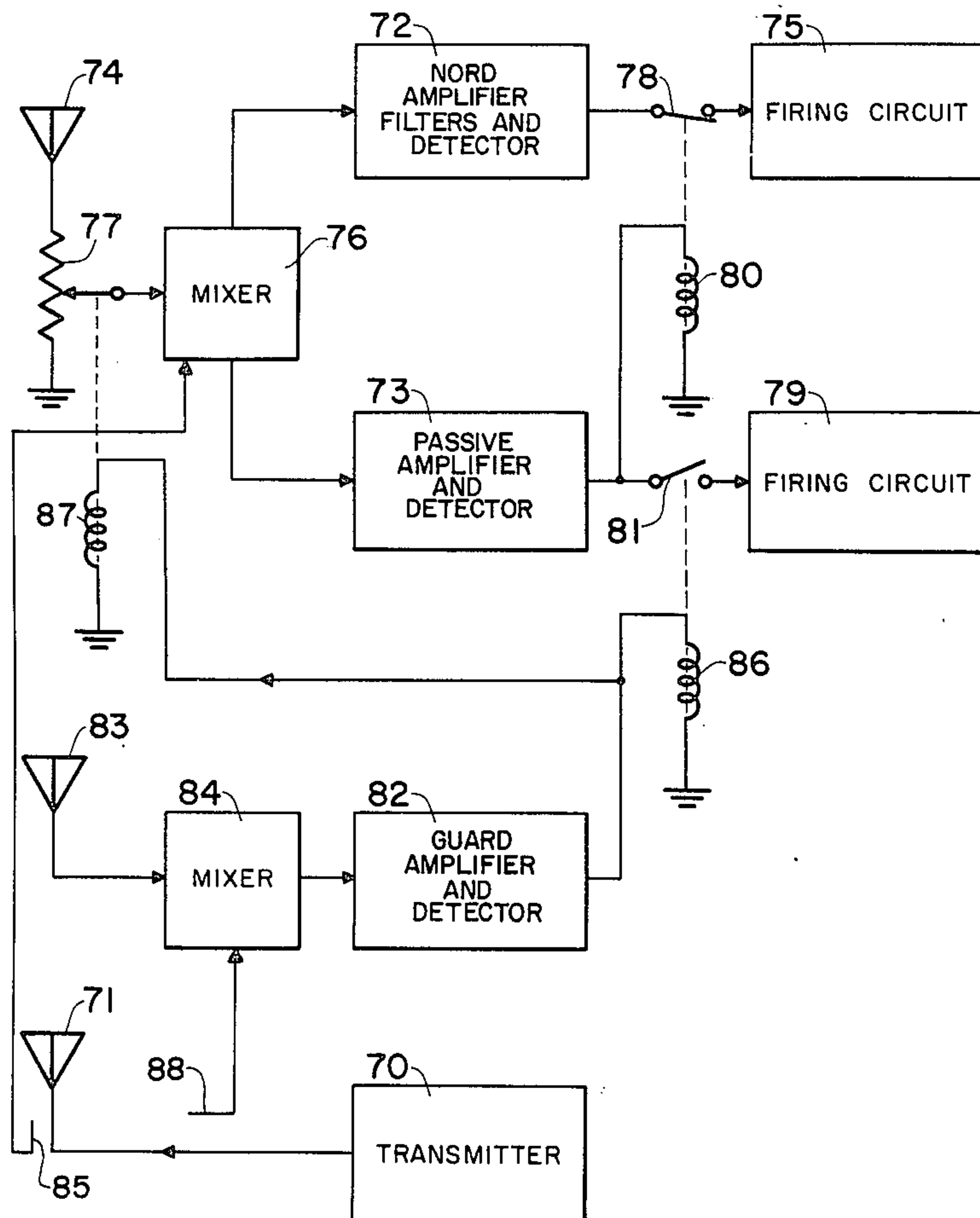
[58] Field of Search **343/7, 13, 12, 17.1, 13.1, 343/7 PF, 18 E; 102/70.2, 70.2 P**

[56] **References Cited**

UNITED STATES PATENTS

3,219,826 11/1965 Letaw, Jr..... 102/70.2 P

8 Claims, 3 Drawing Figures



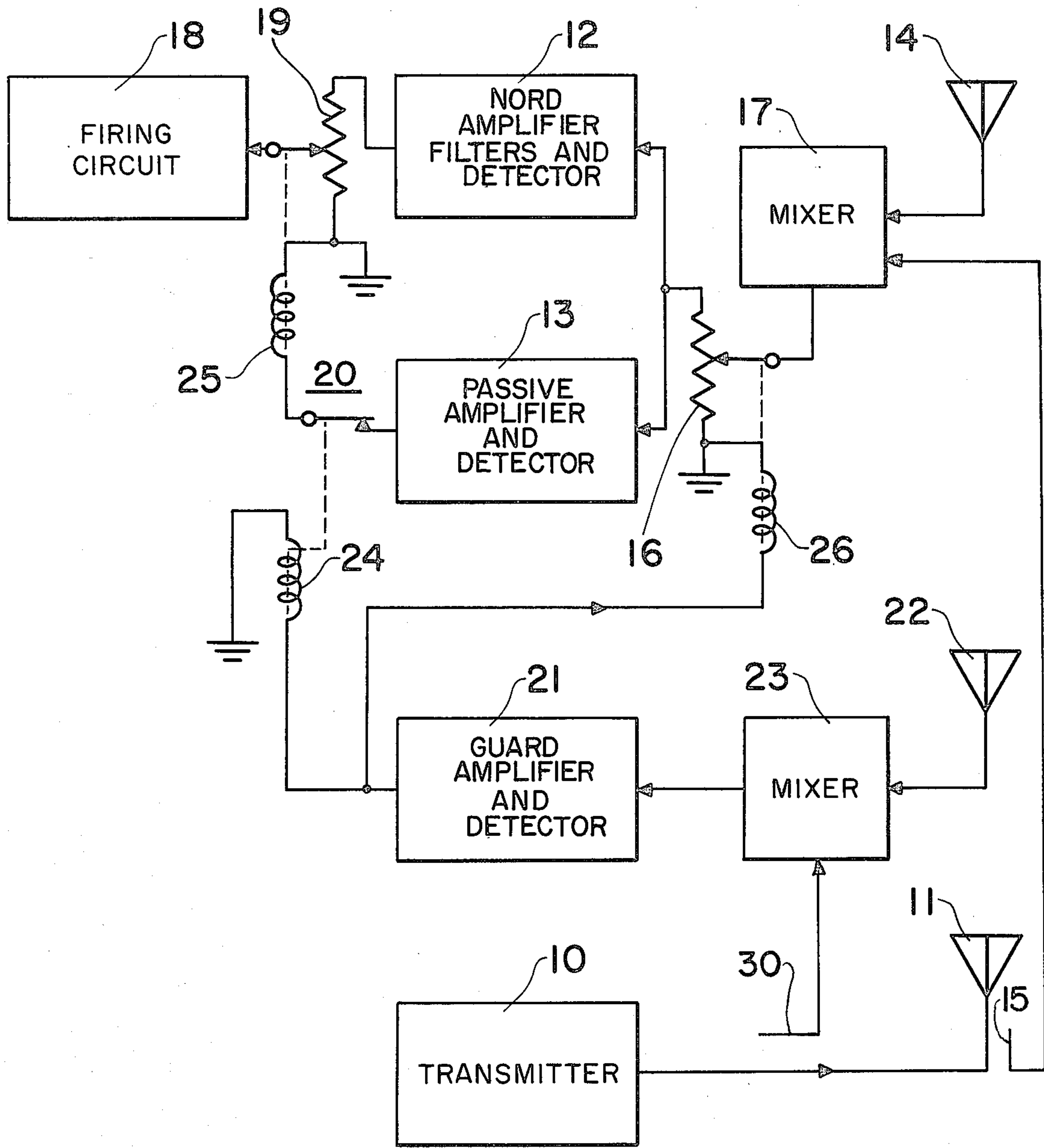


FIG. 1

CARLTON H. CASH
ROBERT A. BOOT
RALPH L. BAUER
BENJAMIN F. HUSTEN
INVENTORS

BY *T. M. Phillips*
J. M. St. Omand
ATTORNEYS

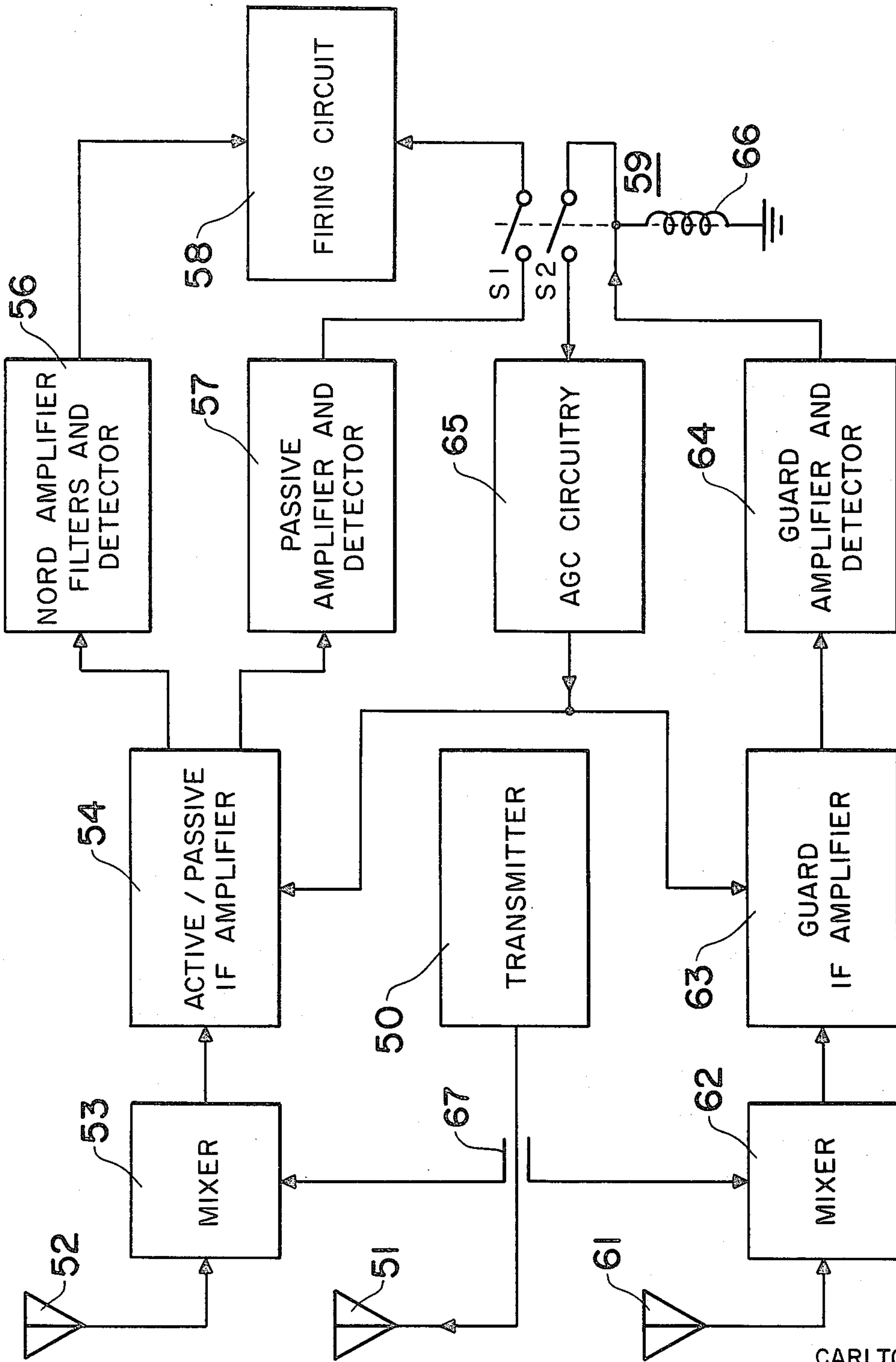


FIG. 2

CARLTON H. CASH
ROBERT A. BOOT
RALPH L. BAUER
BENJAMIN F. HUSTEN
INVENTORS

BY *H. M. Phillips*
J. M. St. Amant
ATTORNEYS

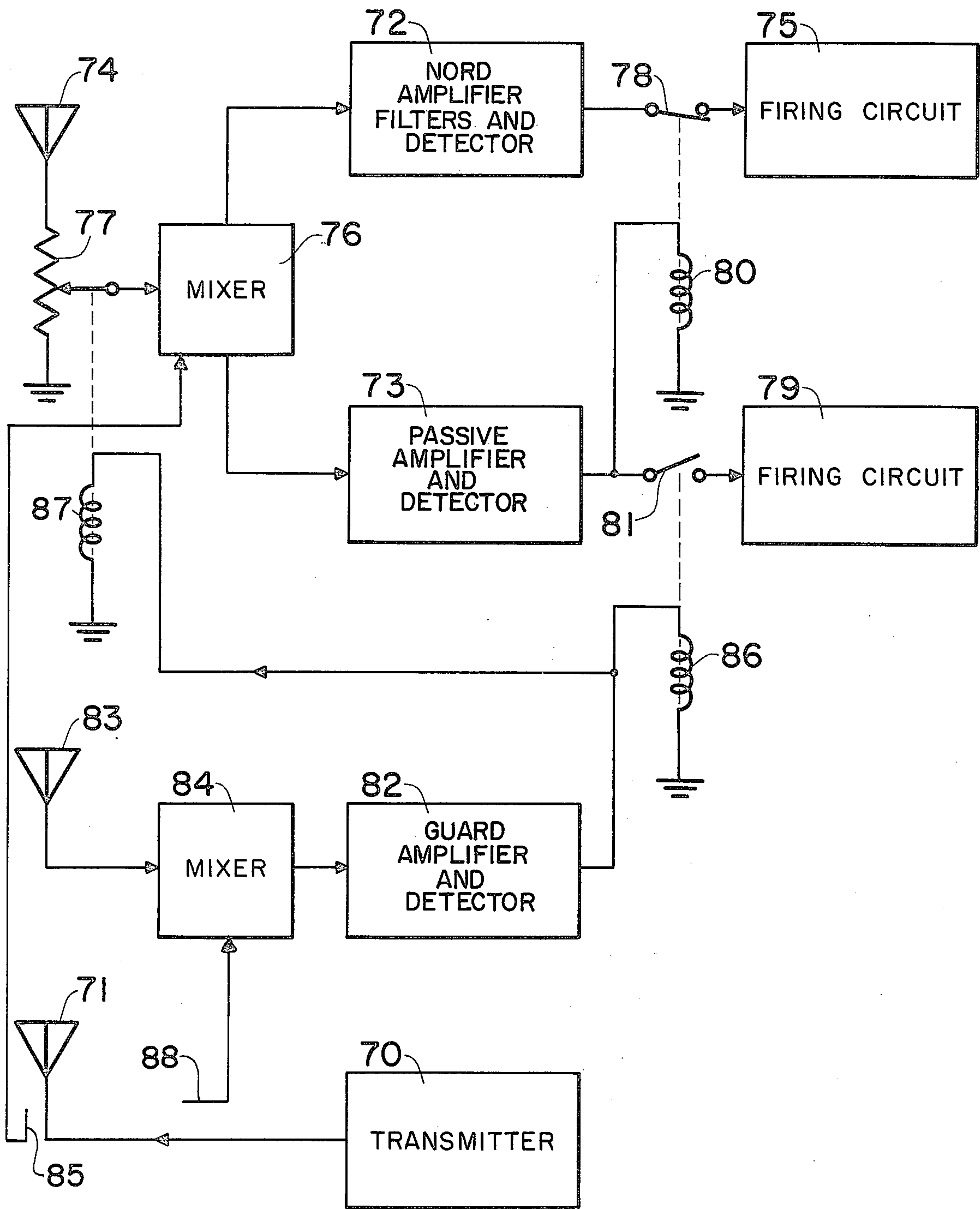


FIG. 3

CARLTON H. CASH
ROBERT A. BOOT
RALPH L. BAUER
BENJAMIN F. HUSTEN
INVENTORS

BY *T. M. Phillips*
J. M. St. Amant
ATTORNEYS

AUTOMATIC ACTIVE/PASSIVE FUZE SYSTEM

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to an automatic active/passive fuze system and more particularly to an automatic active/passive fuze system which eliminates possibility of jammer saturation and subsequent danger of fuze dudding.

In known systems, for example the system shown and described in application Ser. No. 789,459, filed Jan. 27, 1959 by Carlton H. Cash, dudding can be caused by jammer saturation of the detector circuit. Saturation can be caused by reception of a countermeasures signal of the same frequency and strength as the illuminating signal being transmitted by the fuze circuit.

Accordingly, an object of the present invention is the provision of reliable automatic fuzing of guided missile warheads in presence or absence of severe countermeasures environment.

Another object is to provide a fuze system which utilizes jamming energy in conjunction with normal fuze active energy to assure optimum burst localization.

Other objects and many of the attendant advantages of this invention will become readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a generic block diagram illustrating the principle of operation of the invention.

FIG. 2 is a block diagram of a fuze system embodying the invention.

FIG. 3 is a block diagram of another embodiment of the invention.

Referring now to FIG. 1, there is shown a transmitter 10 having an antenna system 11 coupled thereto for radiating radio frequency energy. Nord amplifier filters and detector 12 and passive amplifier and detector 13 are each connected to antenna system 14 through a portion of potentiometer 16 and mixer 17. Nord amplifier filters and detector 12 is connected to firing circuit 18 through a portion of potentiometer 19 while passive amplifier and detector 13 is connected to firing circuit 18 through relay switch 20 and potentiometer actuating coil 25. Guard amplifier and detector 21 is connected to antenna 22 through mixer 23 and to ground through relay coil 24 and potentiometer actuating coil 26 respectively.

The principal of operation is as follows: In the absence of countermeasures (quiet target), transmitter 10 radiates radio frequency energy through antenna system 11 which should have a narrow beam conical pattern to illuminate a target upon intercept. Re-radiated energy from a target (not shown) is received through antenna system 14 which has identical beam characteristics to antenna system 11. Energy thus received is mixed in mixer 17 with an attenuated portion of the transmitted signal by means of coupler 15 to generate a doppler frequency which is detected and amplified in circuit 12 and then fed to firing circuit 18 through a portion of potentiometer 19. Provided the target is within a predetermined fuzing range, a signal of sufficient magnitude will be fed to firing circuit 18 to cause detonation of a warhead.

In the case of an off-target jammer, threshold energy levels resulting from countermeasures will be received by antenna system 14 only when the jammer signal is in the main lobe of the antenna pattern. This energy will be mixed in mixer 17 to generate frequencies which will be detected in both nord amplifier filters and detector 12 and passive amplifier and detector 13. However, the signal output from circuit 13 flowing in coil 25 actuates potentiometer 19 so that the output of circuit 12 is prevented from reaching firing circuit 18. Target doppler signals existing at the output of mixer 17 of FIG. 1 occur over a specified and limited band of frequencies. Signals such as ECM signals not referenced to the randomly modulated signal transmitted from antenna 11 will upon cross-correlation at mixer 17 with a portion of the transmitted signal generate mixer output frequency components extending over a much wider band of frequencies than the dopplers from target reflected components. The presence of energy in amplifier 13 can be construed to be other than within fuzing range target reflected energy and is used to actuate potentiometer 19 through coil 25 to prevent false alarm firing. Amplifiers 12 and 13 may be of the type shown and described on pp 837-849 in Introduction to Statistical Communication Theory, David Middleton, New York; McGraw-Hill (1960).

In the case of an on-target jammer (noisy target) countermeasures energy is received through antenna system 22 and antenna system 14 front side lobes. The antenna pattern characteristics of antenna system 22 may be either omidirectional, forward-looking solid cone, narrow-beam conical inclined forward of antenna 14 main lobe, or variations of these. Countermeasures energy received through antenna system 22 is processed through mixer 23 and amplifier detector 21 and applied to relay coil 24 and potentiometer actuating coil 26. A portion of the signal transmitted is coupled by coupler 30 to mixer 23 to provide the reference signal. The sensitivity level of antenna system 22, mixer 23, amplifier detector 21, and actuating coil 26 is set such that countermeasures energy entering the front side lobes of antenna system 14 will be attenuated by potentiometer 16 so that the threshold level is not reached at the outputs of nord amplifier filters and detector and passive amplifier and detector 13. The function of relay 24 is to disable amplifier detector 13 through relay switch 20 when the output from amplifier detector 21 reaches a predetermined level so that detonation can occur when sufficient countermeasures energy enters amplifier and detector circuit 12. At intercept the jammer will enter the main lobe of antenna system 14 thus increasing the signal fed to amplifier and detector circuit 12 sufficiently to activate firing circuit 18.

In the event jammer power is cut off (blinking jammer) after having previously caused the fuze system to become passive in operation, the output from circuit 21 would decrease, thus, causing relay 20 switch to close and potentiometer 16 to return to its original position. The fuze system then is restored to full active capability.

Referring now to FIG. 2 there is shown a transmitter 50 coupled to an antenna 51 for radiating radio frequency energy. An active channel consisting of receiving antenna 52, mixer 53, active/passive IF amplifier 54 and Nord amplifier filter and detector 56 is connected as one input to firing circuit 58. A passive channel con-

sisting of receiving antenna 52, mixer 53, active/passive IF amplifier 54 and passive amplifier and detector 57 is connected through switch S1 as a second input to firing circuit 58. A guard channel for operating relay 59 consists of receiving antenna 61, mixer 62, guard IF amplifier 63, guard amplifier and detector 64 and relay coil 66. An automatic gain control circuit 65 is connected respectively between S2 of relay 59 and active/passive IF amplifier 54 and guard IF amplifier 63. This AGC functions causes the sensitivity of the active/passive IF amplifier 54 and Guard IF amplifier 63 to be automatically adjusted in accordance with the jammer power being received such that the fuze functions only when the on-target jammer enters the main beam of antenna 52. This assures burst control so that warhead damage is maximum regardless of the amount of jamming power being radiated. Coupling 67 is provided to feed a portion of the transmitted energy from transmitter 50 to mixers 53 and 62.

In operation, with the absence of electrical countermeasures, the active channel functions in the same manner as the system shown and described in Ser. No. 789,459 previously mentioned. However, in the presence of electrical countermeasures, the signal received by antenna 61 is sufficient to produce an output signal from guard amplifier and detector 64 to actuate relay 59 to the closed position. This connects the passive channel to firing circuit 58 thereby permitting firing circuit 58 to be initiated by the countermeasures signal which has already made the active system in-operative. The sensitivity of IF amplifiers 54 and 63 are controlled by AGC circuit 65 so that switching from active to passive operation will be accomplished at desired signal strengths received by antennas 52 and 61. In the event jammer power is cut off after having previously caused the fuze system to become passive in operation, relay 59 and automatic gain control circuits are automatically de-activated thus restoring full active capability to the fuze system.

Referring now to FIG. 3 there is shown a transmitter 70 having an antenna system 71 coupled thereto for radiating radio frequency energy. Nord amplifier filters and detector 72 and passive amplifier and detector 73 are each connected to receiving antenna 74 through mixer 76 and a portion of potentiometer 77. Amplifier and detecting circuit 72 is connected to firing circuit 75 through relay switch 78 while amplifier and detecting circuit 73 is connected to firing circuit 79 through relay switch 81 and to ground through relay coil 80. Amplifier and detecting circuit 82 is connected to guard antenna 83 through mixer 84 and to ground through relay coil 86 and potentiometer actuating coil 87 respectively.

Antenna systems 71, 74 and 83 have the same transmitting and receiving characteristics respectively as antenna systems 11, 14 and 22 of FIG. 1. Re-radiated energy from a target (not shown) is received through antenna system 74. In the absence of countermeasures, the received energy is coherent and is mixed in mixer 76 with a signal from transmitter 70 by means of coupler 85 to generate a frequency which is detected and amplified in circuit 72 and then fed to firing circuit 75 through relay 78. Provided the target is within a predetermined fuzing range, firing circuit 75 is initiated by the output from amplifier and detecting circuit 72, which in turn causes warhead detonation.

In the case of an off-target jammer, threshold energy levels resulting from countermeasures will be by antenna 74 only when the jammer signal is in the main lobe of the antenna pattern. This energy which is incoherent is mixed in mixer 76 and amplified and detected in both circuits 72, 73. Sensitivity levels of circuits 72, 73 are set such that the output signal of amplifier detecting circuit 73 flowing in relay coil 80 opens relay 78 and prevents the output of circuit 72 from reaching firing circuit 75.

In the case of an on-target jammer countermeasures energy is received through antenna 83 and through the front side lobes of antenna 74. Countermeasures energy received through antenna system 83 is processed through mixer 84 and amplifier detector 82 and applied to relay coil 86 and potentiometer actuating coil 87. A portion of the signal transmitted is coupled by coupler 88 to mixer 84 to provide the reference signal. The sensitivity level of antenna system 83, mixer 84, amplifier detector 82, and relay coil 86 is set such that relay switch 81 will be closed when countermeasures become sufficiently strong to enter the front side lobes of antenna system 74. The sensitivity level of antenna system 83, mixer 74, amplifier detector 82 and coil 87 is set such that the energy level (due to countermeasures signal in front side lobes of antenna system 74) in amplifier detector 73 will be insufficient to activate firing circuit 79. However, when the jammer signal enters the main lobe of antenna system 74 and leaves the forward looking lobe of antenna system 83, there is a sharp shift in the relative amount of energy in amplifier detectors 82 and 73. This is because the decrease of energy in amplifier detector 82 will allow control coil to be de-activated (decreasing the resistance of potentiometer 77 to the incoming signal) at the same time a large increase in gain of the signal received in antenna system 74 occurs. Thus, the energy in amplifier detector 73 is sufficient to activate firing circuit 79. In the event the jammer signal is cut off after having previously caused the fuze system to become passive in operation, potentiometer 77, relay 78 and relay 81 automatically de-activate thus restoring full active capability to the fuze system.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A radio fuze system comprising means for transmitting a radio frequency signal in the direction of a target, first antenna means for receiving only the reflected signals transmitted by said transmitting means, a firing circuit, circuit means coupling said first antenna means to said firing circuit for providing an initiating signal thereto when said received signal has a magnitude of a predetermined value, second antenna means for receiving countermeasures signals, and means coupled to said second antenna means for causing said fuze system to respond to said countermeasures signals to prevent dudding past the target.

2. A radar fuze system comprising means for transmitting a radio frequency signal in the direction of a target, first antenna means for receiving reflected signals transmitted by said transmitting means, a firing circuit, active circuit means coupling said first antenna means to said firing circuit for providing an initiating

signal thereto when said received signal has a magnitude of a predetermined value, second antenna means for receiving countermeasures signals, and circuit means coupled to said second antenna means for rendering said active circuit means passive whereby said fuze system will respond to said countermeasures signal for optimum firing.

3. A radar fuze system comprising means for transmitting a radio frequency signal in the direction of a target, first circuit means responsive to said transmitted signal after being reflected from said target for initiating a firing signal for said fuze system, second circuit means responsive to electronic countermeasures signals for preventing said first circuit means from becoming saturated by said countermeasures signals.

4. A radar fuze system comprising means for transmitting a radio frequency signal in the direction of a target, first circuit means responsive to said transmitted signal after being reflected from said target for initiating a firing signal for said fuze system, second circuit means responsive to electronic countermeasures signals for rendering said first circuit means non-responsive to said transmitted signal and responsive to said countermeasures signals whereby dudding is prevented in the lethal range of said target.

5. A radar fuze system comprising means for transmitting a radio frequency signal in the direction of a target, an active/passive circuit normally operating in the active phase responsive to said transmitted signal after being reflected from said target for initiating a firing signal for said fuze system, guard circuit means responsive to electronic countermeasures signals and having an output proportional to the signal strength of said countermeasures signal, and switch means responsive to the output of said guard circuit means for switching said active/passive circuit means from its normal active phase to its passive phase when the amplitude of said guard circuit output reaches a predetermined amplitude.

6. A radar fuze system comprising transmitter means including an antenna system for transmitting a radio frequency signal in a narrow beam conical pattern in the direction of a target, a first receiving antenna having identical beam characteristics to said transmitting antenna for receiving re-radiated energy from the target, first mixer means coupled to said first receiving antenna and to said transmitter means for generating a doppler output signal, firing circuit means having first and second inputs, active amplifier and detector circuit

means coupled to said first mixer means for generating an output signal proportional to the proximity of the target, passive amplifier and detector circuit means coupled to said first mixer means for generating an output signal proportional to the proximity of a countermeasures signal, circuit means coupling the output of said active amplifier and detector circuit means directly to the first of said firing circuit inputs, circuit means including a switch having a first and second position coupling the output of said passive amplifier and detector circuit means to the second of said firing circuit inputs, a second receiving antenna having beam characteristics which excludes the signal transmitted from said transmitter and receptive to all other signals of the operating frequency of said fuze system, second mixer means coupled to said second receiving antenna and to said transmitter means for generating a doppler output signal, guard amplifier and detector circuit means coupled to said second mixer means for generating an output signal proportional to countermeasures signals received in said second receiving antenna, switch actuating means coupled to said guard amplifier and detector circuit means for actuating said switch from said first position to said second position when the output signal of said guard amplifier and detector reaches a pre-determined value, whereby said passive amplifier and detector is connected to the second input of said firing circuit.

7. The system of claim 6 including means for controlling the threshold value at which the system is switched from active to passive in the presence of countermeasures signals.

8. A radar fuze system comprising means for transmitting a radio frequency signal in the direction of a target, first and second firing circuits first circuit means coupled to said first firing circuit including a first receiving antenna responsive to said transmitted signal after being reflected from said target for generating a firing signal to initiate said first firing circuit, second circuit means coupled to said first and second firing circuits including a second receiving antenna for deactivating said first firing circuit and activating a second firing circuit in response to received countermeasures signals, and third circuit means including said second firing circuit responsive to said countermeasures signals received in said first receiving antenna for initiating said second firing circuit.

* * * * *

50

55

60

65