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Cash et al.

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[54] **AUTOMATIC ACTIVE/PASSIVE FUZE SYSTEM**

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[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**

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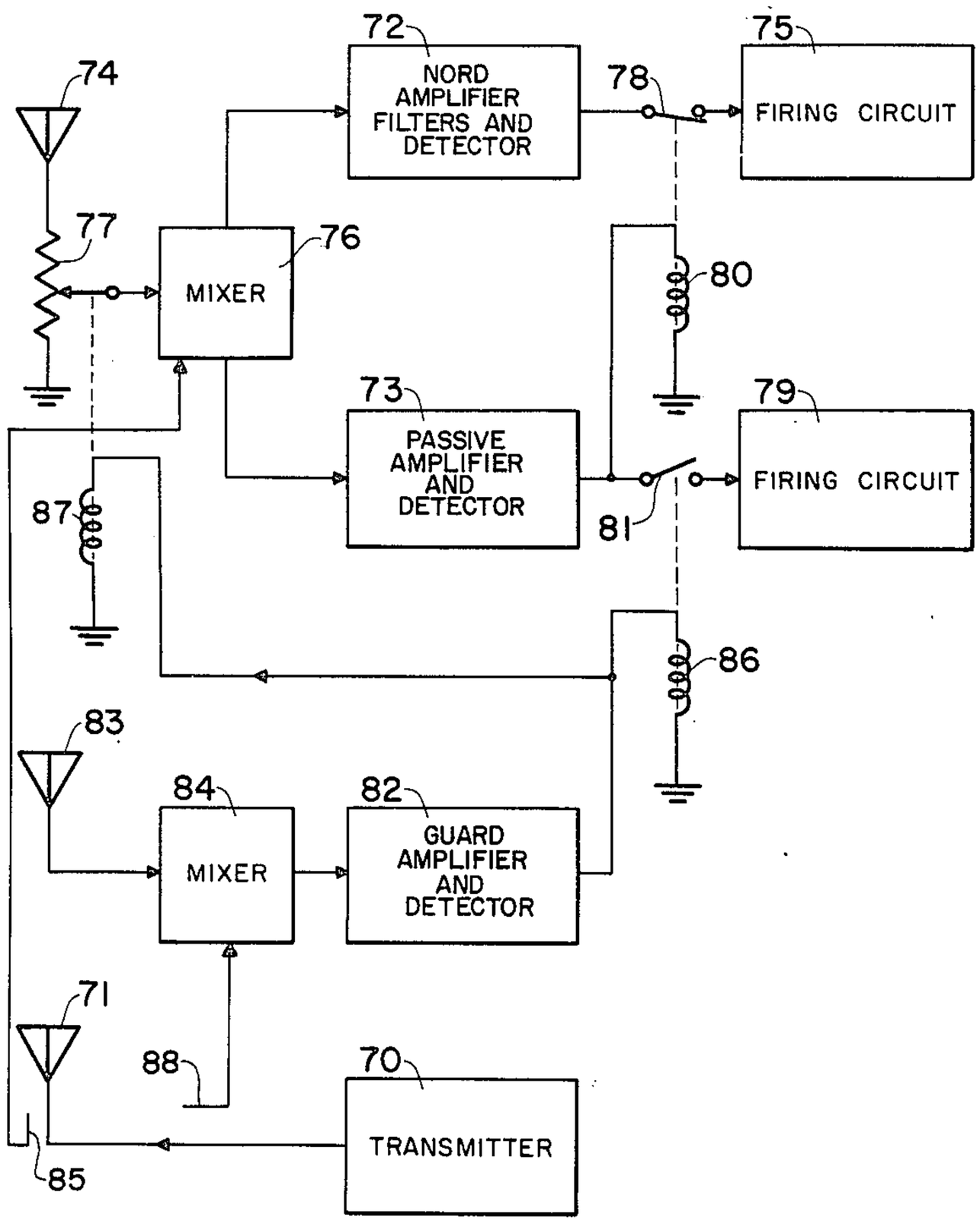
EXEMPLARY CLAIM

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.

8 Claims, 3 Drawing Figures



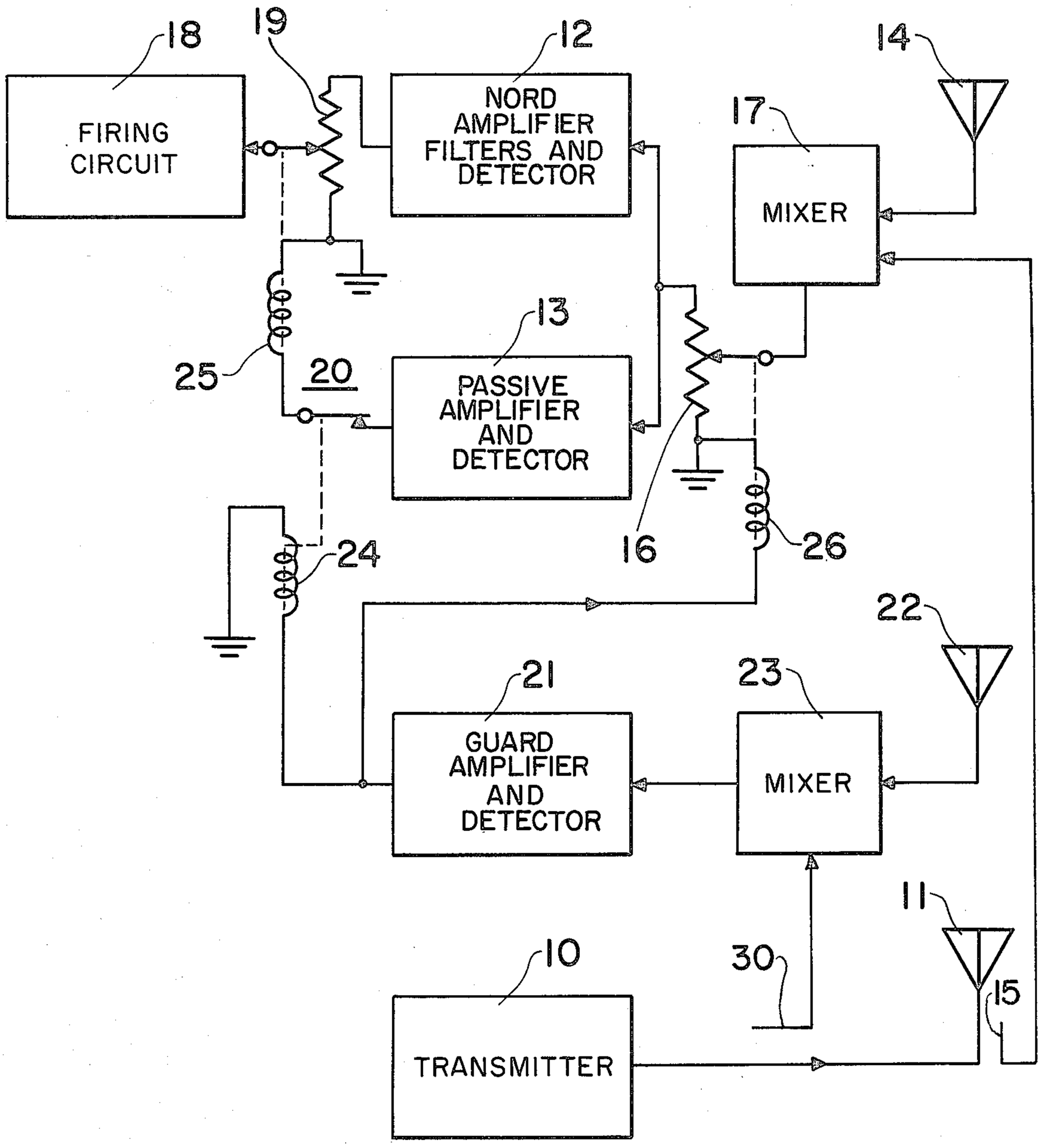


FIG. 1

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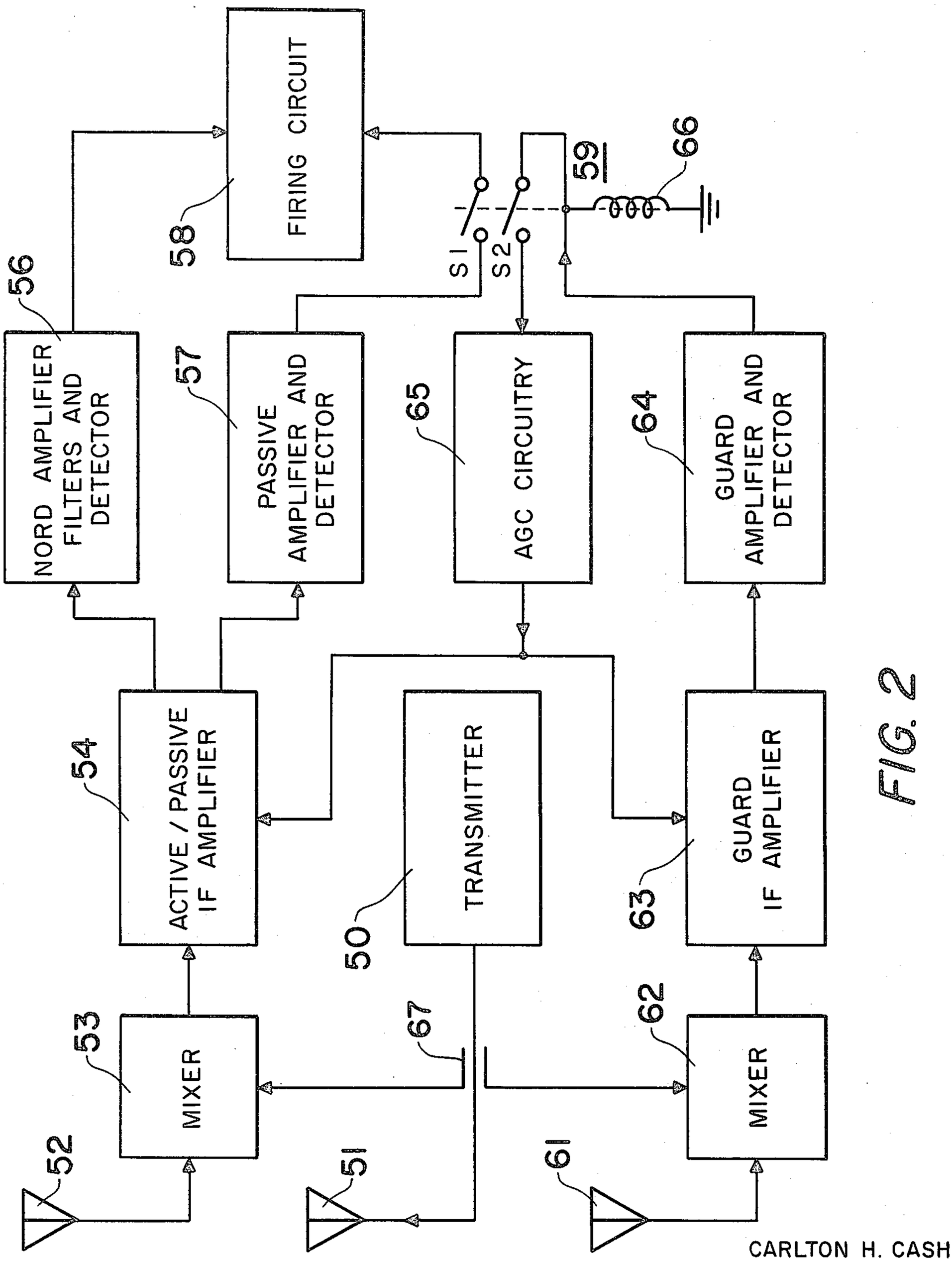

FIG. 2

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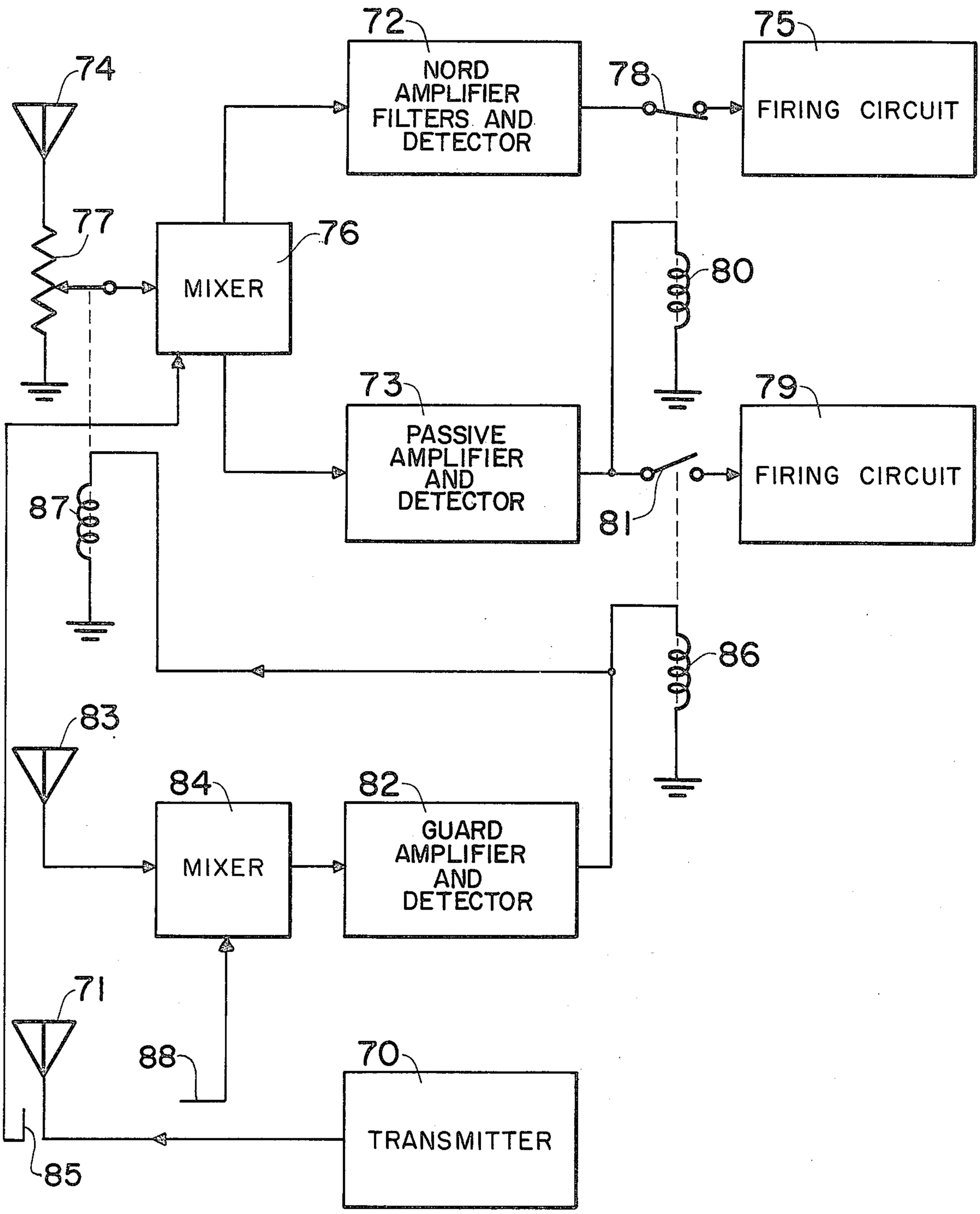

FIG. 3

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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 emboding 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 deactivated (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 deactivate 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 nonresponsive 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.

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