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[54] **PULSE DOPPLER FUZE**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy**

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[58] **Field of Search**.....343/7 PF, 13 SA; 102/70.2 P

[56] **References Cited**

UNITED STATES PATENTS

2,556,109	6/1951	Rust et al.	343/12
2,573,762	11/1951	Free et al.	343/12
2,312,194	2/1943	Roder	179/171.3
2,369,030	2/1945	Edwards	179/171.3
2,403,624	7/1946	Wolff	250/17.555
2,431,344	11/1947	Reeves	343/13
2,511,086	6/1950	Tellier et al.	250/36.18
2,524,494	10/1950	Wood et al.	250/15 T
2,553,018	5/1951	Stafford	343/13
2,554,308	5/1951	Miller	250/6.18
2,643,288	6/1953	Philpott	250/36.18
2,416,367	2/1947	Young, Jr.	343/13
2,415,317	2/1947	Wheeler	250/20.26
2,498,495	2/1950	Jensen	250/20.26

FOREIGN PATENTS OR APPLICATIONS

585,791	2/1947	Great Britain	343/7

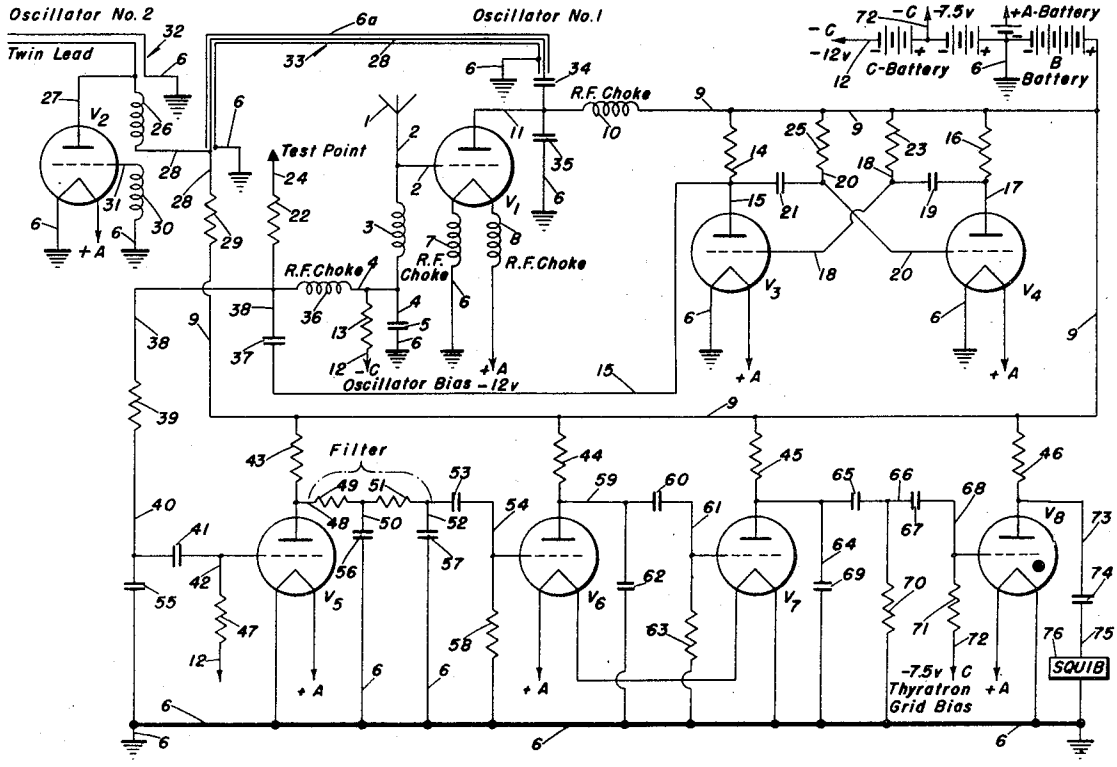
Primary Examiner—T. H. Tubbesing

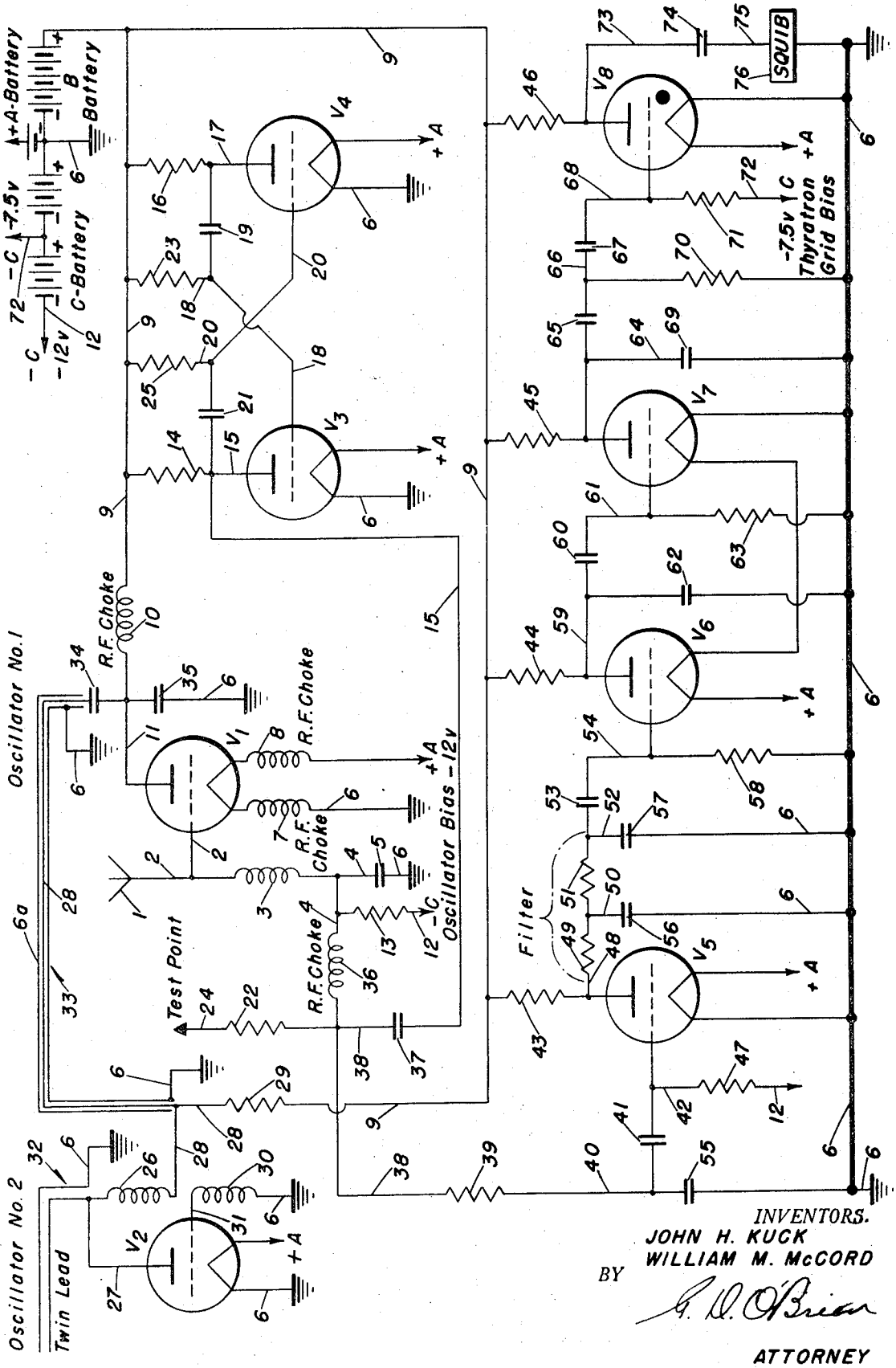
Attorney—Q. E. Hodges and Q. B. Warner

EXEMPLARY CLAIM

1. In a proximity fuze circuit, an antenna a normally ineffective superregenerative radio frequency oscillator coupled to said antenna, said oscillator generating a radio signal to be radiated by said antenna and developing a detected output correlative to the difference between said generated signal and any reflected portion thereof intercepted by said antenna during the period of effectiveness of said oscillator, a multivibrator coupled to said oscillator for applying periodic impulses of a constant duration and repetition rate thereto thereby rendering said oscillator effective for a predetermined period after each of the applied impulses, a second radio frequency oscillator coupled to said superregenerative oscillator and operating at substantially one-half of the natural frequency of said superregenerative oscillator, a source of electricity energizing said superregenerative oscillator, said second oscillator, and said multivibrator, said second oscillator providing a second harmonic signal to said superregenerative oscillator having an amplitude level large relative to the level of any spurious noises thereby to effect constancy in the initiation of each period of effectiveness and to render said detected output insensitive to weak external signals, such as spurious jamming signals.

4 Claims, 1 Drawing Figure





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PULSE DOPPLER FUZE

The present invention relates to proximity fuzes, and more particularly to a type of pulsed proximity fuze which operates on the Doppler principle, emitting discrete pulses of radiation instead of continuously radiating signals.

Heretofore in conventional proximity fuzes it has been customary to generate and radiate continuously a radio frequency signal of substantially constant amplitude. Upon reflection of this signal from a target, a heterodyne signal was produced, usually in the audio frequency range. A serious objection to such continuous signal emitter is that while it is substantially immune to sweep jamming, it is not immune to jamming by an enemy using a repeater type of jammer.

An object of the present invention, therefore, is to provide a proximity fuze circuit that is modified so as not to be subject to the above mentioned susceptibility to repeater jamming, without serious loss in its original degree of immunity to sweep jamming.

Another object is to provide an improved proximity fuze circuit which emits radio-frequency signals in discrete pulses instead of continuously.

A further object is to provide a fuze employing a superregenerative oscillator.

Other objects and many of the attendant advantages of this invention will be appreciated readily as the same becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein the single FIGURE is a circuit diagram, illustrating one embodiment of the invention.

The circuit may be divided arbitrarily into several units, for convenience in explaining the connections and phenomena involved. These units, as here selected, comprise: (1) a superregenerative oscillator; (2) a multivibrator; (3) an auxiliary continuous wave oscillator; and (4) an amplifier.

The superregenerative oscillator herein disclosed by way of example, employs the electronic tube V_1, here preferably a triode of sub-miniature type. An antenna **1** is connected to the grid of V_1, by a wire **2**. An inductance **3** is connected at one end to said wire **2** and its other end to a wire **4**, then through a capacitor **5** to ground **6**. The interelectrode capacitances between the cathode and each of the other electrodes, of course, also provide essential coupling. The tube V_1 has a filamentary cathode, energized by an A-battery of 1.5 volts. Radio frequency choke coils **7** and **8** are connected in the ground lead **6** and the +A lead respectively of said filament, to avoid short-circuiting the interelectrode capacitance between the anode and the cathode and to keep the oscillations out of the battery circuits.

Anode power is supplied to V_1 from the positive terminal of a B-battery, suitably one supplying 180 volts, through wire **9**, a radio frequency choke coil **10**, and wire **11**. Negative bias is furnished to the grid by the full 12 volt C-battery through wire **12** and resistor **13**, and this bias is sufficient to maintain the said grid so negative that normally tube V_1 will not oscillate.

However, to neutralize this bias is the function of the second unit, the multivibrator. This unit comprises the two triodes V_3 and V_4 and the circuits interconnecting them. Each tube, here likewise assumed as of a subminiature type, has a filamentary cathode, grounded at

6 at one end and connected to +A at its other end. Anode power is derived from wire **9**, which is connected to the anode of V_3 through resistor **14** and wire **15**, and to the anode of V_4 through resistor **16** and wire **17**. The grid of V_3 is connected to the anode of V_4 by wire **18**, with blocking capacitor **19** therein, and similarly the grid of V_4 is connected to the anode of V_3 by wire **20** with blocking capacitor **21**. A connection through wire **18** from the grid of V_3 through resistor **23** to wire **9** and a similar connection through wire **20** from the grid of V_4 through resistor **25** to wire **9** complete the multivibrator. The multivibrator output is delivered from the anode of V_3 through wire **15**, capacitor **37**, wire **38** and radio frequency choke coil **36** to the grid circuit of oscillator V_1, as shown.

The auxiliary radio frequency oscillator uses the triode V_2. This has a filamentary cathode shown, energized from the A-battery. An anode inductance **26** is connected at one end to the anode of V_2 through wire **27** and at its other end is connected through wire **28** and resistor **29** to the wire **9**, which as already mentioned is the positive terminal of the B-battery, so that the anode power is thus supplied to V_2. Inductively coupled to the anode inductance **26** is the grid inductance **30**, one end of which is connected to ground wire **6**, while its other end is connected to the grid of V_2 through wire **31**.

Wires **6** and **27** are combined into a twin lead, indicated as a whole by reference character **32**. This twin lead, wherein the two conductors lie closely parallel to each other, acts as a trimmer capacitor, and is adjusted to the desired capacitance by repeated clipping-off of its free end until the frequency of preferably the second harmonic of the oscillations produced by the auxiliary oscillator V_2 is sufficiently close to the frequency generated by the pulsed oscillator V_1.

While, of course, it is not essential that the second harmonic be used, and theoretically the fundamental frequency would serve equally well, it has been found by experiment that more stable operation and greater immunity to jamming may be attained by the use of such harmonic.

The output of the auxiliary oscillator V_2 is delivered through wire **28**, which is preferably the central conductor of a coaxial cable **33** whose outer conductor **6***a* is grounded as shown at both ends, then through capacitor **34**, and wire **11** to the anode of V_1, another capacitor **35** being connected as shown. The capacitor **35** acts as a radio frequency by-pass for both oscillators, V_1 and V_2. This capacitor, however, has sufficient impedance to act also as a common coupling impedance, for the purpose of coupling energy from oscillator V_2 to oscillator V_1.

The fourth unit is the amplifier containing the three triodes V_5, V_6 and V_7 and the thyratron V_8, likewise shown as a triode. The amplifier input signal is derived from oscillator V_1 and passes through wire **4**, radio-frequency chock coil **36**, wire **38**, resistor **39**, wire **40**, capacitor **41** and wire **42** to the grid of V_5.

In the specific example illustrated here, the filamentary cathodes of V_5 and V_8 are individually energized by a 1.5 volt A-battery, but the filaments of V_6 and V_7 which require lower voltages are connected in series, thus each receiving only 0.75 volts. This is a customary expedient in proximity fuzes, and its object is to

decrease the current drain on the necessarily small A-battery. The anode power is derived from the conductor **9**, suitably the positive terminal of a 180 volt battery, which is connected to the anodes of the successive tubes V_5, V_6, V_7 and V_8 through resistors **43**, **44**, **45** and **46** respectively. The grid of V_5 is connected through wire **42**, resistor **47** and wire **12** to the negative terminal of the C-battery, and thus normally biased at the full C-voltage, here assumed to be negative 12 volts.

The anode of V_5 is coupled to the grid of V_6 through wire **48**, resistor **49**, wire **50**, resistor **51**, wire **52**, capacitor **53** and wire **54**. Capacitors **55**, **56** and **57**, and resistor **58** are connected as shown, between the ground wire **6** and the various points indicated on the drawing.

The anode of V_6 is in turn coupled to the grid of V_7 through wire **59**, capacitor **60** and wire **61**, with capacitor **62** and resistor **63** connected as shown.

The anode of V_7 is similarly coupled to the grid of the thyratron V_8 through wire **64**, capacitor **65**, capacitor **67** and wire **68**. Capacitor **69** and resistor **70** are connected as shown, between the ground **6** and the points indicated. Resistor **71** is connected at one end to wire **68** and at its other end to wire **72** which leads to a negative 7.5 volt tap of the C-battery, thus normally maintaining said bias on the thyratron grid.

The output of thyratron V_8 is delivered from its anode through wire **73**, capacitor **74**, wire **75** and squib or detonator **76** to ground **6**, whenever the thyratron fires.

For the purpose of checking the operativeness of the circuit, a high resistance resistor **22** is shown connected to wire **38**, with a wire **24** leading to a suitable test point. The voltage at this point may be measured with a high-resistance vacuum tube voltmeter, to determine the reaction sensitivity of the fuze oscillator V_1, when it is being tested under simulated service conditions, so-called "pole-testing".

While suggested values of a few components, voltages, etc., of the fuze circuit have been indicated, it is to be understood that such values represent merely one specific set of suitably interrelated magnitudes and that many other sets are also possible. Hence the values given are to be taken solely in an illustrative and not a limitative sense.

It will also be understood that in a proximity fuze the antenna is customarily a conical metal cap or thimble mounted on, or embedded in, the tip or nose of the fuze, while the ground connection is made to the metal base of said fuze, which screws on the shell or other projectile, whereby the shell body or the like acts as the "ground".

The operation of the fuze circuit is as follows:

In the present system, the tube V_1 is arranged and connected in a superregenerative circuit, but has a high initial negative bias on its grid, which increases to self-blocking valves automatically in the normal operation of the circuit. In order to overcome this bias, positive pulses are fed to the grid circuit of V_1 from the multivibrator. This multivibrator yields pulses of very short duration, separated by inactive intervals of much greater length. Upon feeding a suitable pulse to the grid of V_1 the bias is momentarily decreased sufficiently to permit self-oscillation to occur. A group of oscillations then builds up rapidly, but soon again "blocks" the tube, before the multivibrator pulse itself ends. For instance, the multivibrator pulse might last for 10 microseconds, whereas the "superregenerative" radiation lasts for only one-half microsecond. During the interval between the multivibrator pulses, however, the excess electrons drain away through the grid resistor **13**, thus restoring the normal −12 volt bias. However, this still prevents resumption of the superregenerative action until the next positive pulse from the multivibrator again neutralizes said bias sufficiently to permit such superregenerative oscillation to ensue. The same procedure thus is repeated over and over, in step with the initiating pulses.

The multivibrator pulse periodicity is uniform but the starting point of the superregenerative oscillator is not uniform unless the signal from the auxiliary, continuous wave, oscillator V_2 is injected.

If the auxiliary oscillator V_2 were not present, the oscillator V_1 would be subject to erratic starting time, due to the fact that oscillation would then be initiated by any random noise signal, of sufficient amplitude, which does not always occur uniformly as to time. However, the auxiliary oscillator V_2 avoids this difficulty, by providing a continuous succession of signals of uniform amplitude, so that at most a delay of one-half cycle could occur. Since the second harmonic of the frequency of this auxiliary oscillator is near the frequency of the oscillator V_1 and its amplitude is large compared to the random noise level, to all intents the oscillator V_1 may be considered to start instantaneously upon receipt of the pulse from the multivibrator.

The primary function of the said auxiliary oscillator V_2 is to eliminate noise output in the detected signal output from the oscillator V_1 and a secondary function is to reduce the supersensitivity at the very start of the pulse, that is, the high amplification that is characteristic of superregenerative oscillators, thus making the fuze less sensitive also to certain forms of jamming other than repeater jamming.

The amplifier unit is of the resistance-capacitance coupled type and here includes three stages plus the final thyratron stage. Grid leak type of detection occurs in the oscillator V_1 and the resulting audio-frequency signal is fed to the first amplifier tube, V_5.

This amplifier has some unusual features, not ordinarily incorporated in the conventional proximity fuze amplifiers, namely, increased filtering and a low-grain first stage based on a low-mu tube, so biased that it permits a large signal swing on its grid without becoming overloaded, and consequently losing gain in this stage due to clipping.

For example, the circuit that contains capacitor **56**, wire **50** and resistor **49** may act as a filter of relatively low impedance, with respect to the output of tube V_5, whereas the next following circuit, containing capacitor **57**, wire **52** and resistor **51** acts as a filter of relatively higher impedance. As an illustration, and without necessarily restricting the components to any specific magnitudes, it may be stated that in one embodiment of the amplifier circuit resistor **49** was 5000 ohms and capacitor **56** was 0.04 mfd, while resistor **51** was 500,000 ohms and capacitor **57** was 500 mmfd. These circuits thus constitute a cascade-connected filter circuit, wherein the second filter has many times the impedance of the first.

These features are made necessary by the fact that the oscillator output contains, in addition to the normal ripple-frequency component, also a higher-frequency signal of much greater amplitude than the ripple signal. Said higher-frequency signal, which specifically is of the repetition frequency of the multivibrator, that is, 10 to 20 kilocycles, must be filtered out and rejected in the amplifier. The amplifier filtering is so proportioned that this higher-frequency component is removed without serious attenuation of the ripple frequency by the filters.

The operation of the squib **76** by the thyratron V_8 is conventional. Briefly, when the thyratron fires, upon receipt of a grid signal sufficiently positive to decrease the normal grid bias momentarily to a value that permits such firing to occur, the thyratron becomes ionized and thus of very low resistance. This permits the capacitor **74**, whose discharge current must be sufficiently large to actuate the squib **76**, which usually requires about one microfarad capacitance, to discharge rapidly through the said squib and the ionized gas-content of the thyratron, thus igniting the squib, which in turn brings about detonation of the shell or the like to which the fuze is attached.

It may be well to point out that while the charging current of capacitor **74** also passes through the squib **76**, said current is limited by the high resistance of resistor **46**, so that it is not capable of igniting the squib. However, in time the capacitor nevertheless becomes charged to substantially the full voltage of the "B-battery". When thus charged, the capacitor can deliver a powerful current pulse upon discharge through the ionized thyratron.

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. In a proximity fuze circuit, an antenna, a normally ineffective superregenerative radio frequency oscillator coupled to said antenna, said oscillator generating a radio signal to be radiated by said antenna and developing a detected output correlative to the difference between said generated signal and any reflected portion thereof intercepted by said antenna during the period of effectiveness of said oscillator, a multivibrator coupled to said oscillator for applying periodic impulses of a constant duration and repetition rate thereto thereby rendering said oscillator effective for a predetermined period after each of the applied impulses, a second radio frequency oscillator coupled to said superregenerative oscillator and operating at substantially one-half of the natural frequency of said superregenerative oscillator, a source of electricity energizing said superregenerative oscillator, said second oscillator, and said multivibrator, said second oscillator providing a second harmonic signal to said superregenerative oscillator having an amplitude level large relative to the level of any spurious noises thereby to effect constancy in the initiation of each period of effectiveness and to render said detected output insensitive to weak external signals, such as spurious jamming signals.

2. In a proximity fuze circuit, an antenna for radiating a radio signal into the surrounding spatial region and for intercepting any portion thereof reflected from a target in the spatial region, a superregenerative radio frequency oscillator coupled to said antenna and including a normally non-conductive electron discharge tube, said oscillator generating a radio signal to be radiated by said antenna upon said tube being rendered conductive and developing a detected output having an instantaneous frequency correlative to the difference between the generated signal and any portion thereof intercepted during the conductive period of said tube, a multivibrator coupled to said oscillator for applying to said tube a single train of periodic impulses of constant repetition rate and uniform duration for rendering said tube periodically conductive during a portion of the duration of each of the applied impulses, a second oscillator coupled to said superregenerative oscillator and operating at substantially one-half of the natural frequency of said superregenerative oscillator, said second oscillator providing a second harmonic signal to said tube having an amplitude level large relative to the level of any spurious noises thereby to effect constancy in the initiation of each period of effectiveness of said superregenerative oscillator and to render its detected output insensitive to weak external signals, such as spurious jamming signals, and means selectively responsive to the frequency of said detected output for exploding the proximity fuze at a lethal range from the target.

3. In a circuit, an antenna, a superregenerative oscillator coupled to said antenna and including an electron discharge tube having at least a grid and an anode, said tube being normally biased to be non-conductive, said oscillator generating an electromagnetic signal to be radiated by said antenna and developing a detected output correlative to the frequency difference between the generated signal and any reflected portion thereof intercepted by said antenna during the conduction period of said tube, biasing means coupled to said grid for normally maintaining said tube non-conductive, a multivibrator coupled to said tube for applying to the grid thereof impulses of constant duration and rate of repetition, each of said impulses having an amplitude suitable for overcoming the effect of said biasing means and render said tube periodically conductive during a preselected portion of the duration of each of the applied impulses, and a continuous wave oscillator coupled to said tube anode in said superregenerative oscillator and operating at substantially one-half of the natural frequency of said superregenerative oscillator, said continuous wave oscillator providing a second harmonic signal having an amplitude level large relative to the level of any spurious noises thereby to effect a constancy in the buildup of oscillations of said superregenerative oscillator in response to each of the applied impulses and to render its detected output insensitive to weak external signals, such as spurious jamming signals.

4. In a circuit for a radio proximity fuze, an antenna for radiating a radio signal into the surrounding spatial region and for intercepting any portion thereof reflected from a target, a normally ineffective first radio frequency oscillator coupled to said antenna and functioning as a transmitter-detector during the period of effectiveness thereof whereby said oscillator

generates a radio signal to be radiated by said antenna means and develops a detected output correlative to the frequency difference between the generated signal and any reflected portion intercepted during said period of effectiveness, a pulse source coupled to said oscillator and emitting pulses of a predetermined constant repetition rate and uniform length, a second radio frequency oscillator coupled to the said first oscillator and operating at substantially one-half of the natural frequency of said first oscillator, said second oscillator continually providing a second harmonic signal to said first oscillator of a preselected amplitude to effect a constancy in the buildup of oscillations of said first oscillator in response to each of the applied impulses and to render its detected output insensitive to weak external signals, such as spurious jamming signals, an amplifier circuit coupled to said first oscillator for developing an initiating signal in response to a detected output of a predetermined frequency, and electroresponsive ignition means responsive to said initiating signals for detonating the proximity fuze.

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