Jan. 19, 1965 M. A. TUVE ETAL 3,166,015

RADIO FREQUENCY PROXIMITY FUZE

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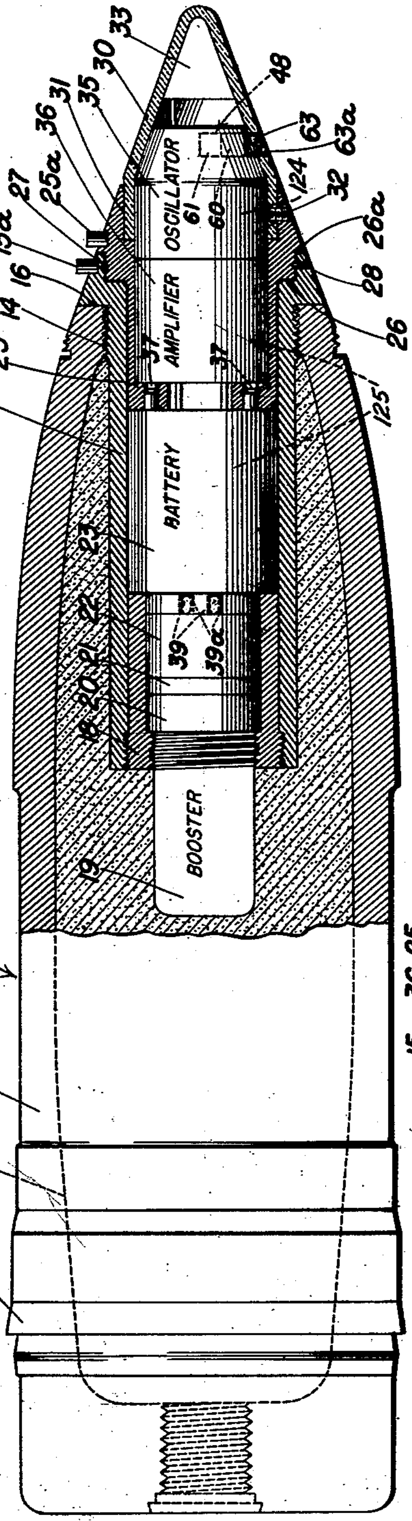

FIG.1.

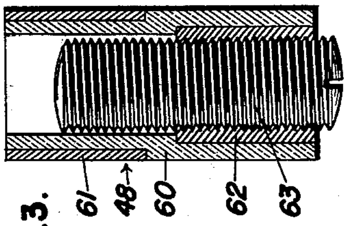

FIG.3.

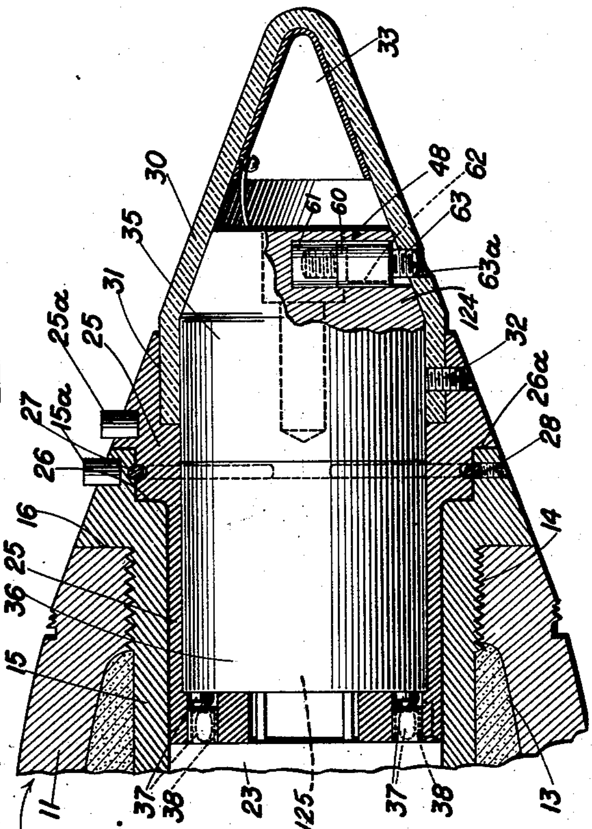

FIG.2.

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RADIO FREQUENCY PROXIMITY FUZE

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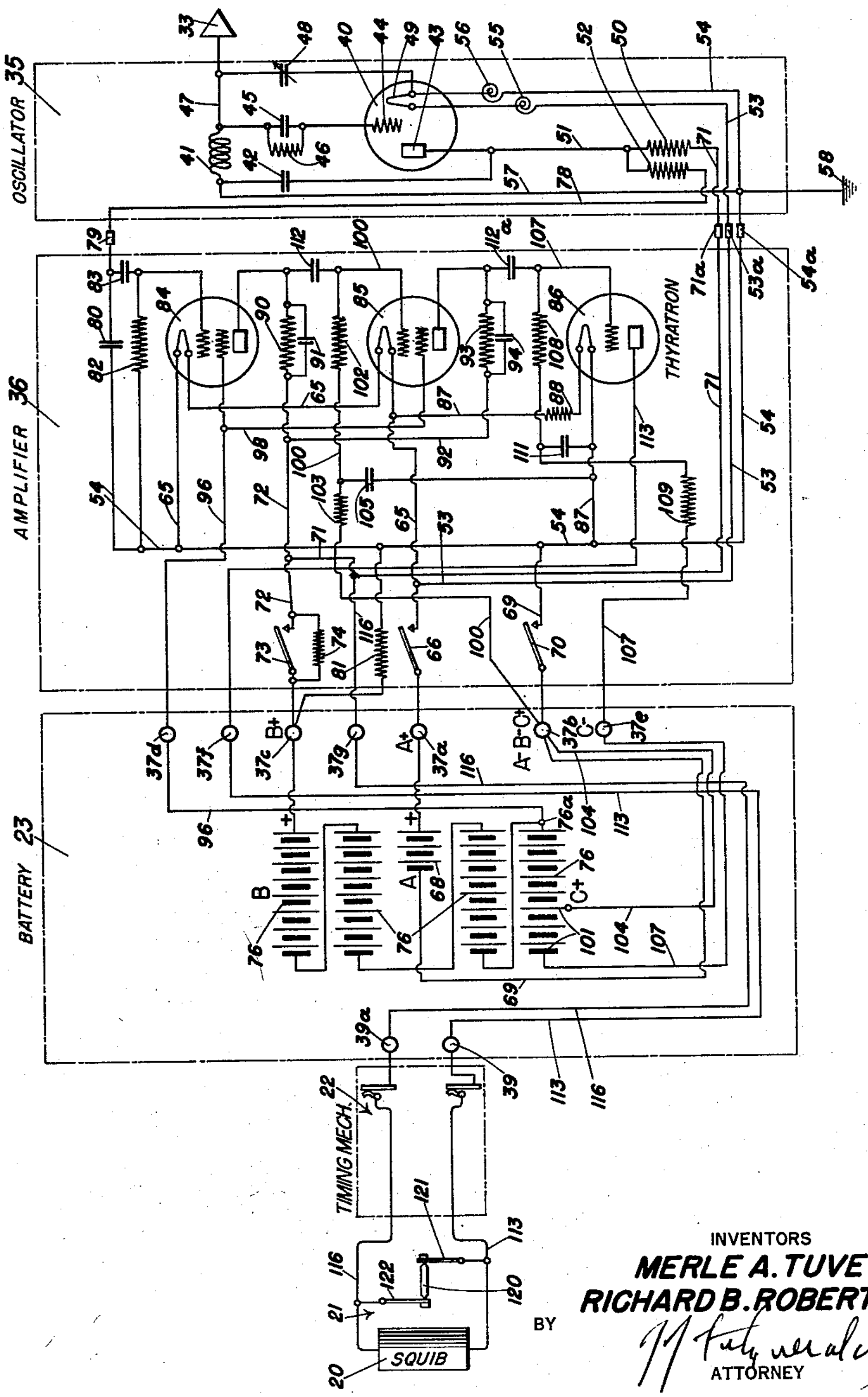
FIG. 4



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RADIO FREQUENCY PROXIMITY FUZE

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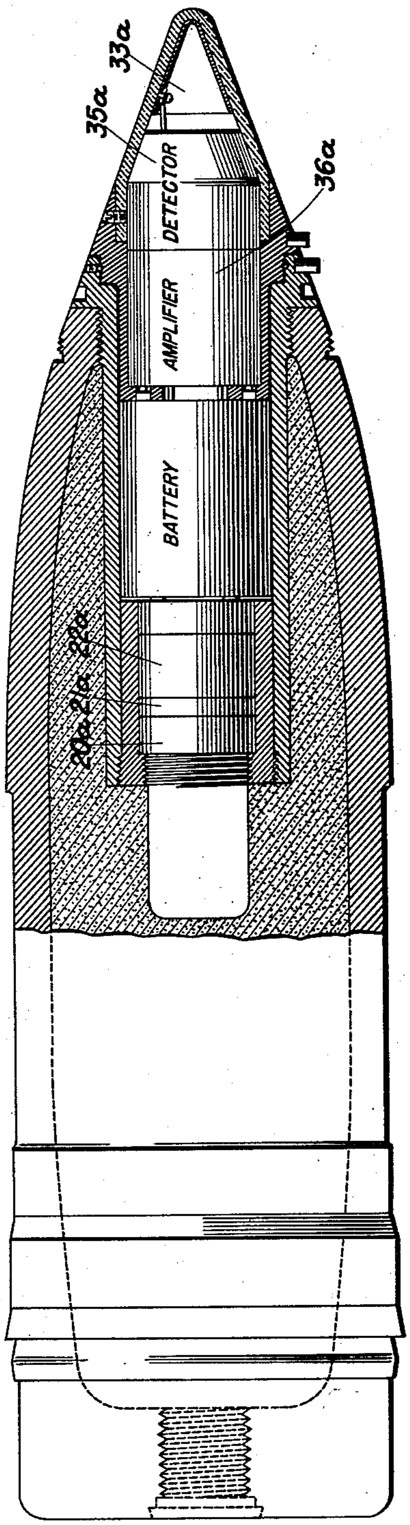

FIG.5.

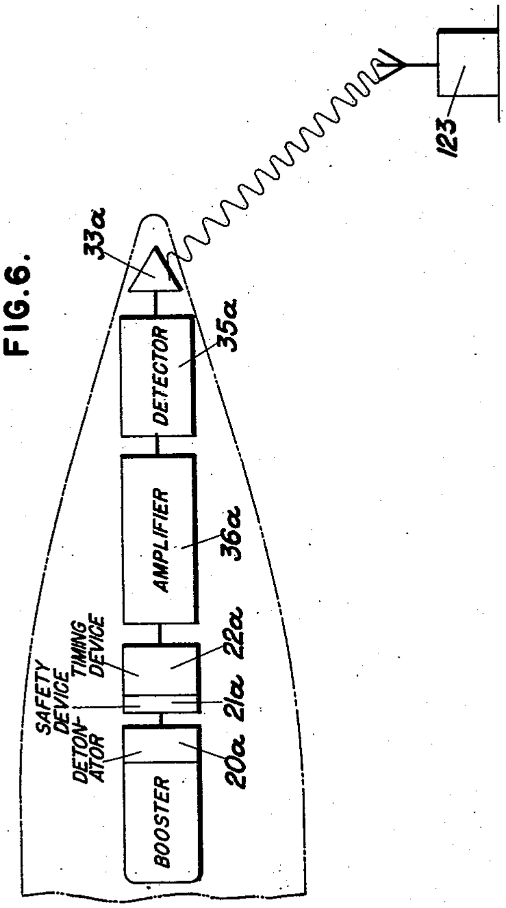

FIG.6.

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RADIO FREQUENCY PROXIMITY FUZE

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Filed Jan. 6, 1943, Ser. No. 471,388
10 Claims. (Cl. 102—70.2)

This invention relates to radio-controlled fuzes for detonating explosive projectiles in proximity to a target, and has particular reference to a novel radio-controlled proximity fuze of rugged and compact construction which is positive and reliable in operation, and may be manufactured in large scale production. While the new fuze is adapted for use in bombs, rockets and other forms of projectiles, it may be used to particular advantage in antiaircraft projectiles, and, therefore, the invention will be described in connection with such a projectile, although it will be understood that it is not limited to this use.

Explosive projectiles of the common types, which include a time fuze or an impact fuze, or a combination of both, are not entirely satisfactory because their effectiveness depends upon a direct hit or upon accurate setting of the fuze timing mechanism, which are difficult to obtain due to the human factor. Also, unexpected changes in the position of the target between the time when the fuze is set and the time when the projectile explodes tend to nullify accurate setting of the timing mechanism. It has been proposed to overcome these objections to the present fuzes by using a means for automatically detonating the fuze in response to proximity of the target, and various forms of proximity fuzes have been devised. In one form, light waves from the projectile are reflected by the target back to a photoelectric receiver in the projectile as it passes the target, the receiver being operable by the reflected light waves to detonate the fuze. Fuzes of this type are objectionable for the reason that they may be operated prematurely by light from some other source than the target. In another form of proximity fuze, sound waves from the target impinge upon a receiver in the projectile, and the receiver is connected to the fuze so as to cause detonation when the sound waves are of sufficient amplitude. It has been found that fuzes of this type are unsatisfactory, at least in antiaircraft projectiles, because the projectile in its flight tends to set up vibrations which actuate the sound receiver independently of the target and thereby cause premature explosion.

It has also been proposed to employ radio waves for controlling a projectile when it is fired at a target. In one form of projectile, radio transmitter and receiver units mounted in the projectile body control the propectile by reflection of radio waves from the transmitter to the receiver by the target. Devices of this type have the advantage that they are not so easily influenced by external sources to cause false actuations. The prior devices of this type, however, are unsatisfactory because no provision is made for withstanding the severe shocks incident to firing the projectile from a gun, and the construction is so intricate and bulky that it is not adapted for mass production and cannot be used in ordinary projectiles.

One object of the present invention, therefore, resides in the provision of a novel radio-operated proximity fuze which is adapted for use in projectiles of standard forms and is positive and reliable in operation. A fuze made in accordance with the invention comprises an oscillator circuit coupled to an antenna, an amplifier, which may have detector action, connected to a suitable point in the oscillator circuit, and a thyratron connected to the output of the amplifier so that it is triggered by a change of predetermined magnitude in the radiation resistance of the antenna due to the proximity of a reflecting surface,

such as an aircraft. A detonating squib electrically connected to the thyratron is operated when the thyratron is triggered. The signal incident to the detection of the reflected radiation is characterized by an increasing amplitude and a decreasing frequency until the projectile containing the fuze passes the target. The frequency depends upon the relative velocities of the projectile and the target along a line joining them, whereas the amplitude depends upon the radiation pattern of the fuze and the distance of the target and also upon the target's reflection pattern.

Another object of the invention is to provide a radio-operated proximity fuze having a thyratron for firing the detonator, and a safety device for preventing premature triggering of the thyratron. The safety device preferably comprises a biasing circuit for the thyratron, including a resistor adapted to retard the charging of an associated condenser and thereby delay triggering of the thyratron until the projectile is at a safe distance from the gun.

Another object of the invention resides in the provision of means for initially short-circuiting the detonating circuit to avoid setting off the detonator accidentally, the short-circuiting means comprising a switch responsive only to a force incident to firing the projectile, such as centrifugal action, for breaking the short-circuit.

A further object of the invention is to provide a novel proximity fuze comprising dual means for detonating a squib, one of the detonating means being operable electrically in response to proximity of a target, and the other being operable mechanically by timing mechanism for insuring explosion of the projectile in the event that it does not pass near enough to the target to operate the proximity responsive means. Preferably, the mechanically operable means are included in the operating train of the proximity responsive means, whereby the fuze may be made in a compact form. Also, in the preferred construction, the proximity responsive means includes a unit at the nose of the projectile which is movable to adjust the timing of the mechanically operable means.

Still another object of the invention resides in the provision of a novel arrangement of the operating means of a radio-operated proximity fuze, by which the construction is sufficiently rugged to withstand the shock incident to firing a projectile from a gun.

These and other objects of the invention may be better understood by reference to the accompanying drawings, in which:

FIG. 1 is a side view of a projectile embodying one form of the new fuze, with part of the projectile broken away;

FIG. 2 is an enlarged longitudinal sectional view of part of the fuze shown in FIG. 1, with parts broken away;

FIG. 3 is an enlarged sectional view of a variable condenser in the oscillating circuit of the fuze;

FIG. 4 is a schematic view of the fuze, showing the electrical circuits;

FIG. 5 is a view similar to FIG. 1 but showing a modified form of the fuze, and

FIG. 6 is a schematic view of the fuze shown in FIG. 5.

The new fuze, as shown, is mounted in an antiaircraft projectile 10 comprising a casing 11 having the usual rotation-producing band 12 and a chamber 13 containing the explosive charge. At its nose the casing is provided with an opening 14 into which a cylinder or can 15 is threaded, the can having an external shoulder 16 engaging the adjacent end of the casing when the can is tightened in the opening. The can projects rearwardly into chamber 13 and has an adapter ring 18 threaded in its inner end for mounting the usual booster 19. The ring 18 also serves as an encasement for a detonator squib 20 in front of the booster, a safety device 21 in front of the squib, and a timing mechanism 22 in front of the safety device. The timing mechanism 22 may be of any desired form and may include a firing pin (not shown) operable through the safety device 21 to explode the detonator or squib 20 when a predetermined time interval has elapsed after firing of the projectile from a gun, depending upon adjustment of the timing mechanism by rotation of its forward part in the ring 18, as will be described in greater detail presently.

Rotatably mounted in the can 15 in front of the timing mechanism is a battery case 23 which abuts against the adjacent end of the adapter ring 18, the case serving to hold the units 20, 21 and 22 firmly in position in the ring. The battery case, in turn, is held in position by a can 25 disposed in the forward end portion of the outer can 15 and having external shoulders 26 and 26*a* engaging corresponding shoulders on the outer can. The inner can 25 is secured against axial movement in the outer can 15 by means of an open ring key 27 engaged in complementary grooves in the two cans, as shown in FIG. 2. While the ring 27 holds the inner can firmly against the battery case 23, it permits rotation of the inner can relative to the outer can and the projectile casing. A screw 28 threaded through the outer can 15 maintains the ring 27 in its effective keying position.

A conical housing 30 made of insulating material is held in a recess 31 in the forward end of can 25 by a set screw 32 and forms the nose of the projectile. The projectile is provided with a conical antenna 33 which, as shown, is mounted within the housing 30, although the antenna may, if desired, be disposed on the outside of the housing.

The inner can 25 contains a radio-frequency oscillator unit 35 to the rear of the antenna 33 and coupled thereto, and to the rear of the oscillator unit is an amplifier 36, the oscillator and amplifier units being connected together by plug-and-socket connections to be described presently, whereby they are rotatable as a single unit with the inner can 25. The amplifier 36 is connected to the battery 23 by plug 37 engaged in sockets 38 formed in hollow bosses on the battery case which project into openings in the rear end of the inner can. The battery case 23 in turn is connected at its rear end to the timing mechanism 22 by plug-and-socket connections 39 and 39*a* for conducting current to the safety unit 21 and the detonator. The timing mechanism 22 may be adjusted for any desired time interval by simply engaging lug 25*a* and rotating the housing so as to turn the forward part of the timing mechanism through the inner can 25 and the battery case. The setting of the timing mechanism may be indicated by the relative positions of the timing lugs 15*a* and 25*a*.

The oscillator 35 may be of any desired form but preferably comprises a triode oscillator 40 and a tank coil 41, one side of the coil being connected through a blocking condenser 42 to the plate 43 of the tube. The other side of the tank coil is connected to the grid 44 of the tube through a condenser 45 which is shunted by a resistance 46. The antenna 33, as shown, is connected by a wire 47 to the tank coil between the coil and the condenser 45. Feed-back in the oscillator circuit is adjusted through a variable condenser 48 connected between the filament 49 of the tube and the wire 47. The plate 43 of the tube is charged through a resistance 50 and a wire 51. The output of the oscillator is conducted through a resistance 52 connected to wire 51 between the plate and the resistance 50. Current for energizing the filament 49 is conducted through wires 53 and 54 and radio-frequency choke coils 55 and 56. The wire 54 is connected by a wire 57 to the tank coil between the coil and the condenser 42 and is also grounded to the projectile casing, as shown at 58. By thus grounding the plate circuit of the oscillator tube, a relatively high radio-frequency voltage may be applied to the antenna 33 from the oscillator coil 41.

The sensitivity of the oscillator described herein is greatest when it is most heavily loaded within its range, and the loading of the oscillator is adjusted by the condenser 48 for controlling feed-back in the oscillator circuit. The condenser 48, as shown, comprises a sleeve 60 made of a dielectric material, and a metal cylinder 61 mounted on the outside of the sleeve at one end. A second metal cylinder 62 is mounted within the sleeve at the opposite end so that there is an axial spacing between the cylinders. The inner plate 62 is internally threaded and receives an adjustable screw 63 extending partly through an opening 63*a* in the wall of housing 30, so that it is readily accessible from outside the housing. Thus the capacity of the condenser may be varied by turning the screw 63. Any suitable oscillator frequency may be used and as large a band of frequencies as possible should be provided to facilitate operation even under adverse conditions. It will be observed that while the antenna 33 is small and compact, its power to radiate electromagnetic waves is substantial because of its connection through the ground 58 to the projectile casing 11. Actually, the casing becomes the main radiating means of the system because of its relatively large size, whereas the antenna may be considered as a means for exciting the casing.

The tube 40 and the other parts of the oscillator are preferably embedded in a suitable potting compound 124 to prevent relative movement, short-circuiting and damaging of the parts due to the shock incident to firing the projectile from a gun. The parts of the amplifier 36 and the battery 23, to be described presently, are also embedded in a potting compound 125 for the same reason.

The conductor 53 in the circuit of the filament 49 extends through a plug-and-socket connection 53*a* into the amplifier unit 36 where it is connected through a wire 65, a set-back switch 66 and a plug-and-socket connection 37*a* to the positive side of an A battery 68 in the case 23. The other side of the A battery is connected through a wire 69, a plug-and-socket connection 37*b* and a set-back switch 70 to wire 54, which extends from the filament 49 into the amplifier unit through a plug-and-socket connection 54*a*. The resistance 50, through which the plate 43 of the oscillator tube is charged, is connected to a conductor 71 leading through a plug-and-socket connection 71*a* into the amplifier unit, where it is connected through a wire 72 to one side of a set-back switch 73 shunted by a resistance 74. Resistance 74 functions to prevent the passage of transients when switch 73 is closed by setback forces, thus minimizing the danger of premature detonation of the fuze. The other side of the switch 73 is connected through a plug-and-socket connection 37*c* to the positive side of a set of series connected B batteries 76 in the case 23.

With the oscillator 35 energized, as the projectile approaches a target, such as an airplane, the radio waves emanating from the projectile are reflected by the target, and the reflected waves change the radiation resistance of the antenna 33. As a result, the loading of the oscillator circuit is changed, whereupon the plate current of the tube 40 also changes. This current change in the plate circuit develops a voltage across resistor 50 which is impressed upon the amplifier 36 through the resistance 52 and a wire 78 connected through a plug-and-socket connection 79 to one side of a condenser 83 in the amplifier unit. The other side of the condenser 83 is connected to the control grid of tube 84, the resistance 82 providing proper grid bias. The condenser 80 serves to by-pass high frequencies to the ground and cooperates with resistor 52 to form a low pass filter.

The amplifier, as shown, is provided with a second stage of amplification, including a tube 85, and the output of the amplifier is used to trigger a thyratron 86. The filaments of the tubes 84, 85 and 86 are connected across the A battery 68. More particularly, the wire 65 leading from the positive side of the A battery connects the filaments of tubes 84 and 85 in series to wire 54 which leads through wire 69 to the negative side of the A battery. Also, a conductor 87 connects the wire 65 through a resistor 88 and the filament of tube 86 to the wire 54. The plates of the amplifier tubes 84 and 85 are connected through load resistors 90 and 93 to the positive side of the B battery 76. That is, the wire 72 extends from the battery 76 to one side of resistor 90, which is shunted by a condenser 91, the other side of the resistor being connected to the plate of tube 84. A conductor 92 connects wire 72 to one side of the other resistor 93, which is shunted by a condenser 94, the other side of the resistor 93 being connected to the plate of tube 85.

The screen grid of the first amplifier tube 84 is connected through a wire 96 and a plug-and-socket connection 37*d* to a screen tap 76*a*. The screen grid of the second amplifier tube 85 is connected through a conductor 98 to wire 96 and the screen tap 76*a*, while the control grid of tube 85 is biased through a conductor 100 connected to the negative terminal of B battery 76 through resistors 102 and 103, plug-and-socket connection 37*b* and wire 104. The C battery 101, as shown, is provided by making a tap-off near the negative end of the series connected batteries 76. A condenser 105 is connected at one side to wire 100 between resistors 102 and 103 and is connected at the other side to wire 87, which leads through conductor 54 to ground at 58 and through set-back switch 70 to the plug-and-socket connection 37*b*.

The grid of the thyratron 86 is biased from the negative side of the C battery 101 through a conductor 107, resistors 108 and 109, and a plug-and-socket connection 37*e*. A charging condenser 111 is connected at one side to wire 87 and at the other side to the wire 107 between the resistors 108 and 109. A coupling condenser 112 is connected between the plate of the first amplifier tube 84 and the wire 100 leading to the control grid of the second amplifier tube 85, and another coupling condenser 112*a* is connected between the plate of tube 85 and the control grid of the thyratron.

The output of the thyratron 86 is led by a conductor 113 through a plug-and-socket connection 37*f*, the battery casing 23, plug-and-socket connection 39, and the timing timing mechanism 22 to one side of the detonator squib 20. The other side of the squib is connected by a conductor 116 through the timing mechanism, the plug-and-socket connection 39*a*, battery case 23, plug-and-socket connection 37*g*, wire 71 and switch 73 to the positive side of the B battery. Thus, when the thyratron is triggered by the amplifiers, the squib 20 is energized and detonates so as to explode the booster 19 and thereby the main charge in the projectile.

In order to prevent accidental energizing of the detonator circuit, there preferably is provided in the safety device 21 a switch comprising a conductive post 120 engaged by spring contact arms 121 and 122, the contact arms and post being connected in series between the wires 113 and 116 so that the squib is normally short-circuited. The contact arms exert considerable pressure against the post 120 to maintain the short-circuit and are mounted excentrically of the fuze, whereby they are movable away from the post to break the short-circuit only by the action of centrifugal force incident to rotation of the projectile when it is fired from the gun.

The set-back switches 66, 70 and 73 may be of any conventional type which is normally open but is closed by the force of set-back incident to firing the projectile from a gun, the switches including suitable locking means (not shown) for holding them in the closed position after they are actuated. Also, the oscillator, amplifier and battery units may take other forms than those illustrated.

In operation, the projectile is accompanied in its flight by a field of radio waves from the oscillator. The field of radiation may be said to "feel out" the target and cause detonation when the target enters the field in proximity to the projectile. More particularly, in the use of the new fuze the condenser 48 is regulated to adjust the sensitivity of the oscillator circuit to any desired value within its range. Also, the can 25 is rotated to adjust the timing mechanism 22 to a desired time setting based upon the estimated distance to the target, the timing mechanism being operable to explode the detonator mechanically at the end of a fixed time interval, for example, five seconds, after the projectile reaches the estimated point for which the lugs 15*a*–25*a* are set. Thus, the timing mechanism does not interfere with the operation of the radio-controlled detonating means but provides for explosion of the projectile in the event that the target does not enter the effective field of the radio waves. Accordingly, damage due to explosion of the projectile in friendly territory is prevented. It is to be understood that any other suitable self-destruction means may be used in place of the timing mechanism 22.

When the projectile is fired from a gun, the usual rifling in the gun barrel acts upon the rotation-producing band 12 to cause rotation of the projectile, and the resulting centrifugal force on the arms 121–122 causes the arms to disengage the post 120 and remove the short circuit of squib 20. Also, the force of set-back incident to firing the projectile closes switches 66, 70 and 73. The closing of switches 66 and 70 energizes the circuits of the filaments in all the vacuum tubes, and the closing of switch 73 connects the plates of tubes 40, 84 and 85 to the positive side of B battery 76. Additionally, the detonating circuit for squib 20 is prepared by the closing of switch 73.

When the oscillator and amplifier are inoperative, before firing the projectile and closing of the set-back switches, the battery 76 provides on the grid of the thyratron 86 and second amplifier tube 85 a negative bias several times cut off. That is, the entire output voltage of the battery 76 is applied as bias on the grids of tubes 85 and 86 (when switch 70 is open), due to the provision of a resistor 81 which is connected from B+ to ground. The grid of the tube 86, in addition, has impressed thereon the output of the battery 101. Upon closing of the set-back switch 70 when the projectile is fired, the condensers 105 and 111 drain through the resistors 103 and 109, respectively, so that the bias voltages on the grid of the tube 85 and on the thyratron grid decrease slowly to the value of the battery 101. As the biasing voltage reaches that of battery 101, the thyratron becomes operative so that it may be triggered as soon as it receives an amplified impulse from the oscillator. The time necessary for the thyratron grid voltage to decrease to the voltage of the C battery 101 depends upon the value of the resistor 109 and the capacitance of the condenser 111. Thus, the biasing circuit for the thyratron 86 provides a supplemental time delay and safety means which is particularly useful in preventing premature detonation of the squib. It will be evident that the amplifier will not trigger the thyratron when initially energized, but will do so only when it receives and amplifies an impulse from the oscillator. It is desired to call particular attention to the fact that the amplifier is of the band pass frequency type and is designed to pass only a relatively narrow range of frequencies. It has been found that an amplifier designed to pass frequencies of the order of from 50 to 300 cycles is satisfactory. The range of the amplifier, for given tubes, is determined by the values of the condensers 112, 112*a*, 91 and 94. That is to say, the condensers 112 and 112*a* serve to determine the low frequency limit of response while the condensers 91 and 94 provide means for determining the upper limit of frequency response.

The amplifier tube 85 has an arming circuit similar to the arming circuit described above, which includes the condenser 105 and the resistor 103. That is, the control grid of amplifier tube 85 is biased to provide a progressively increasing gain during flight of the projectile.

When the oscillator 35 is energized upon closing of its filament and plate circuits, radio frequency waves are generated by the oscillator and emitted from the antenna 33 and casing 11 connected thereto. As the radio waves emitted from the projectile strike an object, such as an airplane, the object acts as a parasitic radiator and reflects a portion of the radiated energy back to the projectile where it causes a reaction upon the oscillator 35. When these reflected waves are in phase with the waves emitted from the oscillator, the oscillator is loaded more lightly, but when the reflected waves are out of phase with the radiated waves, the resulting change in radiation resistance causes the oscillator load to increase, whereby the current in the plate circuit of the oscillator increases.

The current change thus developed in the plate circuit of the oscillator acts through resistance **52** to develop an alternating voltage across resistance **82**, and this voltage is amplified by the amplifier tubes **84** and **85** to trigger the thyratron **86** when the voltage becomes sufficiently great, as by the increasing proximity of the target. The thyratron is triggered at the peak of maximum amplified voltage, at which time the additional positive voltage on the thyratron grid allows plate current to flow. When the thyratron is triggered, the squib **20** is energized by a circuit traceable from the plate of the thyratron through wire **113**, squib **20**, wires **116** and **71**, and switch **73** to the positive side of the B battery **76**. As a result, the squib is detonated and explodes the booster **19** and thereby the main charge in the projectile chamber **13**.

It will be evident from the foregoing that the new fuze is sensitive to the proximity of a target and operates instantaneously to detonate the projectile when the target moves into the effective field of the radio waves. By constructing the oscillator, the amplifier and the other operating means of the fuze as separate units, the fuze may be readily assembled or disassembled and is adapted for mass production. The several operating units may be made of compact form so that the fuze occupies a relatively small space in the projectile. Also, by employing the telescoping cans **15** and **25** and embedding the parts of the oscillator, amplifier and battery units in a potting compound, the fuze is made strong and durable and is adapted to withstand the heavy shock incident to firing the projectile from a gun. The can **25** serves not only as a container for the oscillator and the amplifier but also as a means for adjusting the timing mechanism **22**.

If desired, the proximity fuze may be modified by adjusting the loading condenser **48** so that the oscillator **35** does not oscillate in free space but does so in the presence of an object, such as a target, which changes the radiation impedance of the antenna. Thus, when the oscillator commences to oscillate, due to proximity of the target, the detonator **20** is exploded through the amplifier **36** and the thyratron **86**.

The construction shown in FIGS. 5 and 6 is generally similar to that shown in FIGS. 1 to 4, inclusive, except that the oscillator **35** is omitted and the fuze is operated by a radio detector **35***a*. The detector as shown is connected to a receiving antenna **33***a*, and its output is amplified by an amplifier unit **36***a*. The amplifier is connected through a timing device **22**[9] and a safety unit **21***a* to a detonator **20***a*, as in the construction shown in FIGS. 1 to 4. In operation, a radio transmitter **123** is provided near the gun from which the projectile is fired, the transmitter and the detector **35***a* being tuned to the same frequency. When the projectile is fired, the point at which it explodes is determined by the gunner or his companion control officer who sends out a radio pulse from the transmitter **123**. The pulse is received on the antenna **33***a* and passes to the detector **35***a* and is amplified by the unit **36***a* so as to trigger the thyratron and explode the detonator, as previously described.

We claim:

1. In an explosive projectile, a fuze comprising a radio apparatus in the projectile, a detonator electrically coupled to the apparatus and operable thereby, a timing mechanism for operating the detonator independently of said apparatus, an antenna unit coupled to the radio apparatus and movable on the projectile, and a connection between the timing mechanism and the antenna unit through which said mechanism is adjusted mechanically by said unit, said connection serving also as an electrical connection between the detonator and the radio apparatus.

2. In a projectile containing an explosive charge, a proximity fuze comprising an oscillator having an antenna, an electrically operable detonator for exploding said charge, a thyratron through which the oscillator is coupled to the detonator and operable to pass a current pulse to the detonator for operating said detonator in response to a change in the loading of the oscillator by reflection of magnetic waves emitted therefrom, a biasing circuit means for the grid of the thyratron, and a condenser coupled to the biasing circuit means for rendering the thyratron inoperative for a predetermined time interval, said biasing circuit means operative to provide a first value of negative voltage at the grid of said thyratron for biasing said thyratron cut-off before firing the projectile and switch means connected to said biasing circuit means and operative to close by setback action to provide a discharge path for said condenser and enable said condenser to attain a second value of negative voltage which is applied to the grid of said thyratron through said biasing circuit means a predetermined time after said projectile has been fired.

3. In a projectile containing an explosive charge, an electrical fuze comprising an oscillator for emitting electro-magnetic waves, an amplifier electrically coupled to the oscillator and responsive to a change in the loading of the oscillator due to parasitic waves reflected back to the oscillator, a thyratron having a plate circuit on which the amplified load change is impressed, a source of current electrically coupled to the oscillator and amplifier, a bias circuit coupled to said source for supplying current at a critical negative voltage to the thyratron grid, a charge-detonator squib in the plate circuit of the thyratron, switches in the electrical coupling between the oscillator and amplifier and operable to close by set-back action to energize said oscillator and amplifier, and storage means included in said grid bias circuit operable to discharge once said switches close for reducing said negative grid voltage below its critical value and thereby closing said plate circuit for the conduction of said load change to the squib.

4. In an explosive projectile, a proximity fuze comprising a radio frequency oscillator, an antenna coupled to the oscillator for emitting radio frequency waves therefrom, means coupled to the oscillator and responsive to a change in the radiation resistance of the antenna for exploding the projectile, and adjustable means for varying the loading of the oscillator, said adjustable means including an adjustable screw forming a portion of one plate of a feedback condenser in the oscillator and extending through a projectile casing surrounding the oscillator for providing manual adjustment of said oscillator outside of said casing.

5. In an explosive projectile, a proximity fuze comprising a radio frequency oscillator, an antenna coupled to the oscillator for emitting radio frequency waves therefrom, means coupled to the oscillator and responsive to a change in the radiation resistance of the antenna for exploding the projectile, and a variable feed-back condenser coupled to the oscillator and adjustable from outside the projectile to vary the loading of the oscillator.

6. In a projectile containing an explosive charge, a proximity fuze comprising an oscillator having an antenna, an electrically operable detonator for exploding said charge, an amplifier tube through which the oscillator is coupled to the detonator and through which the detonator is operated in response to a change in the loading of the oscillator by reflection of magnetic waves emitted therefrom, and means for biasing the grid of said tube progressively less negatively during flight of the projectile.

7. In an explosive projectile, a proximity fuze comprising an antenna, an oscillator coupled to the antenna

and normally loaded to non-oscillating condition and becoming operative upon a change in the radiation impedance of the antenna, and means coupled to the oscillator and operable thereby to explode the projectile.

8. In a projectile containing an explosive charge, a proximity fuze comprising an oscillator having an antenna, an electrically operable detonator for exploding said charge, a thyratron through which the oscillator is coupled to the detonator and operable to pass a current pulse to the detonator for operating said detonator in response to a change in the loading of the oscillator by reflection of magnetic waves emitted therefrom, and means including a resistance-capacitance network coupled to the grid of said thyratron for biasing said thyratron at a first value of negative voltage for rendering the thyratron inoperative for a predetermined time interval, switch means coupled between said thyratron and a voltage supply operable to close by setback action and to allow said resistance-capacitance network to attain a second value of negative voltage whereby the capacitance is allowed to discharge through the resistance so that the bias voltage on the grid of said thyratron decreases slowly from said first value of negative voltage to said second value of negative voltage.

9. The combination of claim 8 wherein said means for rendering the thyratron inoperative for predetermined time interval includes a resistance-capacitance network coupled to the grid of said thyratron for biasing said thyratron at a first value of negative voltage, switches coupled between said thyratron and a voltage supply and operable to close by setback action to charge said capacitance to a second value of negative voltage whereby said capacitance is allowed to discharge through said resistance so that the bias voltage on the grid of said thyratron decreases slowly from said first value of negative voltage to said second value of negative voltage.

10. The combination of claim 8 which further includes switch means connected across said explosive charge for providing a short circuit thereacross prior to firing said projectile and ineffective once said projectile is fired due to centrifugal forces acting thereon.

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