

Sept. 7, 1948.

A. E. S. GREEN

2,448,587

DIRECTIONALLY SENSITIVE FIRING ERROR INDICATION

Filed March 18, 1944

3 Sheets-Sheet 1

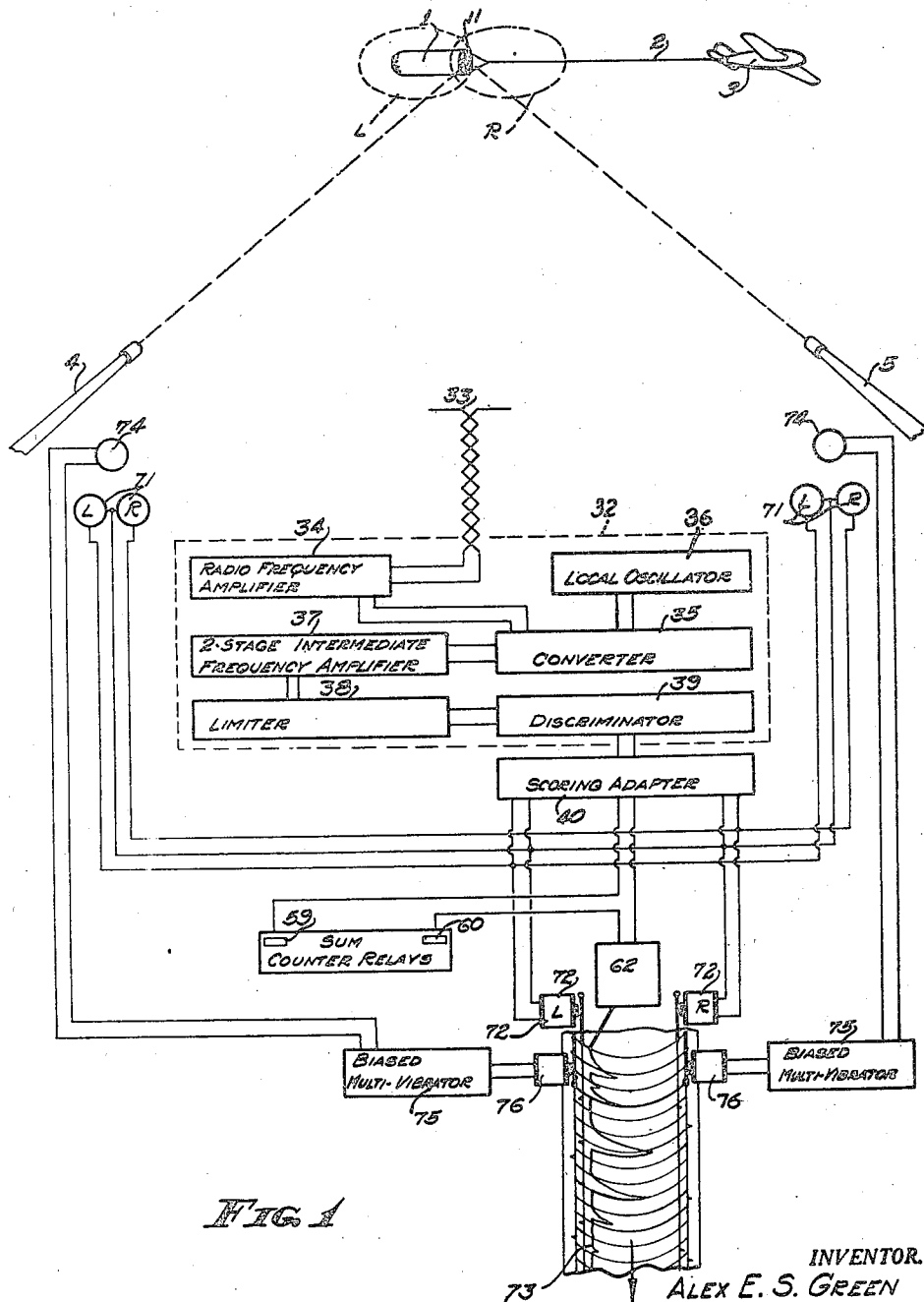


FIG. 1

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3 Sheets-Sheet 2

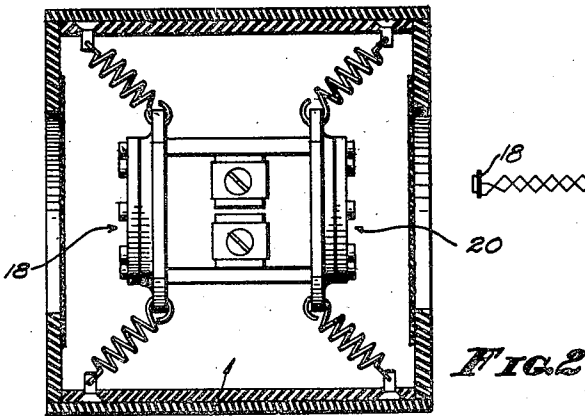


FIG. 2

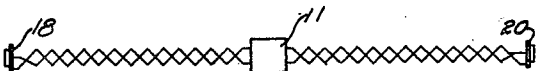


FIG. 3

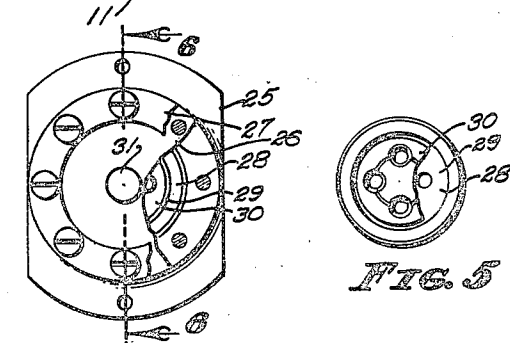


FIG. 4

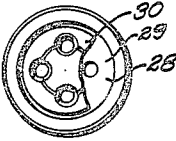


FIG. 5

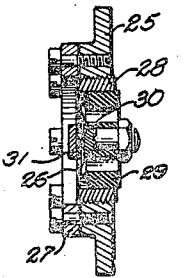


FIG. 6

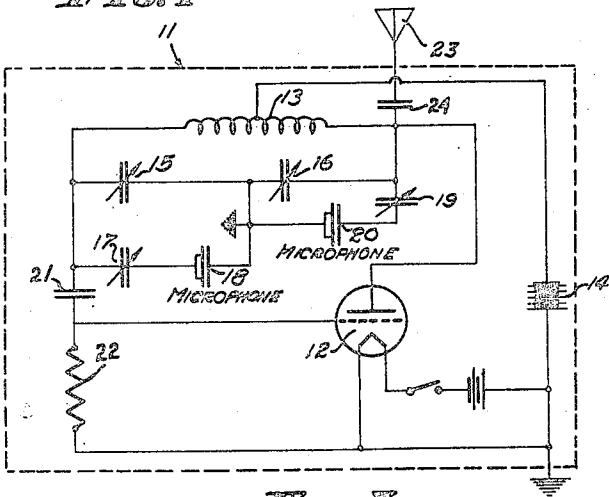


FIG. 7

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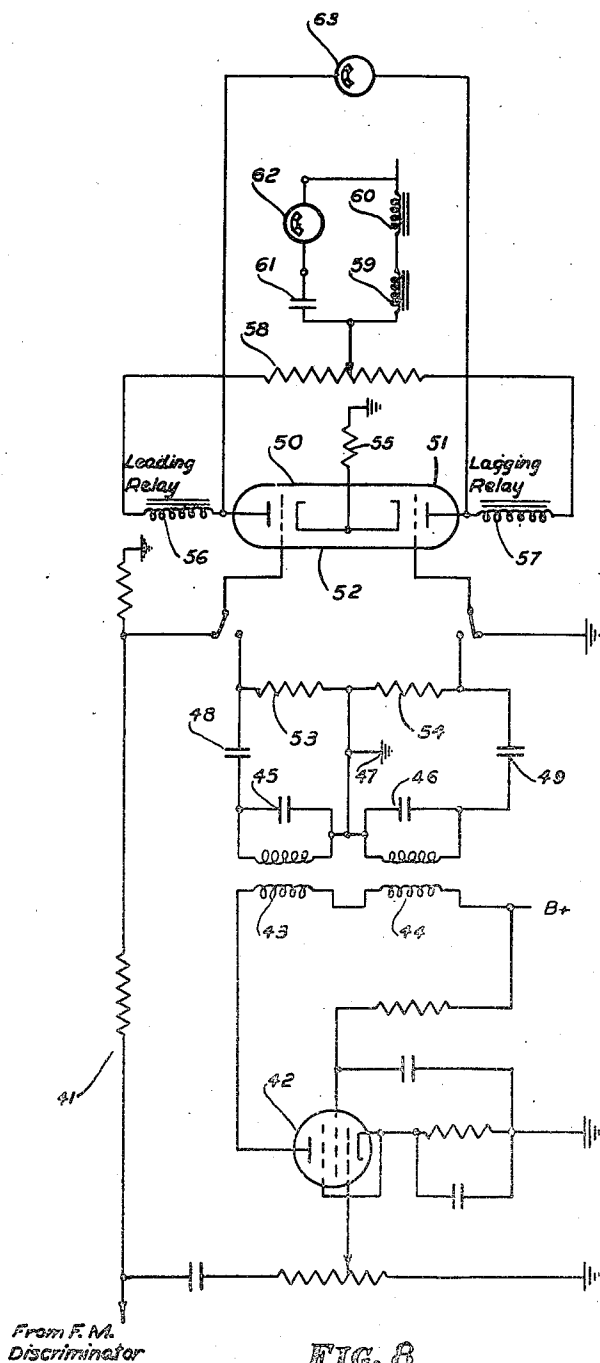
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DIRECTIONALLY SENSITIVE FIRING ERROR INDICATION

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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DIRECTIONALLY SENSITIVE FIRING
ERROR INDICATION

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Application March 18, 1944, Serial No. 527,090

8 Claims. (Cl. 177-352)

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My invention relates to directionally sensitive firing error indication; more particularly, to a means and method of training anti-aircraft gunners by causing to emanate from the practice target a signal which gives indications of the proximity and the direction relative to the target of bullets passing the target.

Among the objects of my invention are:

First, to provide a means and method of training gunners in anti-aircraft fire or training anti-aircraft gunners in aerial gun fire which utilizes the acoustic phenomenon known as the "shock-wave" produced in air by movement of a bullet at speeds in excess of sound.

Second, to provide a means and method of this character whereby the gunner is immediately informed while firing at the target whether his shots are passing close to or distant from the target and whether he is "leading" or "lagging" in his aim, so that he may correct his aim as he continues to fire and thereby develop the requisite "aiming sense"; and further to provide, if desired, a record of the gunner's score for later study.

Third, to provide a novel radio transmitter incorporating a plurality of shockwave sensitive microphones so arranged and of such a nature that, when acoustically excited by the shockwave of a passing bullet, they produce characteristic, distinguishable modulations of the transmitter radiation from which indications of both the magnitude and the direction of the firing error may be obtained.

Fourth, to provide a practical embodiment of the said radio transmitter, capable therefore of indicating both the proximity and the direction relative to the target of bullets passing the target, which is particularly simple, compact, light and rugged in construction and thus well adapted for installation in target sleeves, target rockets, or robot target aircraft, and which can be manufactured at sufficiently low cost to warrant its employment in the aforesaid installations though it be used but once and destroyed.

With the above and other objects in view as may appear hereinafter, reference is made to the accompanying drawings in which:

Figure 1 is a schematic view showing the relationship of target, transmitter, anti-aircraft guns, receiver and indicating and recording devices.

Figure 2 is a partial sectional, partial elevational view of one form of the transmitter wherein directional microphones are employed.

Figure 3 is a schematic view of another form of the transmitter wherein non-directional microphones are employed.

Figure 4 is a front view of one of the microphones.

Figure 5 is a front view of the microphone tension plug.

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Figure 6 is a sectional view of the microphone taken through 6-6 of Figure 4.

Figure 7 is a circuit diagram of the transmitter.

Figure 8 is a circuit diagram of the scoring adapter.

In the exercise of this invention, the target 1, which may be in the form of a sleeve, is connected by a tow line 2 to an airplane 3 and towed past several guns which fire in turn as the target comes in range, two such guns 4 and 5 being indicated in Figure 1. The target contains a transmitter 11, shown generally in Figures 1, 2 and 3 and illustrated more completely in the circuit diagram Figure 7.

The transmitter, which is preferably a frequency modulated transmitter, comprises a vacuum tube oscillator with one condenser microphone shunting the plate trimmer condenser and the other shunting the grid trimmer condenser. More specifically, with reference to Figure 7, the ends of tank coil 13 are connected to the plate and grid of triode 12 and an intermediate point of said coil is connected to one side of a power supply battery 14. A condenser 15, and a plate condenser 16 connect the ends of the tank coil to ground. Grid condenser 15 is shunted by a series arrangement of a trimming condenser 17 and microphone 18. Similarly, plate condenser 16 is shunted by a series arrangement of a trimming condenser 19 and microphone 20. The D. C. potential of the tank coil is blocked from the grid of the triode by a condenser 21. A gridleak resistor 22 joins the grid to ground. The antenna 23 is connected to the plate side of the tank coil through a condenser 24.

The grid and plate condensers 15 and 16 serve to adjust the frequency and the amplitude of the electrical oscillations. The two series trimming condensers 17 and 19 make possible the adjustment of the sensitivity of the two microphones 18 and 20, or, more precisely, the sensitivity of the oscillation frequency to variations in the microphone capacities. These adjustments of frequency, amplitude and sensitivity are, of course, interdependent, e. g., increasing the sensitivity of 20 by increasing the capacity of 19 will also decrease the oscillation frequency and amplitude, which may then be restored to their initial value by decreasing the capacity of condenser 16.

The microphones 18 and 20 are similar in construction and are shown best in Figures 4, 5 and 6. The microphone includes an annular frame 25 over the opening of which is placed a diaphragm 26 held in place on the frame 25 by a clamping ring 27. The opening in the frame 25 is threaded and receives an annular tension plug 28 which bears against the margin of the diaphragm 26 to adjust the tension thereof.

The tension plug 28 is provided with an insert 29 of insulating material which supports on its

outer face adjacent the diaphragm a condenser plate 30. The center of the diaphragm 26 is provided with a weight 31. The insert 29 is perforated and the central portion of the plate 30 behind the weight is recessed. The two microphones may differ only in the masses of their respective weights 31, or they may be provided with identical weights and differ only in respect to their tensions, or both tensions and weights may differ.

By means of the weights 31 and the tensions of the diaphragms, the two microphones may be arranged so that said diaphragms have different natural frequencies of vibration; for example, one microphone may have a natural vibration frequency of 1620 cycles and the other 2400 cycles. The acoustic shockwave from a passing bullet imparts an impulse to the microphone diaphragm which, by reason of its tension and its weight 31, vibrates at its own natural frequency.

The microphones may be directional and located on opposite sides of the transmitter, as indicated in Figure 2, or the microphones may be non-directional in character and spaced a predetermined distance from each other and the transmitter, as shown in Figure 3. In the latter case, one microphone may be located at the forward end and the other at the rearward end of the target sleeve.

In either of the arrangements shown in Figures 2 and 3, the right hand microphone will be more strongly affected by bullets passing on the right side of the transmitter, as viewed in Figures 1, 2 and 3, whereas the left hand microphone will be more strongly affected by bullets passing on the left side of the transmitter.

The microphones described hereinbefore are called "resonant" because of the relatively sustained or "resounding" vibration of their diaphragms resulting from impulsive excitation. Aside from providing a self-identifying sound-sensitive system for directional purposes, these resonant microphones offer several other advantages over, for example, damped or non-resonant microphones, namely:

1. The resonant microphone has greater reproducibility of its dynamic characteristics and greater uniformity of response to impulsive shockwave excitation, because its response depends mainly on easily reproducible characteristics, such as diaphragm mass and diaphragm restoring force, and much less on characteristics difficult to control, such as diaphragm damping constant.

2. The resonant microphone simplifies the electronic problem of measuring the intensity of the shockwave, particularly in that it greatly lengthens the effective duration of the impulse; the effect (diaphragm vibration) of the shockwave lasts approximately 0.020 second, whereas the duration of shockwave itself is much shorter.

3. Resonant diaphragms afford a convenient and reliable method of assuring reproducible diaphragm restoring force (tension) by tuning them to a standard audio frequency.

4. The electrical filter systems required in the receiving station when the directional system with resonant microphones is employed possesses the advantage of filtering out spurious noise of any origin whose frequency differs markedly from the band pass frequency of the filter.

The carrier frequency, modulated periodically by the response of the microphones 18 and 20 to passing bullets, is picked up by a receiver 32 represented in Figure 1. The receiver may be a conventional frequency-modulation receiver

with certain circuits, to be described hereinafter, added for the purpose of informing the gunner and recording his score. The receiver 32 includes an antenna 33, a radio frequency amplifier 34 which feeds into a converter 35. A local oscillator 36 also feeds into the converter 35 and the output from the converter passes through an intermediate frequency amplifier 37, limiter 38 and discriminator 39.

The output of the discriminator 39 is fed into a pentode amplifier tube 42 of the scoring adapter 40, detailed in Figure 8. The resistance 41, which functions whenever the switches are in the position indicated in Figure 8, protects the grid of the tube 52 from the variations of the output voltage of the discriminator during such preparatory operations as tuning the receiver to the signal from the transmitter, in the absence of modulation, optimum tuning adjustments being indicated by zero deflection of the meter 63. As soon as such tuning operations have been completed, the switches are reversed for normal scoring operation of the adapter. Two tuned transformers 43 and 44 are arranged in series in the plate circuit of the pentode 42. Tuning condensers 45 and 46 are connected across the secondaries of the transformers 43 and 44. One of the transformers is tuned so that it responds predominately to the audio frequency of the high-frequency microphone of the transmitter while the other transformer responds predominately to the audio frequency of the low-frequency microphone. The contiguous sides of the secondary of the tuned transformers 43 and 44 are connected to a ground 47. Condensers 48 and 49 connect the other or high ends of the transformer secondaries to the grids of triode sections 50 and 51 respectively, of a dual triode tube 52. Said grids are connected to ground through gridleak resistors 53 and 54.

The cathodes of the two triode sections are connected together and to ground through a cathode resistor 55. The plates of the two triode sections 50 and 51 are connected through relay coils 56 and 57 respectively to the opposite ends of a balance potentiometer 58. The center of the potentiometer is connected to the B supply through parallel circuits, one comprising counter relays 59 and 60, and the other comprising a condenser 61 and recording meter 62.

In brief, the above described scoring adapter is essentially a differential amplifier which gives output currents proportional to two predetermined approximately linear combinations of the two input voltages fed to the grids of the respective triode sections 50 and 51.

The signal currents in the relays 56 and 57 are nearly linear functions of the two input voltages to the triode sections 50 and 51 and serve to define leading and lagging zones around the target, that is, the left-hand and right-hand zones L and R, as viewed in Figure 1. Depending on whether the bullet passes through one zone or the other, the relays 56 or 57 trip corresponding indicating circuits, which may include vibrators 71 strapped to the left and right wrists of the gunner or fire control officer. Thus the instant a bullet passes in proximity to the target the gunner receives a signal vibration at his right or left wrist indicating whether the bullet passed to the right or left of the target, or, in other words, whether the firing error was "leading" or "lagging" with respect to the course of the airborne target. The relays 56 and 57 may

also control a recording circuit in which recording pens 72 mark a moving chart 73.

The recording meter 62 traces on the chart 73 a record corresponding to a definite, nearly linear combination of the responses of the two microphones to the shockwave excitations.

Several guns may fire at the target as it moves along its course, and inasmuch as the target comes in range of the guns in sequence, the indicating circuit may be common to several gunners. For purposes of identifying the scores of the various guns, muzzle blast microphones 74 may be placed near each of the guns and their outputs fed through biased multivibrators 75 to recording pens 76 which trace on the chart 73.

Counter relays may be employed in place of the recording meter 62 if less complete information is satisfactory.

Though I have shown and described certain embodiments of my invention I do not wish to be limited thereto, but desire to include all novelty inherent in the appended claims.

I claim:

1. In an apparatus for determining a spatial relation between a target and passing bullet, a radio transmitter located in the target and comprising: at least a pair of shockwave sensitive microphones, each having a natural period of vibration distinguishable from the other and positioned to detect from different aspects, a shockwave emanating from a passing bullet; and an oscillator common to, and distinguishably modulated by said microphones.

2. In an apparatus for determining a spatial relation between a target and passing bullet, a radio transmitter located in the target and comprising: at least a pair of condenser microphones, said microphones including shockwave sensitive diaphragms carrying weights of different masses for causing said diaphragms, when excited by a shockwave, to vibrate at preselected distinguishable frequencies; and an oscillator common to, and distinguishably modulated by, said microphones.

3. In an apparatus for determining a spatial relation between a target and a passing bullet, a radio transmitter located in the target and comprising: at least a pair of condenser microphones, said microphones including shockwave sensitive diaphragms stretched under tension, and means for varying the tension of said diaphragms so that when they are excited by a shockwave, they vibrate at preselected distinguishable frequencies; and an oscillator common to, and distinguishably modulated by, said microphones.

4. In an apparatus for determining a spatial relation between a target and a passing bullet, a radio transmitter located in the target and comprising: at least a pair of condenser microphones, said microphones including shockwave sensitive diaphragms stretched under tension, means for varying the tension of said diaphragms, and weights carried by said diaphragms, the masses of said weights being so selected and the tensions of said diaphragms being so adjusted that when said diaphragms are excited by a shockwave they vibrate at preselected distinguishable frequencies; and an oscillator common to, and distinguishably modulated by, said microphones.

5. A radio transmitter comprising: at least a pair of microphones, each having a natural period of vibration distinguishable from the other and positioned to detect from different spatial

aspects an acoustical wave, the amplitude of vibration of each microphone corresponding to its spatial aspect relative to the source of acoustical wave; and an oscillator common to and distinguishably modulated by said microphones.

6. A radio transmitter comprising: at least a pair of condenser microphones including diaphragms carrying weights of different masses for causing said diaphragms, when excited to vibrate at predetermined distinguishable frequencies, said diaphragms having amplitude responses corresponding to their spatial relationship to a source of acoustical wave; and an oscillator common to and distinguishably modulated by said microphones.

7. A radio transmitter comprising: a pair of condenser microphones, said microphones including acoustical wave sensitive diaphragms stretched under tension, and means for adjusting the tensions of said diaphragms whereby when subjected to the same acoustical wave they vibrate at preselected different and distinguishable frequencies the amplitudes corresponding to their difference in spatial relationship to a source of acoustical wave; and an oscillator common to and distinguishably modulated by said microphones.

8. A radio transmitter comprising: at least a pair of condenser microphones, said microphones including acoustical wave sensitive diaphragms stretched under tension, means for adjusting the tensions of said diaphragms, weights carried by said diaphragms, the masses of said weights and the tensions of said diaphragms being so selected that when said diaphragms are excited by an acoustical wave, they vibrate at preselected distinguishable frequencies the amplitudes corresponding to their difference in spatial relationship to a source of acoustical wave; and an oscillator common to and distinguishably modulated by said microphones.

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