

July 23, 1963

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3,098,448

PRECISION AND RELIABILITY OF TIMING DEVICES

Filed Nov. 15, 1961

Fig. 1

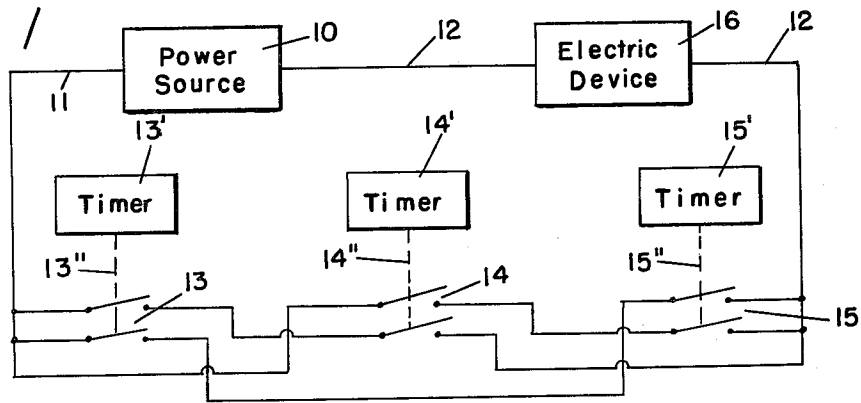
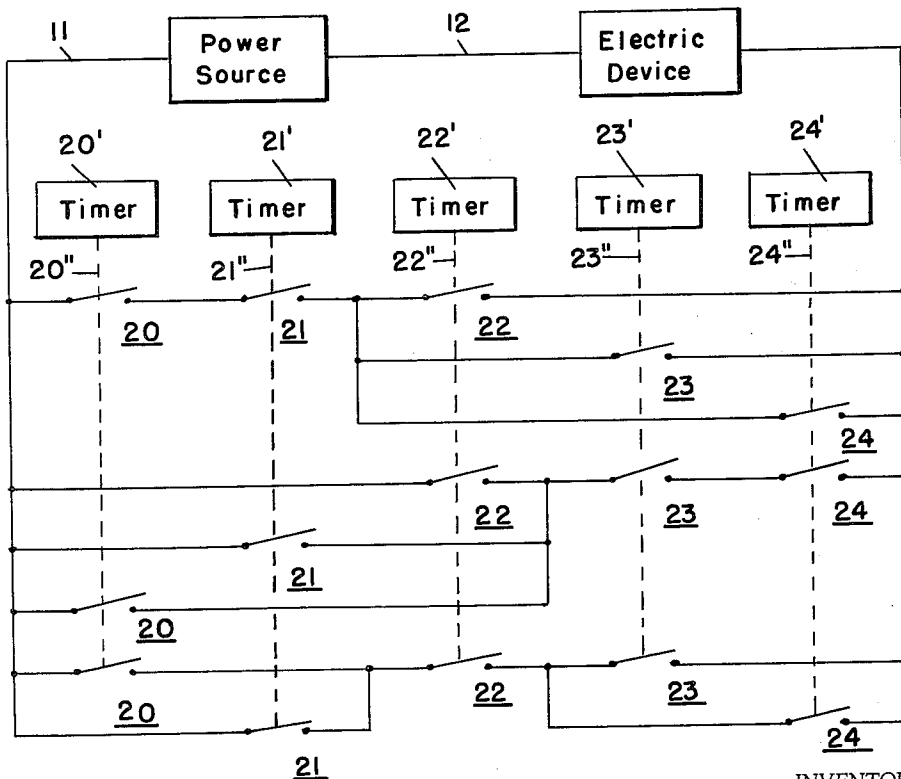


Fig. 2



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3,098,448

PRECISION AND RELIABILITY OF TIMING DEVICES

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Filed Nov. 15, 1961, Ser. No. 152,693

3 Claims. (Cl. 102-70.2)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

This invention relates to timing mechanisms and more particularly concerns such devices having improved precision and reliability of applications such as space vehicles, projectiles, rockets, bombs, guided missiles, and the like.

The satisfactory performance of artillery projectiles, guided missiles, bombs, rockets, and the like, which are detonated or armed by mechanical timers require the timers to have low dispersion and a low fraction of malfunctions. By dispersion is meant the variance of the time that the desired event occurs and is therefore a measure of the precision or reliability of timing. Malfunctions include duds, or mechanisms that fail to operate, and prematures are mechanisms operating a considerable period of time ahead of schedule. Among the factors which tend to increase dispersion and the fraction of malfunctions are the difficulties involved in designing, manufacturing, and assembling intricate mechanisms containing many small parts requiring extremely close tolerances, and the external forces such as angular acceleration, setback, and vibration to which timers are subjected when carried in missiles. In spite of these problems, it has been possible to manufacture large quantities of mechanical timers which function satisfactorily in conventional field artillery and anti-aircraft applications. However, a dispersion and fraction of malfunction considered satisfactory for the latter mentioned applications may well be excessive when the timers are adapted to atomic artillery and costly guided missiles, rockets, and space vehicles were high precision and reliability are vital. This has been recognized for some time as a very serious problem, and project planners and design engineers have attempted to arrive at a workable solution by various methods. One approach is to include mechanical refinements in the design of the timer so that it would meet the stringent requirements. This was done in the mechanical timers for at least one of the current U.S. rockets to the point where they became extremely costly to manufacture and assemble. Another approach to the problem is the utilization of multiple timing assemblies, i.e., where more than one timer per round is used, so that the first of these timers which functions causes arming of the explosive train. When multiple timing of this type is utilized, there is a decrease in the standard deviation of the time-to-burst or time-to-arm of the missile, a decrease in the fraction of duds but an increase in the fraction of prematures. The extent of the increases and decreases depend, of course, upon the number of timers in the missile. The increase in prematures presents a most serious problem, often requiring the addition of safety devices to the timers, and tending to increase the dud rate and cost.

In brief, this invention describes means which permit achievement of low dispersion, with low dud and premature fractions without resort to additional safety and delay devices. The invention requires that the missile carry more than two timers or fuzes wherein a preselected number of these fuzes, greater than one but less than the total number, function to effect detonation or arming of the missile or actuation of the timing device.

Let us therefore first consider the effect on standard

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deviation when a missile contains, say, five fuzes, and functioning of any three thereof is required to detonate the missile. It can be shown that the standard deviation in this instance will be less than the standard deviation of missiles having ten fuzes and wherein the first fuze to function causes missile detonation. Such data will be presented in tabulated form below.

Let us now consider malfunctions. Prior experience with mechanical time fuzes in conventional anti-aircraft and field artillery applications indicates a dud fraction of approximately two percent and a premature fraction approaching one in 10,000 for the individual fuzes. Assuming the same model aforescribed, i.e., five fuzes in each missile and the fuzes so arranged that the first three fuzes to function will cause the missile to detonate, it can be shown that the dud fraction is reduced to less than one in 10,000 and the premature fraction to approximately 1 in a billion. The dud fraction is thus reduced to a satisfactory level and the premature fraction reduced to an extremely low value without the use of additional mechanisms. These data will hereinafter be presented in tabulated form.

It is evident from the above description that the practice of our inventive device in missiles, space vehicles, and the like will effect considerable savings in the manufacture and assembly thereof, which is achieved by the use of relatively inexpensive fuzes or timers to replace more expensive mechanisms, the missile yet retaining its required functional characteristics.

It is a broad object of the invention to provide novel means for enhancing the safety, reliability and precision of missiles, rockets, bombs, projectiles, space vehicles, and the like.

A more specific object of the invention is to provide novel means for reducing dispersion, dud and premature fractions of missiles and the like and yet be devoid of elaborate safety devices and delay mechanisms.

Other objects and advantages will hereinafter become more apparent to those skilled in the art as the disclosure is made in the following detailed description.

For a better understanding of our invention, let us assume that a device contains n timers which are so connected that device operation will occur when exactly k timers function. Based on a timer dud fraction of 2% and a timer premature fraction of 0.01%, it can be shown by mathematical computation that the percentage of duds, prematures and the dispersion of the time to operate of the total mechanism will be reduced as shown in the following table:

n	k	Standard deviation	Percent duds	Percent Prematures
1	1	1.000	2.00	10^{-2}
2	1	0.840	4.00×10^{-2}	2×10^{-2}
2	2	.826	3.96	10^{-3}
3	1	.756	8.00×10^{-4}	3×10^{-2}
3	2	.692	0.12	3×10^{-3}
3	3	.748	5.88	10^{-10}
4	1	.707	1.60×10^{-2}	4×10^{-2}
4	4	.701	7.76	10×10^{-14}
5	1	.674	3.20×10^{-2}	5×10^{-2}
5	3	.552	8.08×10^{-3}	10^{-10}
5	5	.669	9.61	10^{-13}
6	1	.649	6.40×10^{-2}	6×10^{-2}
6	6	.645	11.42	10^{-22}
7	1	.630	1.28×10^{-10}	7×10^{-2}
7	4	.471	5.60×10^{-4}	10^{-15}
7	7	.626	13.18	10^{-23}
8	1	.614	2.56×10^{-12}	8×10^{-2}
8	8	.601	14.92	10^{-30}
9	1	.601	5.12×10^{-14}	9×10^{-2}
9	5	.418	4.03×10^{-5}	10^{-21}
9	9	.598	16.63	10^{-34}
10	1	.580	1.02×10^{-16}	0.100
10	10	.587	18.29	10^{-38}

It should become apparent from a study of the above

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table that for any value of n , the standard deviation is a minimum when k is the median of n , i.e., when n is an odd number and k is made to equal the quantity

$$\frac{n+1}{2}$$

A typical illustration of our multiple timing invention, as shown in the above table, is given by a missile containing 7 fuzes wherein 4 must function before the missile detonates. The standard deviation of detonation time is 0.471 times the corresponding standard deviation of the individual fuzes when based on a realistic 2% dud fraction and 0.01% premature fraction of the individual fuzes. The missile dud fraction will have been reduced to less than 1 in 160,000 and the premature fraction practically non-existent.

The multiple fuzing aforescribed requires the missile fuzing system to be so designed that it will become armed or detonated when the first k of n fuzes function. The drawings schematically illustrate embodiments of such multiple timing arrangements, FIG. 1 requiring functioning of any two of the three timers to assure circuit continuity to actuate a device and FIG. 2 requiring functioning of any three of the five timers.

Referring to the drawings wherein like reference numerals designate like parts, there is shown a suitable power source 10 having electric conductors 11 and 12 leading therefrom. Conductor 11 is connected to opened double-pole switch assemblies 13 and 14 while the other conductor is similarly connected to opened double-pole switch assemblies 15 and 14, all as shown in FIG. 1. Three timers 13', 14' and 15' have arms or linkages 13'', 14'' and 15'' respectively articulating therewith and interconnecting the individual timers and switches, such that, upon functioning of a timer the associated arm connected thereto will function to close its respective switch, and through the circuitry shown, complete a circuit to an electric actuating device 16, serially connected to the power source for detonating an explosive missile. It will be understood, of course, that the arms may partake of any suitable material, such, for example, as aluminum, and their connections to the fuzes and switches may be achieved by conventional methods, the connections, per se, forming no part of the invention. Also, various modifications to the specific circuitry shown for effecting actuation of the device are contemplated and may obviously be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as will hereinafter be defined by the appended claims.

In FIG. 2, there are shown 5 opened triple-pole switch

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assemblies, 20, 21, 22, 23 and 24, each of which is connected to one of 5 timers 20', 21', 22', 23', and 24' by means of an arm 20'', 21'', 22'', 23'' and 24'', similar to the apparatus described above in connection with FIG. 1 of the drawings. In FIG. 2 however, lead 11 will be connected to 3 switch assemblies 20, 21 and 22 while the other lead 12 will be connected to 3 switch assemblies 24, 23 and 22. The closing of any 3 switches by their respective timers and arms will now function to close a circuit to the device for actuation thereof.

Although schematic diagrams are not herein presented for other values of n and k , it is apparent that corresponding circuitries can readily be designed for permitting the successful practice of our invention.

We claim:

1. An electromechanical timing system for detonating explosive missiles which permits the achievement of reduced dispersion and reduced dud and premature fractions, said system comprising an electric power source and an electric actuating device serially connected to each other and to each end, respectively, of an assembly of mechanical timer-electrical switch arrangements, n in number, each of said arrangements comprising a mechanical timer articulated by means of a movable linkage to an opened multiple pole (k in number)-single throw switch, where n equals an odd number and k equals

$$\frac{n+1}{2}$$

said linkage being operatively responsive to close said switch upon functioning of said timer, the poles of all algebraic combinations of said switches taken k at a time being serially interconnected by conductive leads which are so constructed and arranged that the functioning of any algebraic combination of said mechanical timers taken k at a time results in a closed circuit.

2. A system according to claim 1 wherein n equals 5 and k equals 3.

3. A system according to claim 1 wherein n equals 3 and k equals 2.

References Cited in the file of this patent

UNITED STATES PATENTS

2,066,745	Seeger et al. -----	Jan. 5, 1937
2,231,695	Vedder -----	Feb. 11, 1941

OTHER REFERENCES

Manual of Experimental Statistics, by Fraund, Livermore and Miller, Prentice Hall, 1960, pages 22 and 23. (Copy in Scientific Library QA 276 F69.)