

April 29, 1958

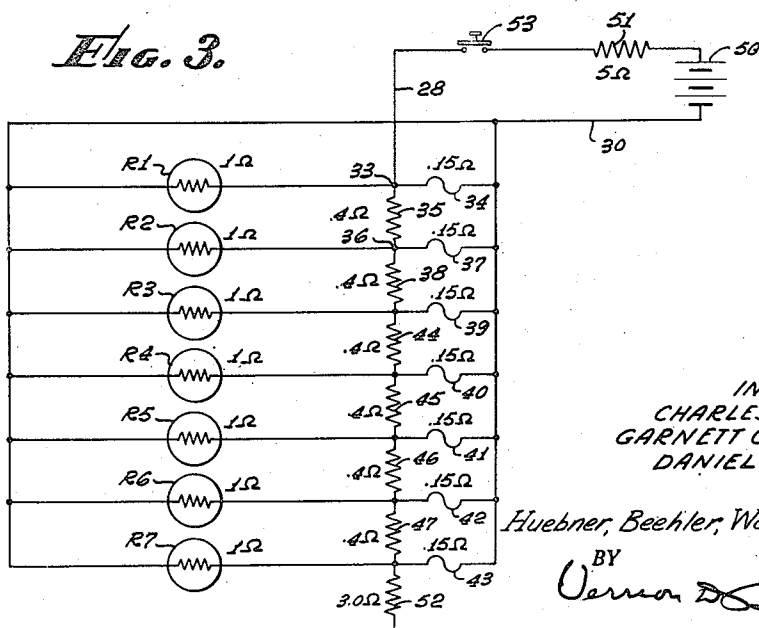
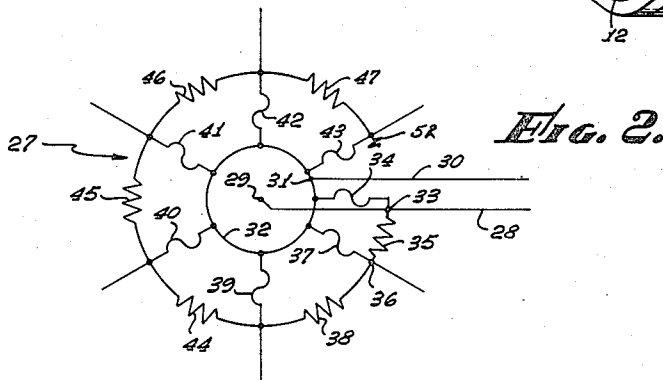
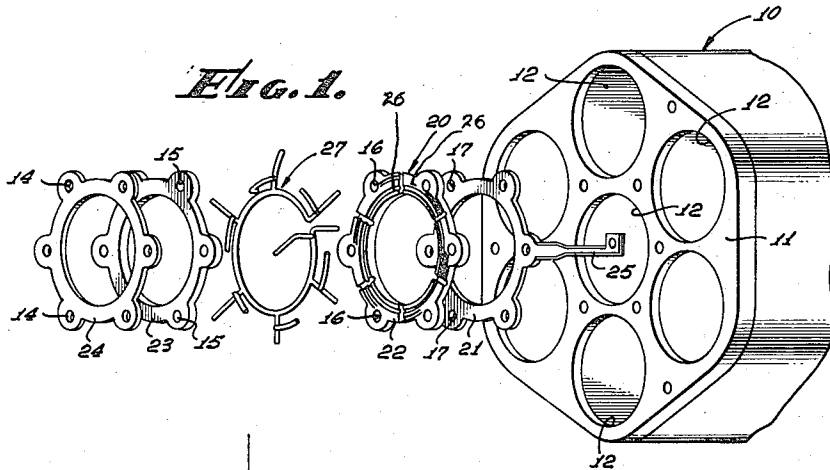
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2,832,265

SQUIB FIRING INTERVALOMETER

Filed Jan. 3, 1956

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 4.

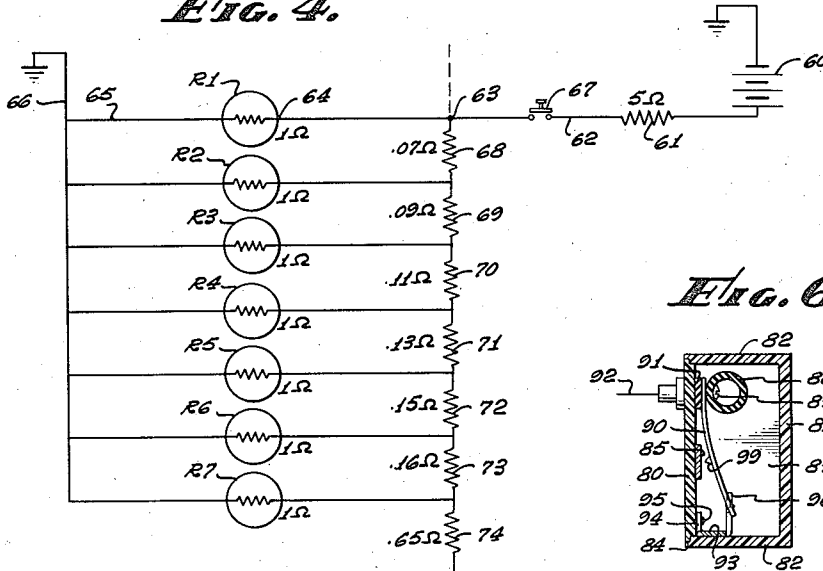


FIG. 6.

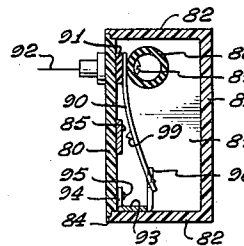


FIG. 5.

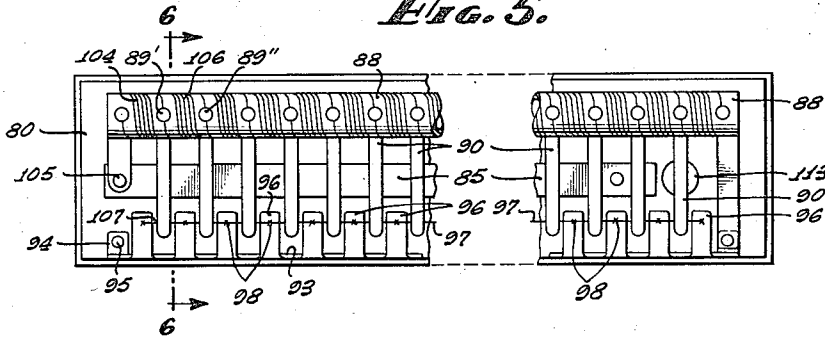
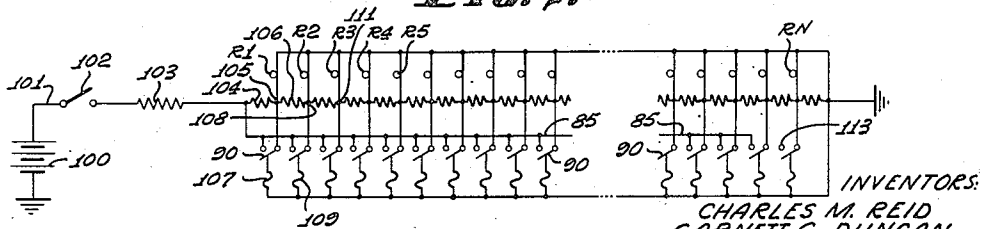


FIG. 7.



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1

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SQUIB FIRING INTERVALOMETER

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Application January 3, 1956, Serial No. 557,032

6 Claims. (Cl. 89—1.7)

The invention relates to military weapons and has particular reference to a launching device by means of which a plurality of missiles in the nature of rockets can be launched simultaneously and preferably in close sequence one after the other in a manner known generally as ripple fire. The launching device is one designed to be carried by aircraft or other vehicles by use of racks or pylons. This is a continuation-in-part of application Serial No. 423,618, filed April 16, 1954.

Since the employment of rockets as missiles to be launched from airplanes has become prevalent, a variety of devices have been constructed to facilitate the launching of missiles of this kind. Practice has dictated that launchers be capable of launching a series of such rockets with each aiming of the launcher. Increased accuracy has been found possible of attainment when the rockets are launched in a rapid sequence, one shortly in advance of the other, so that the rockets stream from the launcher in a continuous stream until the last rocket has been loosed.

Because of the nature of the problem, that is to say, the launching of rockets or perhaps guided missiles under critical circumstances where the time interval is highly critical and where certainty of discharge is imperative, firing mechanisms must be such that they insure against salvo discharge and must also be such that in the event one or more rockets fail to discharge, the remaining rockets will be launched. Dependency upon mechanical release by movement of the rocket, which has been the practice in devices heretofore used, is avoided by substitution of electric timing apparatus. Where prior art practice has turned to electric actuation, it has necessitated employment of heavy electrical loads which is not always attainable on an airplane or if attainable is met only by a load penalty which is highly disadvantageous on military aircraft.

It is therefore among the objects of the invention to provide a new and improved inexpensive rocket firing intervalometer which is highly dependable and which is adapted to function effectively in the event that inadvertent failure in the firing of one or more of a group of rockets might occur.

Another object of the invention is to provide a new and improved positive electric actuated and electrically timed ripple firing system for rockets and similar missiles which is adapted to require a very low power electric impulse for the firing of an indefinite number of such rockets and missiles and which at the same time works positively but at extremely short time intervals between the firing of successive missiles.

Still another object of the invention is to provide a new and improved electric actuated firing mechanism for missiles, the timing of which is unaffected and independent of movement of the missile during discharge and which is otherwise independent of mechanical movement or mechanical timing.

Still further among the objects of the invention is to

2

provide a new and improved small, compact, electric actuated firing mechanism for missiles which is so designed and constructed as to resist deterioration due to vibration, rough handling, and long storage and which moreover is sufficiently compact to be capable of installation in disposable launching devices while at the same time assuring a ripple firing interval on all occasions.

With these and other objects in view, the invention consists in the construction, arrangement and combination of the various parts of the device whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

Figure 1 is an exploded view showing a fragment of a rocket launching housing in perspective and showing one form of the device.

Figure 2 is a schematic view of the wiring circuit of Figure 1.

Figure 3 is a wiring diagram applicable to the schematic representation of Figure 2 in which representative values are shown.

Figure 4 is a wiring diagram of another form of the electrical circuit adapted to the firing of rockets.

Figure 5 is a plan view of another form of electrically actuated firing mechanism.

Figure 6 is a cross-sectional view taken on the line 6—6 of Figure 5.

Figure 7 is a wiring diagram applicable to the form of the device of Figures 5 and 6.

In the transporting and launching of missiles such as rockets the aim is to so mount the missiles that they respond to a ripple firing discharge rather than to salvo discharge. By firing the rockets one at a time even though the time interval be but a very small fraction of a second between successive firings, many advantages accrue. Such advantages include minimization of the reaction effect upon the carrier airplane and a greater ability to direct the overall fire of an airplane so armed on the objective. Because of the critical nature of the device, that is, the desire to have such an apparatus function as nearly perfectly as possible under extreme and dangerous conditions, the firing action must be dependable. Moreover, in view of the fact that the tendency is to construct launchers of such character that they are disposable, the firing mechanism to be practical must be sufficiently small and compact to be mounted in the disposable container and should also be relatively inexpensive so that they can be produced in quantity at low cost. Moreover, employment of such firing mechanisms on planes of the type of jet planes means that they are subjected to tremendous vibrational stresses during flight in addition to frequent rough handling before they reach the launching field. This necessitates a rugged construction in the firing device such that it will be in no way impaired with respect to its performance between the time that it is installed in the launcher and the time when the firing button is pressed.

To assist in understanding the application of the invention here involved, there is illustrated a rocket launcher indicated generally by the reference character 10. Only the rear portion of the launcher is shown inasmuch as the structural details of the launcher are relatively unimportant with respect to the form of firing mechanism herein disclosed and comprising the invention. The launcher is provided with an aft bulkhead 11 which in the view chosen for Figure 1 contains seven rocket tubes indicated by the reference character 12, one being located in the center and the remaining six being equally spaced about the center tube.

In one form of the invention chosen for the purpose

3

of illustration the launcher is provided with an ignition assembly mounted on the aft bulkhead. This assembly is one adapted to be contained essentially within a housing indicated generally by the reference character 20 and comprising the several parts of the exploded view of Figure 1. The housing is provided with an assortment of screw holes 14, 15, 16 and 17 in appropriate parts by means of which conventional screws may be employed to secure the housing to the aft bulkhead.

The housing, as illustrated in Figure 1, consists of a number of parallel elements consisting of a plate 21 lying immediately adjacent the bulkhead, an insulator plate 22, a second insulator plate 23, and a cover plate 24, all of these plates being held together by the same screws already made reference to.

The plate 21 has a shield extension 25 extending laterally therefrom designed to provide a protection for wiring from the initial blast of the rockets and also to provide means for attachment of a ground connection.

The insulator plate 22 is illustrated as provided with suitable grooves 26 designed to match comparable grooves in the plate 23. These grooves are for reception of an ignition spider 27. It is the ignition spider which contains the means for ripple firing the rockets in accordance with a predetermined sequence.

The ignition spider is illustrated schematically in Figure 2 and in that modification consists of an electric circuit composed of a lead-in wire 28 adapted to connect to the rocket firing disc of the center rocket at the point 29. A ground wire 30 connected at the point 31 to a ground circuit 32 supplies the ground connection for all of the rockets including the center rocket.

At a point 33 the lead-in wire is connected in one direction to a fuse 34 which in turn is connected to the ground circuit 32. In another direction contact is made at the point 33 with a resistance 35. From the resistance 35 connections are made respectively at point 36 to a fuse 37 and a second resistance 38. Succeeding fuses are numbered 39, 40, 41, 42 and 43. Succeeding resistances are numbered 44, 45, 46 and 47. The lead-in wire 28 and ground wire 30 are designed to lie within the shield extension 25.

In the exploded view of Figure 1 the ignition spider, shown schematically in Figure 2, features the lead-in 28 as indicated, the ground wire 30 as also indicated, the ground circuit 32, and the fuses 34, 37, 39, etc., the resistances not being specifically illustrated in Figure 1. At the point 36, for example, and at corresponding succeeding points, connection is made to the respective rocket firing squib. For ready identification the firing mechanism may be referred to as in intervalometer directed to the launching of the missiles at predetermined intervals.

For a more complete explanation of the firing mechanism of the intervalometer reference is made to the wiring diagram of Figure 3. In that figure, for example, a source of power is illustrated as originating in a twenty-four volt battery 50, although it will be appreciated that an A. C. circuit is as effective in this device as a D. C. circuit.

In the circuit illustrated a time delay resistance 51 may be employed if need be to compensate for the current characteristics of the source of power. The rockets are numbered in sequence in Figure 3 beginning with R1 indicating the center rocket and then respectively the surrounding six rockets R2, R3, R4, R5, R6 and R7.

Values are given to the various resistances and fuses by way of example as being values which are operable when subjected to the source of power of twenty-four volts. It will be noted that the internal firing resistance of a squib in the rocket in each instance is one ohm. Each of the seven fuses is provided with an identical resistance of .15 ohm. The resistances are each provided in the illustration with values of .4 ohm. For successful performance, however, there should be included a final

4

resistance 52 having an arbitrary value greater than the sum of the previous six resistances, which value can be 3.0 ohms. The presence of the final resistance is made such that it is representative of what would be a continuation of the circuit, inasmuch as the resistances of the fuses and resistances preceding it in the circuit are balanced to take into consideration an aggregate resistance equal to the sum of the several resistances which follow. When the last rocket is to be fired for the timing to continue accurately there should be a weighted resistance such as the resistance 52.

In the example illustrated it is assumed that a minimum of 3.0 amperes will be employed although a current closer to 5.0 amperes is more satisfactory in that it provides a greater margin of dependability. When contact is made as by means of a push button 53, current is immediately connected to the rocket R1 and the fuse 34 through point 33. The rocket, however, will be delayed in firing a small fraction of a second sufficient to have the current burn out the fuse 34. Current will be deflected to the fuse 34 and the resistance 35 and the respective circuits in which they are connected. Upon the burning out of the fuse, current will then become sufficient to ignite the squib in the rocket R1. The resistance of the fuse 34 is made such that it will burn out at a predetermined time interval which may be .01 second or some other chosen interval. After the squib of the rocket R1 has burned out, most of the current which flows through the resistance 35 to the point 36 will be deflected to the fuse 37 until it is blown, and then to the firing squib of the rocket R2. It will be apparent that the delay in the firing of the rocket R2 is a matter of time determined by the length of time required to burn out the fuse 37 plus the time required to ignite the squib in the rocket R2. Following the burning out of the squib in the rocket R2, most of the current flowing through the resistance 38 will then be deflected through the fuse 39 until that is burned out in a predetermined time interval, after which the current will then become sufficient to fire the squib of rocket 3. Thus, each fuse acts as a short circuit, shorting out the corresponding rocket until said fuse is blown after a predetermined delay. This progress of current continues through all of the fuses and all of the resistances except the resistance 52. Because of presence of the resistance 52, the last two rockets R6 and R7 will be fired at the same predetermined time interval rather than almost simultaneously as might be the case should the resistance 52 be omitted. A regulated time interval of ripple firing is therefore assured and this interval can be very accurately controlled, at least sufficiently accurately for proper aiming and firing of the series of rockets by selection of fuses and resistances of properly balanced ohm value. Inasmuch as most rockets are built to a predetermined value of resistance in the firing squib, namely, approximately one ohm, the other values will be balanced accordingly.

In another more simplified form of the circuit illustrated in Figure 4, fuses have been dispensed with and the values of the resistances balanced to compensate for exclusion of the fuses. Again in this circuit the resistance of the firing squibs in the rocket is assumed to be one ohm.

In the modified circuit a source of power 60 is fed through a resistance 61 here selected as a resistance of five ohms. The current follows a lead-in wire 62 until it reaches a point 63 where it is adapted to divide, part of the current continuing to the point 64 where it is connected to the firing squib of rocket R1. A ground circuit element 65 is connected to a ground circuit 66; a button 67 is designed to start the chain of firing.

In this form of the invention resistances 68, 69, 70, 71, 72 and 73 have gradually increasing values, those values being illustrated on the wiring diagram as .07 ohm increasing at increments of .02 ohm until the last

5

resistance increment of .01 ohm. An end resistance 74 of .65 ohm is provided, that resistance being slightly less than the sum of all of the preceding six resistances. The value of the end resistance 74 is selected so as to be substantially the equivalent of a continuation of the circuit. This assures firing of the last rocket in the same predetermined sequence as those preceding it. There need also be a compensating factor for rocket R2 and succeeding rockets due to a portion of the current flowing into those rockets in quantities still insufficient to fire the respective rockets until the rocket immediately ahead of it in the circuit is fired.

Of further importance in this form of the circuit is the fact that the resistances 68, 69, etc., can be made to very small values, namely, in values of hundredths of an ohm increasing by increments of as little as .02 ohm. By keeping these values small, a great many rockets more than seven can be fired in the same accurate sequence by the same firing technique. The limit on the number of rockets thus fired runs into several hundred before resistance values become too high to be practical. At this point, however, additional rockets could be fired by running a lead-in wire in a different direction to a new sequence of rockets. The time interval between the firing of rockets with a circuit of this kind can be accurately controlled to intervals in the neighborhood of .040 second or at intervals shorter or longer than such intervals. The time intervals can be further controlled to some degree by the value of the current impulse sent into the system through the button 67.

It will therefore become apparent that a very accurate timing mechanism is possible by employment of extremely simple electrical structure and the use of fuse and resistance elements of elementary character, the values of which can be readily determined and employed. Ignition spiders can be made up following the scheme disclosed with a great degree of economy without sacrifice of accuracy and dependability of timing. Such ignition spiders are readily insertable in the ignition housing. Where it may be desired to fire at a different ripple sequence, ignition spiders having different sets of values can readily be replaced for those removed from the housing.

In the form of device illustrated in Figures 5, 6 and 7 an intervalometer is disclosed mounted upon a plate 80 of dielectric material over which is adapted to be applied a box-like top or lid 81. The top has side walls 82 and end walls 83 such that the top can be sealed around a perimeter 84, thereby to completely protect the interior of the box and make possible, if desired, the drawing of a vacuum on the interior or the filling of the interior with some appropriate protective gas to insure against deterioration of the mechanism housed therein.

A bus bar or contact strip 85 extends longitudinally throughout a substantial portion of the length of the plate 80. The bus bar is preferably made of some effective conductor such as copper. This is fastened to the plate by some appropriate conventional means, preferably by employment of an adhesive. On one side of the bus bar is a tube 88 of dielectric material, the tube being supported in the positions shown in Figures 5 and 6 by posts 89 which at the same time may serve as a binding post. At each station marked by a binding post a light leaf spring 90 is secured between the tube 88 and a strip 91 of some appropriate dielectric material. By making contact between the post 89 and the leaf spring 90 an electric contact is assured between the leaf spring and a lead 92 from the binding post.

On the opposite side of the plate 80 is an elongated bracket 93 having a base flange 94 secured by rivets 95 to the plate 80. On the other side of the bracket are a series of equally spaced overlying legs 96, the spacing of which is clearly shown in Figure 5.

The leaf springs 90 are shown spring pressed against a

6

very fine fusible wire 97 which extends over the legs 96 and which is soldered at points 98 on each leg. In this way each length of wire between adjacent legs is independent structurally of every other length of wire. Each leaf spring 90 carries a contact point 99 which is adapted to make contact with the bus bar 85 when the spring is released by the breaking of the section of fine wire 97 which holds that particular spring in the initial position illustrated best in Figure 6.

By reference to Figure 7 in combination with Figures 5 and 6 it will be noted that current may be supplied from a source such as a battery 100, the battery being grounded at one terminal and having a hot lead 101 extending from the other terminal through a discharge switch 102, thence through an initial resistance 103 and a secondary resistance 104 to a point 105. Rocket squibs for successive rockets are indicated by R1, R2, R3, R4, R5 . . . RN. The number of squibs may be virtually any number. Current from the source 100 when connected by closing of the discharge switch 102 flows through the resistances 103 and 104 and thence is passed to the rocket squib R1, thereby igniting the first rocket. By reason of the presence of resistance 106 of five ohms and the presence of a resistance of two ohms in a fuse 107, power is applied to the first rocket squib which has a resistance nominally of one ohm. The rocket squib receives twice as much current as the first fuse 107 and is the first to function, firing within a few milliseconds. It will be noted that the resistance 106 consists of a number of turns of wire around the tube 88 between a contact 89 and a contact 89' for respectively the first and second rocket squibs. Succeeding resistances between each pair of rocket squibs are of equal values of five ohms and succeeding fuses 107 for each succeeding connection are equal in value and of two ohms.

After the squib circuit for squib R1 is broken by the current, the voltage on the first fuse 107 approximately doubles causing it to break within a few milliseconds. Breaking of the fuse 107 which comprises the first length of fine wire permits the corresponding leaf spring 90 to drop until the contact point 99 makes contact with the bus bar. The current then is passed directly from the bus bar to point 105. Next the current from point 105 reduced in voltage by resistance 106 for a few milliseconds passes to contact point 103 and is diverted first through the one ohm squib R2 of the second rocket firing that rocket. The current is then diverted through a fuse 109 breaking the fuse 109 which in turn causes the leaf spring 90 second in line to drop and make contact with the bus bar 85. This causes current to travel from the source 100 through the bus bar and through the second leaf spring, after which upon reaching a contact point 111 the current fires the squib R3, then travels through the appropriate fuse, breaking the fuse and causing the next leaf spring 96 to drop into contact with the bus bar in the manner previously described. It will be apparent therefore that each time a leaf spring 90 makes contact with the bus bar 85 a rocket squib is ignited firing the appropriate rocket, the resistance immediately preceding it is shorted out and there is no build up of resistances as the operation proceeds through the firing mechanism. Consequently any number of rockets could be fired in this fashion without any appreciable increase in drain upon the current.

The firing mechanism proceeds through the entire sequence of squibs save one terminating in the energizing of the squib RN. This results in blowing the appropriate fuse and closing the circuit to the bus bar. One squib remains to be fired, namely, the squib RN. A disc 113 cooperable with the squib RN is appropriate for connection to a shut-off circuit, not shown, which can be employed to completely disarm the entire firing mechanism so that upon reloading there can be no inadvertent discharging.

In the event of abnormal functioning, as for example

a rocket shorted out, a slow burning fuse may be placed in series with each rocket lead to assure the breaking within a few milliseconds of the circuit even though it be shorted to ground. Upon the breaking of such a fuse, normal firing will resume. A fuse can be placed in series with the rocket squib to bring about a more constant ripple rate. Such fuse would be given a value sufficient to hold only long enough to assure that the squib receives sufficient energy to fire whereupon the fuse would break. Functioning in this manner, any extra delay due to the late breaking of the bridge wire in the rocket squib is compensated for and balanced out so that the squibs all fire at a normal interval.

Under still other circumstances should there be a faulty contact of one of the intervalometer switches, namely, a leaf spring 90 and appropriate contact point 99 with the bus bar, after burning out of the fuse wire, the ripple firing will nevertheless continue normally due to current by-passing through the appropriate resistance. The resulting delay before continuation of normal firing would usually be not greater than twice the normal ripple interval. In any event, all the rockets would be fired.

Under still other circumstances a broken fuse wire somewhere in the middle of the intervalometer might exist. Although this would upset the ripple pattern by causing simultaneous firings in both directions from the break point at the same time, nevertheless the rockets on both sides still fire consecutively from the point nearest the break until the point remotest therefrom has been reached. This ripple firing pattern will be slightly erratic as compared to normal rate but even so the likelihood of salvo firing of all of the rockets simultaneously is avoided. The ripple firing may occur in small bunches but such ripple firing is preferable to inadvertent salvo firing. Such circumstances as broken fuse wires can, however, be virtually avoided under all circumstances by providing a high margin of safety in the spring design such that the fuse will not break under even the most severe shock and vibration conditions incurred in shipping, rough handling and flight without at the same time making the fuse any more greatly resistant to breaking at the proper electric current value. Ripple firing units or intervalometers of the type herein described have been designed and operated on a ten millisecond ripple interval. It will be appreciated from the disclosure that the interval can readily be altered to give any other reasonably firing interval by a readjustment of values on the resistances and fuses, consistent with the power available.

There has accordingly been described a compact, inexpensive intervalometer for the ripple firing of missiles which is sturdy in its construction so as to resist disturbance on account of physical conditions, which is operable with a great degree of reliability from a small power source, thereby minimizing weight penalty while at the same time making it possible to ripple fire virtually any number of rockets from existing aircraft power supplies.

While we have herein shown and described our invention in what we have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of our invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described our invention, what we claim as new and desire to secure by Letters Patent is:

1. An electric actuated ripple firing circuit for a series of squib fired missiles comprising a source of electric power having a ground connection and having a power line therefrom, a series of separate parallel connections from the power line for grounded squib units of equal known electrical resistance values, a separate electrical resistance element between the power line and each connection, a by-pass circuit between each connection and the power line on the power source side of the re-

sistance element first in line, said circuit having a normally open switch therein, a fuse element of resistance different from the resistance of squibs with which the circuit is to be used connected between each connection and ground, said fuse element having a physical engagement with an arm of the switch and being adapted normally to hold said switch arm in open position and to enable closing said switch upon fusing of the fuse.

2. An electric actuated ripple firing circuit for a series of squib fired missiles comprising a source of electric power having a ground connection and having a power line therefrom, a series of separate squib units of equal known electrical resistance values connected in parallel between said power line and ground, a separate electrical resistance element between the power line and each squib unit, a by-pass circuit between the power line side of each squib unit and the power line on the power source side of the resistance element first in line and having a normally open switch therein, a fuse element of resistance different from the squib resistance connected between the power line side of each squib and ground, said fuse element being adapted normally to hold said switch in open position and to enable closing said switch upon fusing of the fuse.

3. An electric actuated ripple firing circuit for a series of squib fired missiles comprising a source of electric power having a ground connection and having a power line therefrom, a series of separate squib units of equal known electrical resistance values connected in parallel between said power line and ground, a separate electrical resistance element between the power line and each squib unit, a by-pass circuit between the power line side of each squib unit and the power line on the power source side of the resistance element first in line and having a normally open switch therein, a fuse element of resistance different from the squib resistance connected between the power line side of each squib and ground, said fuse element being adapted normally to hold said switch in open position and to enable closing said switch upon fusing of the fuse, the switch in circuit with the squib unit last in line being connected only to a circuit separate from the common circuit of the preceding switches.

4. An electric actuated ripple firing device for a series of missiles comprising a base plate, an elongated dielectric member mounted on the base plate and extending longitudinally thereof, a plurality of separate connections on the dielectric member, an input binding post, a plurality of resistance elements on said dielectric member interconnected at connection points in series to said binding post, each of said connection points being connected to one of said separate connections, a resilient switch arm extending transversely outwardly from each connection, a plurality of spaced arms and a section of relatively fine fuse wire between each pair of adjacent arms, each said section being connected to ground and being engaged beneath and supporting one of said switch arms in spring tension, a single bus bar on the base plate extending under all said switch arms and being connected to said input binding post.

5. An electric actuated ripple firing device for a series of squib fired missiles comprising a base plate, a rod of dielectric material mounted on the base plate and extending longitudinally thereof, a plurality of firing connections extending from the rod through the base plate, an input binding post, a plurality of resistance elements connected in series to said binding post and extending around said rod, a connection intermediate each pair of adjacent resistance elements to one of said firing connections, a resilient switch arm extending transversely outwardly from each firing connection, a plurality of spaced arms and a section of relatively fine fuse wire between each pair of adjacent arms, each said section being connected to ground and being engaged beneath and supporting one of said switch arms under spring tension, a

single bus bar on the base plate extending under all said switch arms and being connected to said input binding post.

6. An electric actuated ripple firing device for a series of squib fired missiles comprising a base plate, a hollow cover adapted to be sealed at an edge thereof around the base plate and to provide thereby a gas tight chamber, a member of dielectric material mounted in said chamber on the base plate and extending longitudinally thereof, a plurality of squib connections extending from the member through the base plate, an input binding post, a plurality of wire resistance elements interconnected at connection points in series to said binding post and extending along said member, each of said connection points being connected to one of said squib connections, a resilient switch arm extending transversely outwardly from each connection, a bracket on the base plate having a plurality of spaced arms and a section of relatively fine fuse wire between each pair of adjacent arms, each said

section of fuse wire being connected to ground and being engaged beneath and supporting one of said switch arms in spring tension, a single bus bar on the base plate extending under all said switch arms except the switch arm last in line, said bus bar being connected to said input binding post, and a separate connection beneath said switch arm last in line.

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