April 25, 1944. F. J. HOOVEN 2,347,481

TIMING DEVICE

Filed July 22, 1939 2 Sheets-Sheet 1

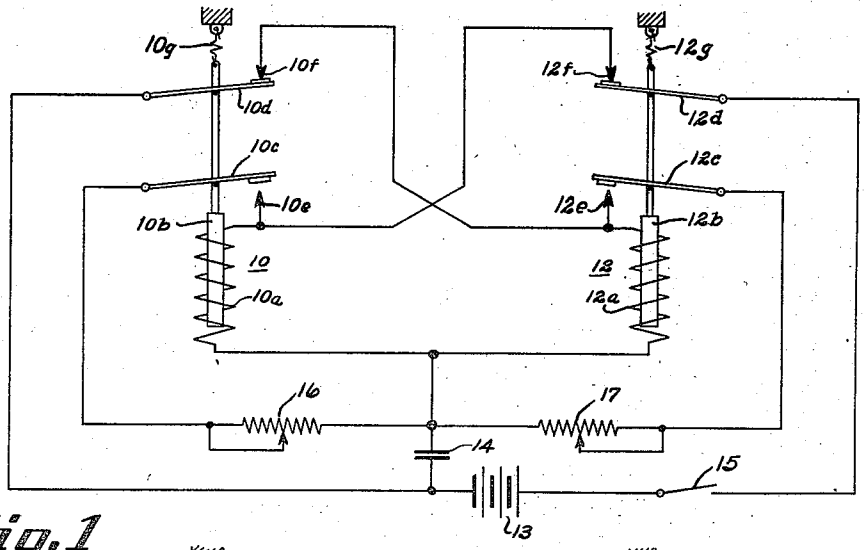

Fig. 1

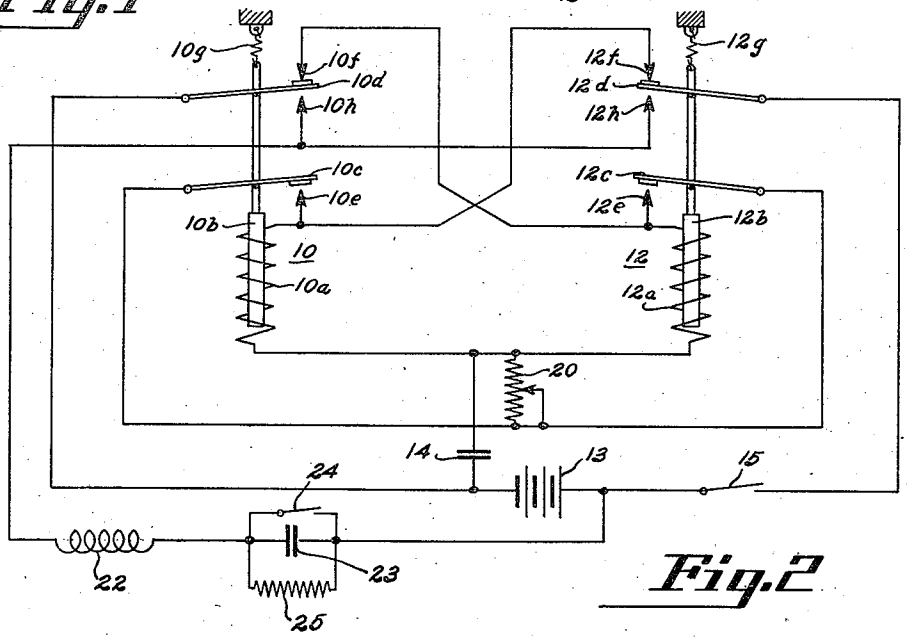

Fig. 2

Inventor

Frederick J. Hooven

By Marechal & Roe

Attorneys

April 25, 1944. F. J. HOOVEN 2,347,481

TIMING DEVICE

Filed July 22, 1939 2 Sheets-Sheet 2

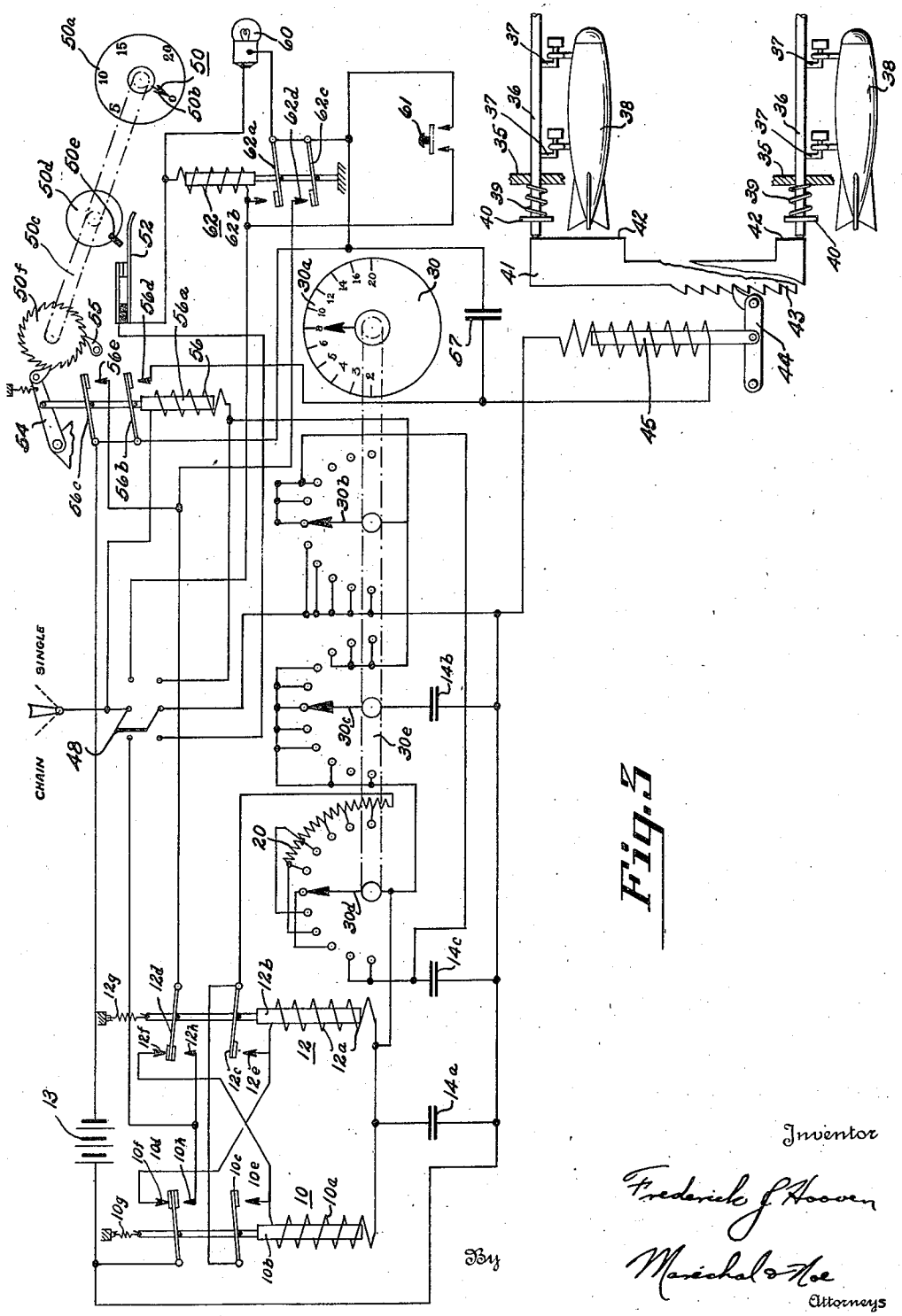

Fig. 2

Inventor
Frederick J. Hooven
By Marechal & Noe
Attorneys

Patented Apr. 25, 1944

2,347,481

UNITED STATES PATENT OFFICE

2,347,481

TIMING DEVICE

Frederick J. Hooven, Dayton, Ohio

Application July 22, 1939, Serial No. 285,908

16 Claims. (Cl. 177—380)

This invention relates to timing devices and more particularly to devices for establishing electrically a series of periodic impulses adapted for the control of a periodically recurrent function.

It is a principal object of the invention to provide a timing device which is simple in construction and operation, light in weight, and which provides for establishing accurate, uniform and predetermined time intervals.

It is a further object to provide such a device in which the time intervals are controllable over a wide range with simplicity and accuracy.

It is also an object to provide a device of this character for producing a series of timed impulses adapted for the control of a periodically recurrent function where both the time between the impulses and the actual duration of the impulses are predetermined and controllable.

It is a further object to provide a control device for use with a bomb rack for effecting the rapid sequential release of a plurality of bombs at uniform time intervals apart and at a desired frequency, and in predetermined number as determined by the operator.

Other objects and advantages will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings—

Fig. 1 shows schematically a simple timing arrangement for securing periodic operation at predetermined time intervals of a plurality of relays;

Fig. 2 is a diagrammatic representation of a similar circuit incorporating a control circuit and a frequency multiplying control; and

Fig. 3 is a diagrammatic showing of a complete system as arranged for the sequential release of a plurality of bombs.

In accordance with the present invention a timing device is provided which is adapted to effect the generation of a series of periodic timed impulses, the impulses being of predetermined duration, and at properly spaced uniform intervals. Such series of impulses may be utilized for the control of a periodically recurrent function, where such timed sequence of operations is desired, for effecting suitable operation of a device. Since the invention provides for producing a series of impulses electrically and with extremely simple apparatus, and embodies very simple and readily operable means for the control of the timing period thereof, the device is highly useful where simplicity, reliability and low weight are important factors.

A preferred field of application of the device is for the control of the dropping of a plurality of bombs from an aircraft or the like. Where it is desirable to provide for the dropping of a plurality of bombs in predetermined timed sequence, at relatively brief time intervals apart, the present invention provides a highly satisfactory control for this purpose, which is highly simple in construction and operation, and which involves only a low weight and substantial freedom from complexity in operating mechanism. It provides for example for the dropping of bombs at a predetermined desired rate such for example at rates varying from two per second to twenty per second under simple manual control on the part of the operator; and such limits and range of speeds may be subject to substantial variation as desired. It further provides for the preselection by the operator of a predetermined number of impulses to be generated, and hence of a predetermined number of bombs to be dropped, following which the device ceases its functioning, while providing visual indication to the operator at all times of the number of operations completed and remaining to be completed. The device also preferably incorporates a manual control by means of which the operator may individually effect the release of the bombs when that operation is desired. While not limited to the utilization of the periodic timed impulses for the releasing of bombs, that function forms a preferred field of application for the device, and will be referred to hereinafter in connection with the detailed description of the operation of the mechanism.

Referring to Fig. 1 of the drawings, this figure shows diagrammatically a simple timing circuit for securing the alternate operation of a plurality of relays 10 and 12, in timed relation one with the other. A source of electrical energy is shown at 13 as comprising a battery, such as utilized upon an aircraft, though other suitable sources of direct current potential may likewise be utilized.

One side of the power source shown as the negative is connected through a condenser 14 with each of the energizing coils 10*a* and 12*a* of the two relays 10 and 12. The relays have armatures 10*b* and 12*b* each of which carries a pair of contact arms 10*c*, 10*d* and 12*c*, 12*d*. Fixed contacts 10*e* and 12*e* are arranged to be closed by switch arms 10*c* and 12*c* respectively upon the actuation of the relays, while switch contacts 10*f* and 12*f* are arranged to be closed by switch arms 10*d* and 12*d* respectively upon deenergization and release of the respective relays. Retractile springs 10*g* and 12*g* cause the return of the armatures and associated switch arms to the non-actuated position upon the deenergization of the respective relays, to positively open contacts 10*c*, 12*c* and 10*e*, 12*e*, and to cause the closing of contacts 10*d*, 10*f* and 12*d*, 12*f*.

The energizing circuit through coil 10*a* is completed through contacts 12*f*, 12*d* of relay 12 so that relay 10 may be energized only when relay 12 is deenergized. Similarly the energizing circuit for coil 12*a* is completed through contacts 10*f* and 10*d* of relay 10 so that relay 12 may be

energized only during the time that the relay 10 is deenergized.

Thus the circuit for relay 10 includes condenser 14, coil 10a, contacts 12f and 12d, manual control switch 15, and back to the positive side of the power source 13. And upon closing of switch 15 current flow takes place to cause the building up of a charge upon condenser 14. The rate of such flow of charging current will vary with the actual values of capacitance and resistance in the circuit, beginning at a high value and progressively decreasing in amount as the charge on the condenser builds up.

Contacts 10c and 10e upon closing establish a shunt circuit around the coil 10a of relay 10 which includes a variable resistor 16 through which a portion of the charging current flowing through condenser 14 may pass following actuation of the relay. Similarly contacts 12c and 12e upon closing establish a shunt circuit around the coil 12a which includes variable resistor 17 through which a portion of the current passing through condenser 14 may pass.

The operation of this device is as follows. Upon the closing of manual switch 15, and with both relays deenergized, an energizing circuit for relay 10 is established through condenser 14, coil 10a, switch contacts 12f, 12d, through switch 15, and back to the opposite side of the power source. A circuit is also closed through coil 12a, but since there is no difference of potential in this circuit, relay 12 does not operate. A maximum flow of current takes place through the circuit of relay 10 as described, beginning the charging of condenser 14, this flow resulting in the operation of relay 10 to strongly attract armature 10b, thereby closing contacts 10c, 10e, and opening contacts 10d and 10f. The opening of the latter contacts opens the circuit through relay 12, and makes it impossible for that relay to be actuated. The closing of contacts 10c, 10e establishes the shunt circuit around the coil 10a including variable resistor 16. The effect of thus placing a resistor in parallel with the coil 10a is to reduce the effective resistance in the charging circuit of condenser 14, thereby reducing the time required for the building up of the charge within the condenser. As the charge increases, the flow of current will decrease, and ultimately reach a point at which there is insufficient current flow to maintain the relay in actuated condition. When such point is reached relay 10 releases, opening contact 10c, 10e, and closing contacts 10d, 10f. The latter establishes a circuit through coil 12a and the now charged condenser 14. The condenser immediately begins to discharge at a maximum rate, resulting in actuation of relay 12, thereby opening the circuit through coil 10a at contacts 12f, 12d, and closing the shunt circuit through resistor 17 at contacts 12c, 12e. Thus as soon as the relay has been actuated, the shunt circuit for controlling the time required for the discharge of the condenser is established, and the relay remains energized as long as there is a sufficient flow of discharging current. When the value of the discharge current falls below a predetermined point, it is no longer sufficient to maintain relay 12 in actuated condition, and this relay then releases, again establishing the charging circuit through relay 10. Such operations thereafter continue as described and because the periods of time between successive operations are dependent upon the electrical characteristics of capacitance and resistance, they are subject to predetermined control and are maintained with considerable accuracy as so selected.

In order to effect regulation of the period during which the relays remain energized, and hence controlling the time intervals between actuation of the two relays, resistors 16 and 17 may be properly adjusted. Upon increasing the values thereof, up to the maximum point where the shunt circuit would be entirely open, it will be apparent that the characteristics of the charging and discharging circuits will be determined by the values of capacity of the condenser, and the fixed resistance in the circuit, primarily that of the relay coils themselves; and that under such circumstances the maximum time to effect charging and discharging will be required hence resulting in longer time intervals between operations. If desired, it will be clear that additional resistance can be inserted in series with the condenser to further extend the time required for charging and discharging thereof.

On the other hand when the values of resistance are decreased to the minimum which represents a short circuit around the respective relay coils, which however is not established until after the completion of actuation thereof, it will be clear that the minimum time will be required thereafter to complete the charging or discharging of the condenser, since the charging resistance has been substantially eliminated, and hence this results in producing shorter time intervals between operations.

It will also be clear that the actual period necessary for these operations will vary with the capacitance of condenser 14, and that this may be varied as well as the resistance in the charging circuit, to secure a variable time of actuation. Using very large values of capacity discharging through small resistances at a high rate results in high currents and consequent probability of deterioration of the contacts. Likewise an amount of internal resistance in the condenser comparable with the resistance of the charging or discharging circuit may cause faulty operation so that it is generally found desirable, in attaining the higher operating speeds, to reduce the capacity of the timing condenser rather than by the use of a very low adjusting resistor. This is readily accomplished by the use of a plurality of electrolytic condensers arranged to be selectively included in the circuit, the use of such condensers being desirable in view of their relatively large capacity and small space requirements. However because it is usually not practicable to secure extreme accuracy in the capacity of such condensers, the concurrent use of adjustable resistors has also been found desirable.

It will thus be observed that each relay, assuming it to have similar electrical and physical characteristics, will require substantially the same length of time to actually close following initiation of flow of the charging or discharging current, and will be maintained in actuated condition by substantially the same rate of current flow through the two coils. Thus there is a constant factor in the timing period represented by that time required for the release of one relay and the operation of the other; and a variable factor representing the time during which each of the relays remains in its actuated condition. This latter factor is subject to variation and control as described above, and may be made relatively short in proportion to the first factor such as an interval corresponding approximately with or even less than the time required for the mechanical movements, or may be made substan-

tially longer than this period, for example up to many times that period.

It will likewise be understood that where the two relays have similar characteristics, and where it is not necessary to secure separate control over the time during which one of the relays remains in actuated condition with respect to the other, a single resistor may be incorporated in place of the two variable resistors 16, 17, which single resistor is placed in circuit with both the charging and the discharging circuits, to give similar capacitance-resistance characteristics therein, and to bring about a similar time during which each of the relays remains in energized condition.

Such an arrangement is shown diagrammatically in Fig. 2 in which the relays 10 and 12 are each provided as described above with the actuating coils and other parts 10a to 10g and 12a to 12g respectively. However in place of the separate resistors 16, 17, a single resistor 20 is provided, made suitably variable, and connected to be placed in shunt circuit with the respective relay coils 10a and 12a so as to be alternately incorporated in the charging and the discharging circuits of condenser 14 following actuation of the respective relays. Variation of this resistor produces variation in the length of time during which the flow of charging current or discharging current continues in excess of that minimum value required to maintain the relay armature in actuated condition, and hence provides for regulating the period of actuation and the frequency of operation in the same manner as resistors 16, 17 described above.

Furthermore Fig. 2 shows additional contacts 10h and 12h arranged to be closed respectively by contact arms 10d and 12d upon actuation of the respective relays 10 and 12. These contacts 10h and 12h are connected in a circuit which includes a solenoid 22, a multiplying condenser 23, and one side of the power source 13. A control switch 24 is arranged to short circuit condenser 23 and thus to effectively remove it from the circuit of solenoid 22. This condenser performs the function of multiplying the effective frequency of generated impulses in a manner hereinafter described.

Considering first the case where switch 24 is closed, and hence condenser 23 removed from the circuit of solenoid 22, it will be apparent that upon actuation of relay 10, closing contacts 10d and 10h, a circuit is completed through the power source, said contacts, solenoid 22, closed switch 24, and back to the other side of the power source. As a result thereof current flows through solenoid 22, producing a timed electrical impulse for effecting a control operation as desired. Upon the release of relay 10, and the subsequent actuation of relay 12, it will be seen that the power source is no longer included in the circuit of solenoid 22, and hence no energization of the solenoid takes place upon actuation of relay 12. Consequently, a timed actuation of solenoid 22 occurs once for each operation of relay 10, with no corresponding energization upon operation of relay 12.

However when switch 24 is open thereby including multiplying condenser 23 in the circuit, the closing of switch contacts 10d and 10h establishes a flow of charging current through condenser 23 which energizes solenoid 22. Upon release of relay 10 and actuation of relay 12, closing contacts 12d and 12h, a discharging circuit is established through said contacts, and the solenoid 22, through which there occurs a flow of discharging current from the charged condenser 23. This flow of discharging current produces a second energization of solenoid 22. Thus under these conditions solenoid 22 is energized in definite timed relation to the actuation of both relays 10 and 12, and as will be clear, any change in the frequency of operation of said relays will result in a corresponding change in the timing of the energizations of solenoid 22. Thus by the simple utilization of switch 24, the frequency of energization of solenoid 22 can be multiplied or doubled if desired.

It will also be apparent that the actual duration of flow of charging and discharging current in the circuit of solenoid 22 may be made independent of the contacts 10d, 10h and 12d, 12h when condenser 23 is included in the circuit. Thus by suitable selection of the electrical characteristics, i. e., capacitance and resistance, in the circuit of solenoid 22, the charging and discharging currents may be so regulated as to have decreased to a substantially low value at the time of opening of the respective switch contacts in the circuit; as a result therefore arcing and injury to the contact points may be reduced to a minimum. Further it will be also clear that where it is desired to effect the actuation of an auxiliary device under the control of solenoid 22, particularly where such device has parts requiring any material period of time for resetting after one actuation in preparation for the next, this circuit provides for a strong timed operating pulse through solenoid 22, which can then be terminated promptly, by reason of the substantial completion of flow of charging or discharging current, affording the mechanism ample time for resetting, prior to the subsequent operation of the other relay and the generation of a subsequent operating pulse through the solenoid. Hence the beginning of each timed pulse is accurately controlled, but the solenoid is not unnecessarily maintained in energized condition during the time interval that the timing relays continue to be energized. By terminating the flow of current through the solenoid in a lesser period of time, the mechanism controlled thereby is given adequate time for resetting, and damage to the switch points is substantially eliminated.

Where an odd number of impulses is desired, that is where the operation terminates with the energization of relay 10, it is clear that a charge might be left upon condenser 23, and if not dissipated, would interfere with the beginning of a subsequent cycle of operations, delaying those operations by a half cycle. Accordingly it is preferred to place a high resistance 25 across condenser 23 through which any residual charge thereon can be dissipated, but which is of such high resistance as to not materially alter the characteristics of the system during normal operation.

Fig. 3 shows the application of the present invention to an arrangement for dropping bombs in predetermined timed sequence. The relay parts and switch contacts 10 to 10h and 12 to 12h are as described above, and are similarly identified for easy reference. In order to secure predetermined timed operation of the device at a rate to be manually selected, a plurality of condensers 14a, 14b and 14c are utilized. Likewise a tapped resistor 20 is arranged to be incorporated in the charging and discharging circuits of said condensers in the manner of relay 20 described above. A manual control switch 30 is provided comprising an indicating dial 30a upon which the speeds are shown, and three switch arms 30b, 30c, and

30*d*, preferably arranged in separate planes or decks and actuated by a common shaft indicated at 30*e*. The switches have a series of positions shown as eleven in number, corresponding to the indicated speeds on the dial 30*a*, a representative series of such speeds being 2, 3, 4, 5, 6, 8, 10, 12, 14, 16 and 20 operations per second. In order to secure such variable range of operations, these switches are made to selectively control the incorporation of the several condensers and variable resistors in circuit as will be described more in detail hereinafter.

The bomb rack is shown diagrammatically at 35, comprising a series of release arms 36 having depending fingers 37 upon which the bombs 38 are retained. A compression spring 39 acting against a collar 40 fastened to the arms 36 normally tends to withdraw said arms and to effect the release of the bomb. However a cam plate 41 is arranged in line with each of the arms 36, and has a cam face 42 thereon of varying length, which normally engages the arms 36 and prevents their movement to release the respective bombs. Cam plate 41 is provided with ratchet teeth 43, and a pivotally mounted pawl member 44 is arranged to engage said teeth to effect the notching of the cam plate upwardly. Operation of the pawl 44 is effected electrically by means of a solenoid 45, each actuation of which causes the pawl to lift the cam plate by one notch. As shown the several faces 42 are such that the lowermost arm 36 will be released upon the first actuation of pawl 44, and since the face in contact with the next uppermost arm 36 is proportionately wider, it will be released upon the second pawl operation. Similarly each successively higher bomb will be caused to be released upon each additional pawl operation. It will be understood that other suitable mechanism for effecting sequential operations of the character described, upon a series of energizations of solenoid 45, may be utilized as desired.

In some cases it may be desired by the operator to secure complete manual control of the release of the bombs, and in others to secure the timed sequence operation as described herein. To provide for securing such selective operations, a double-pole, double-throw control switch 48 is provided which when thrown to one position as shown to the left, provides for securing timed sequential operation, and when thrown to the right provides for individual control of the operations by manual means. The description will be directed primarily to the former type of operation with the switch 48 thrown to the left to establish the predetermined and timed sequential operation of the system.

In order that the operator may manually control the operations of the system and also receive an indication of the exact status of the operation at any time, a manually controlled preselector device 50 is provided having an indicating dial 50*a* upon which are indicated the total number of operations to be performed, for example the total number of bombs held in the rack. A manually adjustable pointer arm 50*b* is arranged for cooperation with such scale, and upon manual operation, is adapted to effect rotation of a shaft 50*c*. This shaft carries a cam disk 50*d* having a cam pin 50*e* thereon which is arranged to effect the opening of a limit switch 52 when the desired number of operations have been completed. The pin 50*e* is related to the indicating arm 50*b* in such manner that when arm 50*b* stands at the zero or off position, switch 52 is open but at any operative position at which arm 50*b* may be set, switch 52 is closed.

The shaft likewise carries a toothed wheel 50*f* with which there engages a notching pawl 54 and a non-reverse pawl 55. A solenoid 56, corresponding in function and operation with solenoid 22 as described above in connection with Fig. 2, is provided with armature 56*a*, which carries switch arms 56*b* and 56*c*. The armature likewise is connected to the pivoted pawl member 54 so that upon each actuation of solenoid 56 the pawl is actuated, and the toothed wheel is advanced one step.

Upon adjustment of the preselector device 50 to move the indicating hand away from the off position, limit switch 52 closes, and a circuit for an indicating light 60 is closed, indicating to the operator that the system is preconditioned for operation. The arm 50*b* is adjusted to a position corresponding to the number of operations which it is desired to secure, and as will be clear the adjustment of this arm to a proper indicating value on the dial will indicate the number of operations which will take place before the limit pin 50*e* opens the limit switch 52.

With the preselector device thus adjusted, and the indicator device 60 operated, the operator may depress a manual push button 61 which closes an energizing circuit through hold-in relay 62, such circuit being completed through the closed contacts of limit switch 52. Upon operation relay 62 closes its contact arm 62*a* upon contact 62*b*, and thereby establishes a holding circuit around push button switch 61 so that the latter may be released after its initial operation. Relay 62 also carries a switch arm 62*c* which closes upon contact 62*d*, thereby closing a circuit from one side of the power source through switch contacts 10*d*, 10*h*, or 12*d*, 12*h*, through the switch 48, and to one side of relay 56, which in turn is connected to the opposite side of the line by one of the arms of switch 30, and back to the opposite side of the power source either directly or through one of the doubling condensers 14*b* or 14*c*, depending upon the setting of switch 30. Accordingly energization of solenoid 56 occurs, in definite timed relation with the operation of relays 10 and 12. Upon each operation of relay 56, switch arm 56*b* closes contact 56*d*, and connects the operating solenoid 45 with the power source so as to secure the release of a bomb.

In order to avoid unnecessary arcing of the contacts 56*b* and 56*d*, an arc-suppressing condenser 57 is connected across such contacts to avoid objectionable arcing therein. Likewise upon operation relay 56 closes switch arm 56*c* upon contact 56*e*, the latter establishing a shunt circuit around the contacts 10*d*, 10*b* and 12*d*, 12*h* so that assurance will be provided that the last operation will be certain of being completed, regardless of the exact point in the cycle at which the limit switch 52 opens.

Operation of relay 56 continues in predetermined timed sequence under the control of the relays 10 and 12, each operation effecting the notching of the preselector device 50 by another step. Finally when the predetermined number of operations has been completed, as determined by the initial setting of control arm 50*b*, limit pin 50*e* engages the movable contact of the limit switch 52, thereby opening the circuit through the control relay 62 and extinguishing the indicating light 60 and deenergizing both relays 10 and 12. As above described however the last cycle of operation is continued through contacts

56c, 56e, but upon completion of that operation, the entire system is disconnected from the power source and further operation is terminated.

In order to secure control over the speed at which the bombs are dropped, switch 30 is manually adjusted to the desired rate as indicated on face plate 30a. In the initial position corresponding for example to 2 operations per second, the several switch arms 30b, 30c and 30d are so connected as to include all three condensers 14a, 14b and 14c in parallel as timing condensers, the capacities of these units being suitably selected as required. For example condenser 14a and 14b may have a capacity of 250 m. f. and condenser 14c of 500 m. f. Under these conditions the total capacities in circuit with relays 10 and 12 is 1000 m. f.

In the second position in order to obtain a speed of three operations per second, the switches are arranged to disconnect condenser 14b from the timing circuit, thereby giving a net capacitance of 750 m. f.

In the next position corresponding to four operations per second, condenser 14b is reconnected in the timing circuit and condenser 14c is disconnected, thereby providing a timing capacity of 500 m. f.

In order to secure speeds of five and six operations per second, the same capacity is utilized, and variable values of resistance 20 are incorporated in the shunt circuit for the relays 10 and 12, these values being selected to give a more rapid fall in the charging and discharging currents as described above, so as to secure deenergization and release of the relays at proper controlled time intervals.

In order to secure speeds of eight, ten and twelve operations per second, the same capacitance and resistance conditions as established for the timing intervals of four, five and six operations per second, respectively, are obtained, with the incorporation of condenser 14c into the circuit of coil 56, as a multiplying condenser to obtain the doubling action as described above. That is to say, with the manual control member adjusted in any of its positions from two to six operations per second, the circuit does not incorporate a doubling condenser in circuit with relay 56, and hence energization of relay 56 occurs only once for each operation of relay 10, and does not occur upon actuation of relay 12. However switch 30, when adjusted to give speeds of eight, ten and twelve operations per second, effects the incorporation of condenser 14c in circuit with the coil 56 where it acts as a speed doubling device, so that coil 56 is energized upon each energization of relay 10 and likewise of relay 12.

In order to secure speeds of fourteen, sixteen and twenty operations per second, the switch 30 is arranged to include only condenser 14a in circuit with the relay coils and with suitably adjustable values of resistance 20 included in the shunt circuit therewith upon each actuation of the relays 10 or 12. Switch 30 in these positions likewise effects the substitution of the smaller capacity condenser 14b in the circuit as a doubling condenser so that relay 56 is energized upon each actuation of either relay 10 or 12, the smaller capacity condenser 14b requiring a shorter time to become charged and discharged.

It will of course be clear that the actual values and speeds of operation are given as illustrative, and that they may be varied over substantially wide limits in order to secure properly timed periodic impulses for whatever control purposes are desired.

As explained above, the throwing of switch 48 to its right-hand position disconnects the timing device from the actuating circuit of relay 45, and makes the energization of this latter relay dependent solely upon manual control button 61. Since switch 48 when in the right-hand position, with the preselector device 50 in its off position, opens the circuit from the power source to the limit switch 52 and the coil of hold-in relay 62, it will be clear that hold-in relay 62 will not be energized upon the closing of the push button 61, and hence in this condition the device provides for the individual operation of relay 45, and the consequent dropping of a bomb, in direct relation to each operation of the manual push button.

The device therefore provides a highly satisfactory and extremely simple timing device in which there is generated a series of timed impulses accurately spaced as to time, and of predetermined controlled duration. Such impulses may be utilized as desired, for effecting control of a recurrent function, and are of especial adaptability for controlling the release of a series of bombs or the like. Proper control is supplied for the operator, and likewise suitable indication is given at all times of the status of the device. It is simple in construction, and does not add weight which might be objectionable for use upon an aircraft. Similarly it is adapted for operation by the power source usually present in an aircraft.

While the process herein described, and the form of apparatus for carrying this process into effect, constitute a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise process and form of apparatus, and that changes may be made in either without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A timing device of the character described adapted to be energized from a source of electrical energy and to establish predetermined uniform time intervals comprising a plurality of electromagnetic relay means, a circuit for each said relay including control contacts actuated by the other relay and arranged to be closed only upon deenergization of said other relay, a timing condenser, connections for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof, said relay being maintained in actuated condition during continuance of the flow of charging current in excess of a predetermined value, connections effective upon release of said relay for establishing a circuit for the other of said relays for the discharge of said condenser, said other relay being maintained in actuated condition during continuance of the flow of said discharge current in excess of a predetermined value, resistance means separate from and adapted to be associated with said relays respectively for controlling the time of charge and of discharge thereof, and means for including the same resistance means alternately in circuit with each of said relays after the actuation thereof.

2. A timing device of the character described adapted to be energized from a source of electrical energy and to establish predetermined uniform time intervals comprising a plurality of

electromagnetic relay means, a circuit for each said relay including control contacts actuated by the other relay and arranged to be closed only upon deenergization of said other relay, a condenser, connections for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof, said relay being maintained in actuated condition during continuance of the flow of charging current in excess of a predetermined value, and connections effective upon release of said relay for establishing a circuit for the other of said relays for the discharge of said condenser, said other relay being maintained in actuated condition during continuance of the flow of said discharge current in excess of a predetermined value, means adapted to be placed in circuit with said relay and said condenser for varying the time required for the charging current and discharging current of said condenser to fall below said predetermined minimum value to thereby vary the length of time during which each of said relays remains energized, and means for excluding said time varying means from the charging and discharging circuits for said relays until after initial actuation thereof and for then including said time varying means in said circuits to provide for said timing control while assuring positive actuation of said relays.

3. A timing device of the character described adapted to be energized from a source of electrical energy and to establish predetermined uniform time intervals comprising a plurality of electromagnetic relay means, a circuit for each said relay including control contacts actuated by the other relay and arranged to be closed only upon deenergization of said other relay, a timing condenser, connections for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof, said relay being maintained in actuated condition during continuance of the flow of charging current in excess of a predetermined value, and connections effective upon release of said relay for establishing a circuit for the other of said relays for the discharge of said condenser, said other relay being maintained in actuated condition during continuance of the flow of said discharge current in excess of a predetermined value, a single resistance means for controlling the time required for the charging and discharging of said condenser, and means for connecting said same resistance means in circuit with said condenser and said relays alternately upon the actuation thereof to thereby vary the length of time required for the current through said relay to fall below said predetermined minimum value with resultant release thereof.

4. A timing device of the character described for controlling the periodic dropping of bombs and the like adapted to be energized from a source of electrical energy and to establish predetermined uniform time intervals comprising a plurality of electromagnetic relay means, a circuit for each said relay including control contacts actuated by the other relay and arranged to be closed only upon deenergization of said other relay, a timing condenser, connections for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof, said relay being maintained in actuated condition during continuance of the flow of charging current in excess of a predetermined value, and connections effective upon release of said relay for establishing a circuit for the other of said relays for the discharge of said condenser, said other relay being maintained in actuated condition during continuance of the flow of said discharge current in excess of a predetermined value, means for varying the time required for the charging and discharging currents to fall below said predetermined minimum including means for varying the capacitance-resistance characteristics of the circuit, and means for including the same time varying means in circuit with one and then the other of said relays immediately following the actuation thereof in order to provide said timing control with positive actuation thereof.

5. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses which comprises a plurality of relay means each having circuit control means associated therewith, a condenser, circuit connections providing for establishing a charging circuit for said condenser for one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, and means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a single control circuit, and switch means operated by said relays for effecting periodic alternate introduction of said single control circuit into the circuit of said first and second relays.

6. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses which comprises a plurality of relay means each having circuit control means associated therewith, a timing condenser, circuit connections providing for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, and means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a control circuit, a solenoid in the control circuit, a multiplying condenser in circuit with said solenoid and adapted to be charged from the source of electric energy, switch contacts operated by said relay means for effecting closing of a charging circuit through said solenoid and said multiplying condenser, and switch means carried by the other of said relay means for closing a discharge circuit of said multiply-

ing condenser through said solenoid to effect timed actuation thereof upon actuation of each of said relays.

7. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses which comprises a plurality of relay means each having circuit control means associated therewith, a timing condenser, circuit connections providing for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon a release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, and means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a control circuit, a solenoid in the control circuit, a multiplying condenser in circuit with said solenoid and adapted to be charged from the source of electric energy, switch contacts carried by said relay means for effecting closing of a charging circuit through said solenoid and said condenser, and switch means operated by the other of said relay means for closing a discharge circuit of said multiplying condenser through said solenoid to effect actuation thereof upon actuation of each of said relays, and control means for removing said multiplying condenser from the solenoid circuit to provide for actuation thereof in response to operation of only one of said relays.

8. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses which comprises a plurality of relay means each having circuit control means associated therewith, a timing condenser, circuit connections providing for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon a release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, and means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a control circuit, a solenoid in the control circuit, a multiplying condenser in circuit with said solenoid and adapted to be charged from the source of electric energy, switch contacts carried by said relay means for effecting closing of a charging circuit through said solenoid and said condenser, and switch means operated by the other of said relay means for closing a discharge circuit of said multiplying condenser through said solenoid to effect actuation thereof upon actuation of each of said relays, the flow of current through said solenoid during charging and discharging of said condenser being maintained for a period of the order of or less than the period during which said relays remain in actuated condition.

9. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses for controlling the dropping of bombs and the like which comprises a plurality of relay means each having circuit control means associated therewith, a condenser, circuit connections providing for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a control circuit, a solenoid in said control circuit adapted to be repeatedly energized at uniform intervals corresponding to the timed operation of said relays, counter-mechanism actuated by said solenoid at each energization thereof to count the number of such actuations, and means controlled by said counter mechanism for effecting the opening of said relay circuits to terminate the operation of said relays after completion of a predetermined number of such operations.

10. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses for controlling the dropping of bombs and the like which comprises a plurality of relay means each having circuit control means associated therewith, a condenser, circuit connections providing for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a control circuit, a solenoid in said control circuit adapted to be repeatedly energized at uniform intervals corresponding to the timed operation of said relays, counter-mechanism actuated by said solenoid at each energization thereof to count the number of such actuations, means operable to effect deenergization of said relays

when said solenoid has been actuated a predetermined number of times, and additional circuit control means to assure completion of each actuation of said counter mechanism including the last actuation thereof.

11. A timing device of the character described adapted to be energized from a source of electrical energy and to establish periodic timed impulses for controlling the dropping of bombs and the like which comprises a plurality of relay means each having circuit control means associated therewith, a condenser, circuit connections providing for establishing a charging circuit for said condenser through one of said relays to effect actuation thereof while the other relay remains deenergized, said first relay remaining energized while the flow of charging current therethrough exceeds a predetermined value, circuit connections effective upon release of said first relay for establishing a circuit through said second relay for the discharge of said charged condenser, said second relay remaining energized while the flow of discharging current therethrough exceeds a predetermined value, thereby securing alternate timed operation of said relays, means associated with said charging and discharging circuits for varying the capacity-resistance characteristics thereof to predetermine the length of time required in said charging and discharging operations, a control circuit, a solenoid in said control circuit adapted to be repeatedly energized at uniform intervals corresponding to the timed operation of said relays, counter-mechanism actuated by said solenoid at each energization thereof to count the number of such actuations, limit switch means actuable after a predetermined number of operations of said solenoid to deenergize said relays, manually operable means for setting said limit switch to a position corresponding to a desired number of operations indicative of the number of bombs to be dropped, and means operable only after said manually operable means has been set to a predetermined operative position for indicating that said device is preconditioned for operation.

12. A timing device for use in the sequential dropping of bombs and the like comprising a timing circuit adapted upon being energized to produce a series of periodic impulses of preselected variable frequency at uniform intervals following such energization, a counter mechanism adapted to be set for a predetermined number of operations, means for actuating said counter mechanism at each of said periodic impulses, means controlled by the operation of the counter mechanism for opening and disabling the timing circuit following said predetermined number of actuations thereof, and means for by-passing said circuit opening means during the operating movement of said counter mechanism to assure completion of each actuation thereof including the last actuation.

13. A timing device for use in the sequential dropping of bombs and the like comprising a timing circuit adapted upon being energized to produce a series of periodic impulses of preselected variable frequency uniformly commencing immediately following such energization, counter mechanism having a zero position and a series of operative positions corresponding to the desired number of bombs to be dropped, means for effecting step by step operation of said counter mechanism from any of its said operative positions to its zero position in response to said periodic impulses, a limit switch in the timing circuit actuated by said counter mechanism selectively in relation to the position of said mechanism in its said operative or in its said zero position, and circuit control means under manual control for closing the circuit through said limit switch to energize and initiate operation of said timing circuit to produce said timed impulses until the desired predetermined number of operations have been completed, said circuit being maintained through said limit switch until the return of said counter mechanism to its said zero position.

14. A timing device for use in the sequential dropping of bombs and the like comprising a timing circuit adapted upon being energized to produce a series of periodic impulses of preselected variable frequency uniformly commencing immediately following such energization, counter mechanism having a zero position and a series of operative positions corresponding to the desired number of bombs to be dropped, means for effecting step by step operation of said counter mechanism from any of its said operative positions to its zero position in response to said periodic impulses, a limit switch in the timing circuit actuated by said counter mechanism selectively in relation to the position of said mechanism in its said operative or in its said zero position, means controlled by said limit switch means and adapted to be actuated upon adjustment of said counter mechanism to any of its operative positions to effect control of an indicator showing said device to be preconditioned for operation, and circuit control means under manual control for closing the circuit through said limit switch to energize and initiate operation of said timing circuit until the desired predetermined number of operations have been completed, said circuit being maintained through said limit switch until the return of said counter mechanism to its said zero position.

15. A timing device for use in the sequential dropping of bombs and the like comprising a timing circuit adapted upon being energized to produce a series of periodic impulses of preselected variable frequency uniformly commencing immediately following such energization, counter mechanism having a zero position and a series of operative positions corresponding to the desired number of bombs to be dropped, means for effecting step by step operation of said counter mechanism from any of its said operative positions to its zero position in response to said periodic impulses, a limit switch in the timing circuit actuated by said counter mechanism selectively in relation to the position of said mechanism in its said operative or in its said zero position, circuit control means under manual control for closing the circuit through said limit switch to energize and initiate operation of said timing circuit to produce said timed impulses, means for maintaining said limit switch circuit closed until the desired predetermined number of operations have been completed, said circuit being maintained through said limit switch until the return of said counter mechanism to its said zero position, and a selector switch operable to disable said maintaining means to provide for individual control of said operations by said manual control.

FREDERICK J. HOOVEN.