United States Patent

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[73] Assignee **The United States of America as represented by the Secretary of the Air Force**

[54] **PROGRAMMABLE INTERVALOMETER**
3 Claims, 4 Drawing Figs.

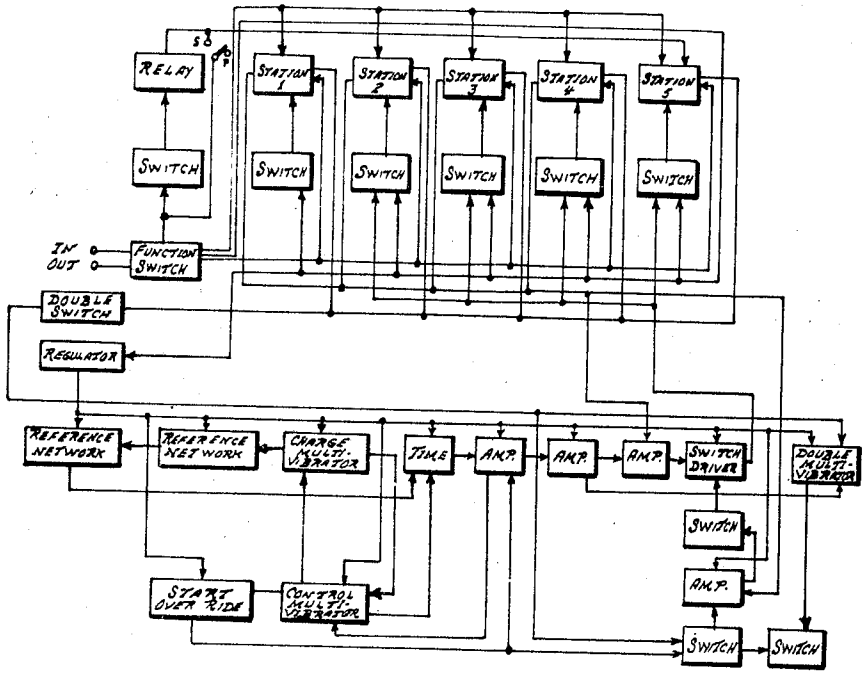
[52] **U.S. Cl.** **317/139,** 307/141.8, 317/137, 317/140, 317/148.5
[51] **Int. Cl.** **H01l 47/14**
[50] **Field of Search** 317/139, 134, 136, 137, 140, 135, 138,

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ABSTRACT: A series of relay release stations which, when activated, connect power for launching. Activation is controlled by transistor switches, all but the first requiring a pulse from a switch driver and all but the first and second having clamping circuits to prevent activation until a voltage is impressed from the preceding relay. Timing is controlled by a selection of capacitors and variable resistors through a ganged switch. An initial power delay can be used.



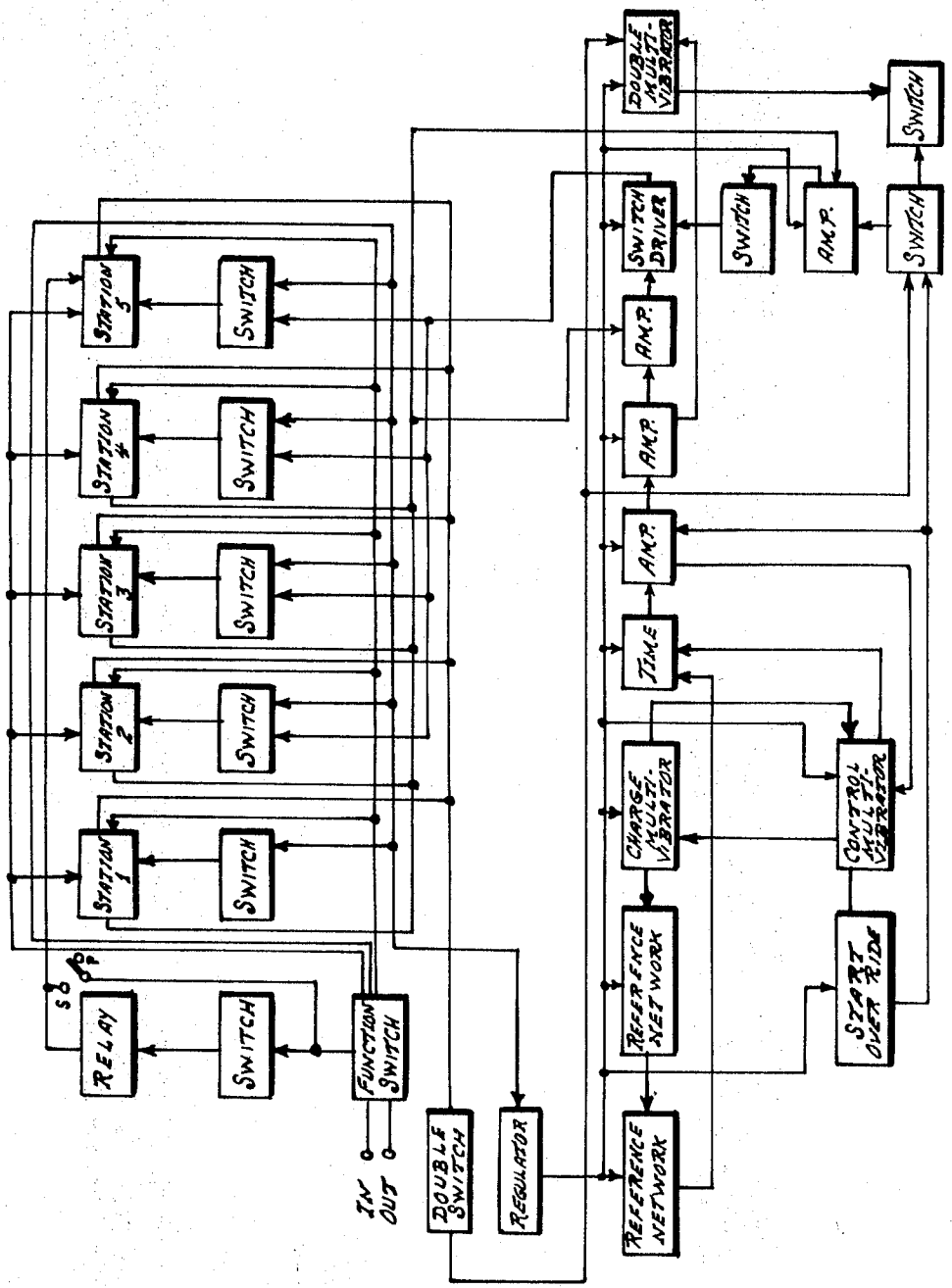


FIG. 1

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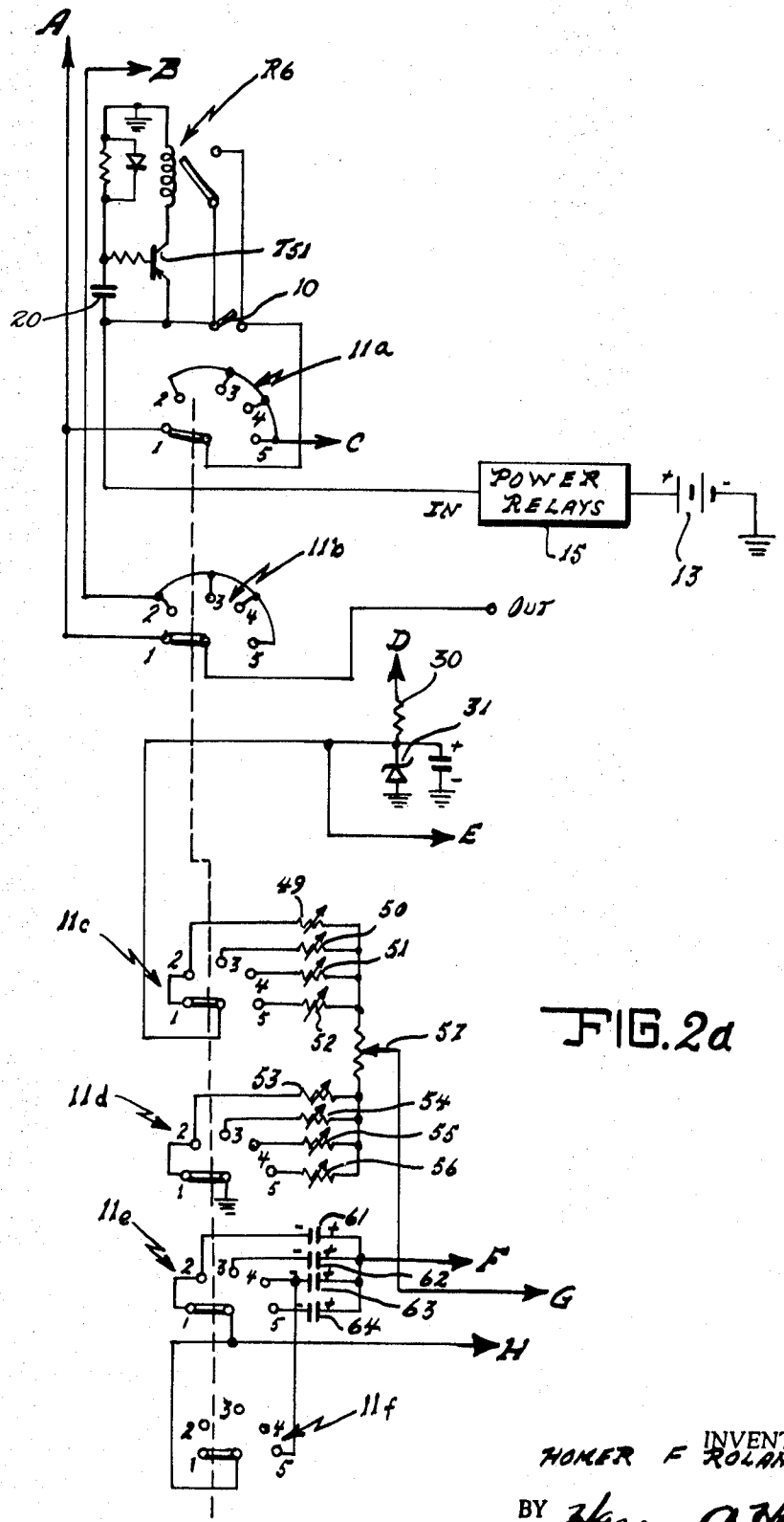


FIG. 2d

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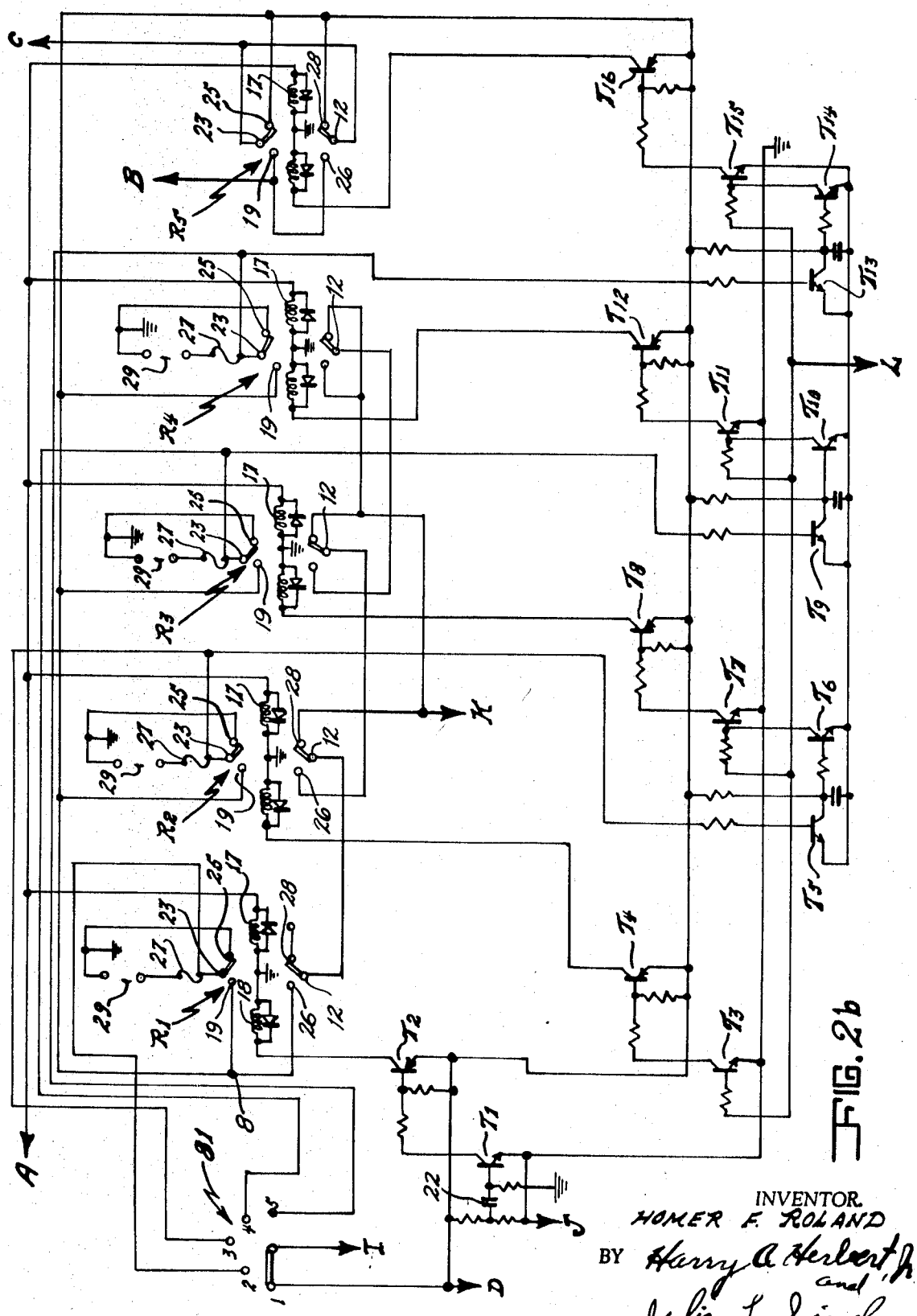


FIG. 2b

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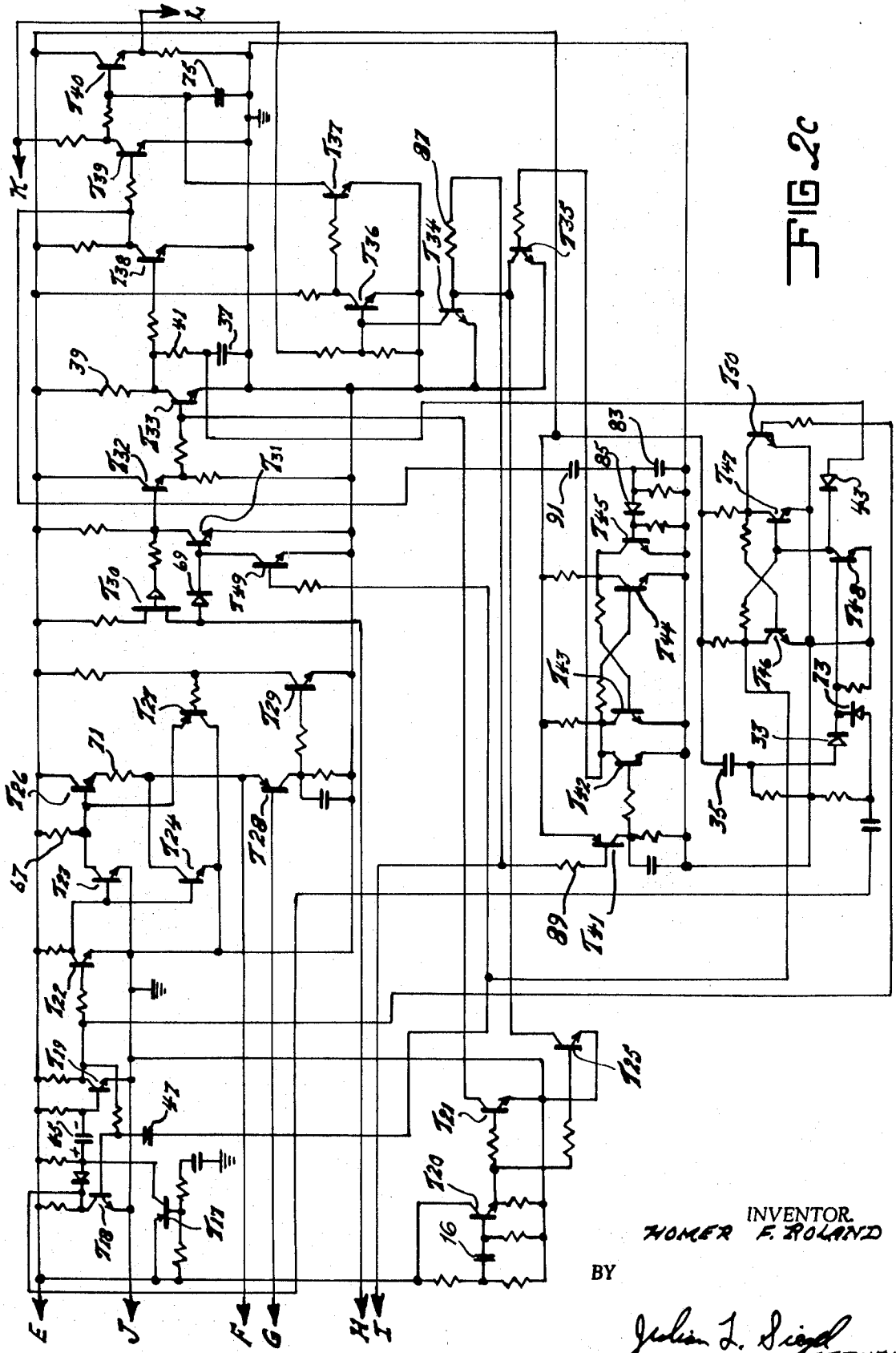


FIG 2C

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PROGRAMMABLE INTERVALOMETER

BACKGROUND OF THE INVENTION

This invention relates to a sequential releasing of stores and more particularly to an electronic intervalometer.

In the past there have been many techniques for the automatic release of stores, however the present invention offers a novel and improved system which is more flexible and precise than that available in the prior art.

SUMMARY OF THE INVENTION

The device is a hybrid mechanical-solid state intervalometer with flexibility permitting programming of event time intervals to one thousandth part from 50 milliseconds to 6 seconds. It is compatible with a start time control for other sequential intervalometers and allows variation of time intervals of programmed events.

It is an object of the invention to provide a novel intervalometer which can be used for releasing stores.

It is another object to provide an intervalometer capable of programming for either manual or ripple launch.

It is still another object of the invention to provide an intervalometer in which after an interruption reapplication of launch power will override and fire the next station in line.

It is yet another object to provide an intervalometer which is programmable for doubling the time interval between any two adjacent stations.

It is still another object to provide an intervalometer that does not require idler or warmup power to launch power application.

These and other advantages, features and objects of the invention will become more apparent from the following description taken in connection with the illustrative embodiment in the accompanying drawings, wherein:

FIG. **1** is a block diagram showing an embodiment of the invention.

FIGS. **2***a*, **2***b*, and **2***c* are circuit diagrams showing the details of that shown in FIG. **1** wherein the letters at the points of the arrows denote the connecting points of the several drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. **2***a*, **2***b* and **2***c* in conjunction with FIG. **1**, ganged functional switch **11** provides for resetting the intervalometer and selecting the time scale used and is also a means for arming the associated dispenser. Position **1** on functional switch **11***a* with the application of external power from voltage source **13** through power relays **15**, applies a reset signal to coils **17** of relays **R1** to **R5**. Position **2** of switch **11***c* to **11***f* selects a time scale of 50 milliseconds to 100 milliseconds as explained in this example. Position **3** is a time scale of 100 milliseconds to 600 milliseconds. Position **4** is a time scale of from 500 milliseconds to 1 second. Position **5** is a time scale from 1 second to 6 seconds.

Relays **R1** through **R5** are magnetic-type latchup relays and once thrown to alternate positions they remain magnetically latched until such time as the reset signal from position **1** of the functional switch is applied to coils **17** of the individual relays. As shown in FIG. **2***b*, relays **R1** to **R5** are in the correct position for launching upon the application of a launch signal.

Switch **10** with associated circuitry including relay **R6** overcomes multiple releases if the aircraft has erratic power or chattering relays when the launch impulse power is applied. Launch power and aircraft raw power are the same and is controlled by the pilot's launch switch. This power may be acquired via relays indirectly from the batteries. Since not all relays and switches close without chatter, it becomes necessary to overcome this undesirable condition by the incorporation of relay **R6** and transistor **T51**. Any "make" and "break" of launch power for whatever reason will cause the next launch station in line to be launched. Switch **19** would normally be open if the intervalometer is the first in a series. For intermediate or terminal positions it would be closed. Relay **R6** is a make-break relay with the application of power each time. When switch **10** is open, the application of power to the intervalometer stations and circuitry can be delayed for a period such as 30 milliseconds after the final closure of aircraft launch power relays **15**. If the aircraft launch power relays do not close and hold but have a tendency to chatter, the switch circuit for relay **R6** will not function. After power has been applied to the circuitry for 30 milliseconds, transistor **T51** goes into conduction, closes the contacts of relay **R6** bypassing open switch **10** and applies power to the intervalometer. Transistor **T51** as shown in the present embodiment is a PNP device and the base, at the first application of power, is shorted to the emitter by capacitor **20**. As this capacitor charges to the applied voltage (approximately 30 milliseconds) transistor **T51** is turned on and operates relay **R6** to the other position. It is assumed that if launch power is applied for a full 30 milliseconds that all aircraft relays involved have ceased chattering and are fully closed and that a stable operation of the intervalometer can commence. Once relay **R6** has operated, power is routed via switch **11***a*, pins **2**, **3**, **4** or **5**, to pins **23** and **12** of relay **R5**. Due to the magnetic latchup features of relay **R5**, pins **23** and **12** are, at preflight, latched to their respective pins **25** and **28**. Power is routed across this junction to pin **19** of relay **R1**, **R2**, **R3**, **R4** and all switch circuitry for these relays. Application of power immediately saturates transistor **T1** which in turn saturates transistor **T2** causing relay **R1** to operate to the alternate position and applies power to the detent of relay **R1** thereby launching. Capacitor **22** at the base of transistor **T1**, when charged, cuts off resistor **T1**, cutting off resistor **T2** and removing power from pin **8** of relay **R1**. Relay **R1** always operate with the appearance of power and there is no delay at this station. All other relays, **R2**, **R3**, **R4** and **R5**, await timed signals or power "break" or "make" at the aircraft launch control. This circuit is not used except when the intervalometer is the prime intervalometer in a series and functions each time a launch impulse is applied.

The invention is explained with five stations, four of which are used for launching and the last for power transfer. Relays **R1** through **R4** provide prior to any launch signal mechanical shorts through pins **23** and **25** and across fuzes **27** and explosive detents **29** which are devices for ejecting munitions or stores. The fifth station including relay **R5** can transfer power to the next sequential launcher. Transistors **T1** and **T2** (one of the transistor switches shown in FIG. **1**) controls launch impulse power from relay **R6** and immediately launches station **1**. When relay **R6** applies power to pins **23** and **12** of relay **R5**, this power is also applied to the emitter of transistor **T2** and the collector of transistor **T1**. Capacitor **22** in the base of transistor **T1**, at the initial application of power, acts as a short and drives transistor **T1** into saturation which then drives transistor **T2** into saturation thereby energizing coil **18** of relay **R1**. This energizing causes contact with pins **19** and **26**, thereby applying power across the detent for launch. When capacitor **22** is fully charged, transistor **T1** cuts off, thus cutting off transistor **T2** and also cutting off current flow in coil **18** of relay **R1** which remains in contact with pins **19** and **26** due to the magnetic latch feature. Stations **2**, **3**, **4**, and **5** are launched only on command from transistor **T40** (the switch driver in FIG. **1**). Aircraft raw power is applied to the explosive detents when a launch signal is received and all associated switch circuitry from stations **1** through **5** operate from raw aircraft power as opposed to regulated power.

Regulated power is that power taken from the junction of diode **31** and resistor **30** and is used only in the precision timing circuitry of the intervalometer. Raw power is used in all other positions including the detents. Raw power is received from the aircraft launch switch operated by the pilot, via the IN terminal. From the IN terminal it is routed via relay **R6** and associated switch **10** to the wiper of switch **11***a*. From the wiper the power is routed via pins **2**, **3**, **4** or **5** to pins **12** and **28**

of relay R5. From these pins it is routed to, in addition to other places, pin 19 of relays R1, R2, R3 and R4. When either of these relays operate, power at that relay operates the detent at that station. When relay R5 operates, and always the last to operate, power is transferred via pins 19 and 26 to switch 11*b*, pins 2, 3, 4 or 5, and thence to the OUT terminal and so to the next intervalometer in the series, if such exists.

All timing and control circuitry can be regulated to 22 volts by the action of Zener diode 31. The intervalometer does not have warmup or idle power. Upon the application of launch power, all circuitry must come to its power applied static condition, then commence its function.

The override circuitry consists of transistors T20, T21 and T25 and associated components. This circuitry functions only with the application of launch power. For example, if launch power has been once applied and at some time later interrupted and reapplied, it will function again. It serves the purpose of starting the control multivibrator (to be explained), and of immediately launching the next station in line after station 1 has been launched.

An interruption of power renders the intervalometer inert. Immediately applying launch power after station 1 has launched causes transistor T20 to saturate due to capacitor 16 in the base acting as a short. Saturation of transistor T20 causes transistor T21 to saturate which places the base of transistor T33 at or near zero potential. Transistor T33 being cut off drives transistor T38 into heavy conduction; this cuts off transistor T39 thereby causing transistor T40 to conduct heavily. The voltage developed at the emitter of transistor T40 is applied to the bases of transistors T3, T7, T11 and T15. Transistor T3 saturates, driving transistor T4 into conduction and operates relay R2 and launches station 2. Although transistors T7, T11 and T15 receive the same voltage from transistor T40, they cannot conduct since they are held cut off due to the clamp action of transistors T5 and T6, T9 and T10, and T13 and T14. As relay R2 operates pin 23 contacts pin 19 and removes the clamp of transistor T7; however, during the time pin 12 is transferring from pin 28 to pin 26 power is removed from transistor T39 which of course cuts off transistor T40 so that the following station cannot launch. It should be noted that the time constant in the base of transistor T20 is short compared to the time required for any relay to operate. Even though transistor T20 and transistor T21 have returned to a quiescent state and pin 19 of relay R2 has left pin 28 thereby removing the power from transistor T39, capacitor 75 tends to hold transistor T40 into conduction a sufficient time to assure positive operation of relay R2.

In the operation of the control multivibrator, which includes transistors T46 and T47, upon application of power, diode 33 and its associated capacitor 35 in conjunction with transistor T48 forces the multivibrator to assume the condition where transistor T47 is cut off and transistor T46 is conducting heavily. This condition is achieved during the time it takes for station number 1 to be launched or in the event of interruption or reapplication of power for the next station in line to be launched. When power is applied to the override circuitry, transistors T20, T21 and T25 of the start override circuitry is short-circuited placing the base of transistor T33 and the amplifier at ground potential which assures that it is cut off. Capacitor 37 starts charging to its B plus via resistors 39 and 41 and the charging slope is essentially a ramp function lasting for approximately 3 milliseconds. After this time diode 43 is driven into conduction which in turn drives transistor T47 into conduction, switching transistors T46 and T47 of the control multivibrator to the alternate condition. As the collector of transistor T46 swings positive, transistor T49 is short-circuited and a start transient is applied to the base of transistor T18.

The charge multivibrator which includes transistors T17, T18 and T19 provide the same starting conditions that exist in the control multivibrator. This multivibrator must have sufficient time to achieve a static condition after the application of power prior to the receipt of the starting transient to the base of transistor T18 from the control multivibrator. Transistor T50 like the start override circuitry functions with each application of power. It serves the purpose of charging to full B plus capacitor 45 in the charge multivibrator in the short period of time prior to the receipt of the start impulse from the control multivibrator. Once this multivibrator is in operation, transistor T49 is effectively out of the circuit. The starting pulse from the control multivibrator via capacitor 47 causes charge multivibrator to switch to its alternate start which is for a duration of approximately 28 milliseconds. It is necessary that this multivibrator function for each launch power impulse for all stations except station 1.

The reference network consists of potentiometers 49 to 57, capacitors 61 to 64 and transistors T22, T23, T26, T27, T28 and T29. Potentiometer 57 is a precision heliopot for setting the corrected time for the time scale being used and trim potentiometers 49 to 56 are for calibration. The setting of potentiometer 57 determines the potential to which reference capacitors 61 to 64 can charge. The immediate application of power forces the collector of transistor T19 of the charge multivibrator to go to ground potential. This causes transistor T22 to be cut off which causes transistors T23 and T24 to be fully conducting or short circuited. As a result, the base of transistor T26 is placed at ground potential and also the emitter of transistor T28 which in turn places the positive side of the reference capacitors at ground potential. This is the static condition which remains until the charge multivibrator functions from the start impulse signal from the control multivibrator. When the charge multivibrator flips to its alternate state, the collector of transistor T19 goes positive, which in turn drives transistor T22 into full saturation and cuts off transistors T23 and T24. This permits the base of transistor T26 to be connected via resistor 67 to B plus which in turn drives transistor T26 into full conduction and simultaneously transistor T24 permits the emitter of transistor T28 to swing away from its grounded condition. At the same time as the start impulse from the control multivibrator to the charge multivibrator, transistor T49 is short circuited placing the base of transistor T31 at ground potential which via diode 69 places the negative side of the chosen reference capacitor at ground potential which has the effect of switching the ground of the reference capacitors from the positive to the negative side. As transistor T26 goes into conduction, resistor 71 limits the peak current flow. The reference capacitor is charged along the following route: ground to the emitter of transistor T49 through the collector, through diode 69 to the negative side of the reference capacitor. The positive side is tied to B plus through resistor 71 and transistor T26. Charging of the reference capacitor continues until the emitter of transistor T28 reaches a level slightly higher than the setting of potentiometer 57 and this drives transistor T28 into saturation which in turn shorts transistor T29. Short circuiting transistor T29 drives transistor T27 into full saturation cutting off transistor T26 and charging of the reference capacitor ceases. This condition is held precisely until such time as the charge multivibrator flips back to its static state. With reversion to the static state of the charge multivibrator the following occurs: the collector of transistor T19 goes to ground potential permitting the collector of T22 to go positive. This in turn drives transistors T23 and T24 into conduction which cuts off transistor T26 or continues the holdoff action relieving transistor T27 of the duty, and at the same time places the positive side of the reference capacitor at ground potential which places the negative potential of the reference capacitor across diode 69 with respect to ground. Simultaneously with reversion of the charge multivibrator to its static condition, the control multivibrator via the feedback loop from transistor T18 is reset to its static condition via diode 73 and transistor T48 which removes the short from transistor T49 from the base of transistor T31.

The timing circuit uses field effect transistor T30 and associated circuits as a constant current generator. The discharge of the reference capacitor via diode 69 and the transistor T30 is extremely linear and the time for total discharge is a function of the amount of charge established on

the reference capacitor by the setting of potentiometer 57. Discharge of the reference capacitor causes transistor T31 to remain cut off which permits transistor T32 to conduct heavily. This continues until such time as the reference capacitor is discharged, at which time transistor T31 goes into conduction and cuts off transistor T32. This is the action of the timing circuitry and functions each time against the charge on the reference capacitor which in turn is governed by the charge capacitor and its associated charging and regulation components.

The switch driver including transistors T39 and T40 control the immediate application of launching power. The base of transistor T40 is shunted to ground by capacitor 75 and transistor T37, transistor T36 and the no voltage potential on pin 77 of relay 1. This situation causes transistor T36 to be cut off which in turn drives transistor T37 into conduction which clamps the base of transistor T40 to ground potential and no output transients or launch signals from transistor T40 can be applied to the transistor switches of the launch stations. This permits the first station to be launched independent of the timing system and allows the timing system to reach functional status. When relay R1 operates to launch station 1, raw aircraft power is applied to the base network of transistor T36 driving it into full saturation which cuts off transistor T37. T37 and T36 remain in this state until station 2 is launched. When the first station is launched, pin 12 of relay R1 contacts pin 26 and transfers power to pins 12 of relays R2, R3, R4 and R5. Since these relays have not as yet operated, pins 19 and 12 are "made" and apply power to the collector of transistor T39 and the base network of transistor T36. With the discharge of the reference capacitor transistor T32 cuts off, transistor T33 cuts off, transistor T38 cuts on, transistor T39 cuts off, and transistor T40 goes into conduction. At the emitter of transistor T40 a ramp function voltage is generated which is applied to the switch circuits of stations 2, 3, 4, and 5. Station 2 is launched and stations 3, 4, and 5 are blocked off due to the clamping action of transistors T5, T9 and T13 being tied to pins 23 of relays R2, R3, and R4. As relay R2 is operated to launch, pin 23 of station 2 makes contact with pin 79, exploding its detent and removing the clamp from transistor T6 which places the switch circuitry for station 3 in a receptive condition. Station 2 has now been launched automatically by the timing circuit and the next cycle has commenced and will continue to cycle provided power is not interrupted and until such time as station 5 launches and transfers launch power to the next sequential launcher. Until relay R2 has operated the base of transistor T5 is at ground with transistor T5 cutoff. Transistor T6 is at saturation since the base is tied directly, via an RC network, to raw power. Saturation of transistor T6 causes transistor T7 to be cut off thereby causing transistor T8 to be cut off. Operation of relay R2 causes power via pins 23 and 19 to be transferred to the base of transistor T5 driving it into saturation. This cuts off transistor T6 and removes the clamp from transistor T7. Were a launch impulse from transistor T40 present, relay R3 would operate. However, as relay R2 operated power was removed from transistor T39, the launch impulse from transistor T40 is cut off. The capacitor in the collector of transistor T5 tends to slow the cut-on action of transistor T5 until the launch impulse from transistor T40 has fully decayed. Station 3 will now operate when the next launch impulse appears at transistor T40. This will occur when "break-make" action occurs from the pilot's launch switch or when the timing circuitry runs down and generates a launch impulse at transistor T40. The launch impulse at transistor T40 can be generated either by "break-make" or timer action.

The transfer of launch power to the next sequential launcher is delayed the same time as the time interval between stations 1 through 4 which permits equal time spacing between all stations in a series of intervalometers provided all intervalometers are programmed for the same time setting. Any intervalometer within a sequential chain may have its own specific time programmed, which means that by using sequential intervalometers varying time patterns of launch can be achieved.

The double multivibrator serves the function of doubling the time between any two adjacent stations. If double switch 81 is in position 1, the double multivibrator will not function for a complete station launch cycle. Transistor T41 is cut off with the application of power and transistor T38 via the three feedback loop through capacitor 83, diode 85 and transistor T45 which causes transistor T43 to be cut off. This in turn causes transistor T35 to be in full conduction and grounds the base of transistor T34 which effectively takes this transistor out of the circuit. Double switch 81 can be in position 2, 3, or higher for programming a particular double. With the switch in one of these positions, transistor T41 conducts heavily with the application of power, which in turn shorts transistor T42 which in turn drives transistor T43 via transistor T44 into saturation. As a result, transistor T35 is taken effectively out of the circuit. Transistor T34 is still effectively out of the circuit since there is no B plus applied to its base through resistor 87 because this connects to the ground position of the relay of the station preceding the double. When this station is launched and pin 23 moves to connect pin 19 of the relay, raw aircraft power is applied to the base of transistor T41 via resistor 89 and to the base of transistor T34 via resistor 87 which cuts off transistor T41 and at the same time permits transistor T34 to go into heavy conduction grounding the base of transistor T36. This in turn shorts transistor T37 which places a short across the base of switch driver transistor T40 and consequently no output signal can develop and be transmitted to the next station of the launch stations. However, the trigger pulse for the control multivibrator is still developed at transistor T33. All circuits function normally up to the final output for a launch impulse at transistor T40. With the beginning of the next timing cycle when the collector of transistor T38 goes positive and the feedback moves through capacitor 91 and diode 85, transistor T49 drives transistor T44 into heavy conduction causing the collector of transistor T43 to cut off. This in turn causes transistor T35 to go into full conduction and places a short across the base of transistor T34, which effectively removes it from the circuitry permitting the timing circuitry to function normally for the remainder of the stations to be launched.

I claim:

1. An intervalometer comprising:
   a. a series of release stations, each station including a launch relay having set and reset terminals and a transistor switch feeding the relays;
   b. a source of voltage having one terminal connected to the set terminal and the other to the reset terminal of each of the relays;
   c. means for applying the voltage to the first launch relays of the series of stations;
   d. time control means connected to the launch relays for automatically activating successive stations following the first station, said means being connected to the launch relay and including selectable banks of resistors and capacitors with one terminal of the resistors being selectably connected to the voltage source and the other terminal to the bank of capacitors;
   e. a switch driver connected to the transistor switches of the second and succeeding stations;
   f. a series of clamping circuits connected to the third and succeeding transistor switches, the clamping voltage being fed from the reset terminal of the preceding station; and
   g. antichatter means interposed between the source of voltage and the launch relays including,
      1. a protection relay having switch contacts controlling the source of voltage to the launch relays and a relay coil with a grounded first terminal;
      2. a transistor having the emitter connected to the voltage source and the collector connected to the second terminal of the coil;

3. a capacitor and a first resistor interposed between the voltage source and the first terminal of the relay coil; and
4. a second resistor interposed between the base of the transistor and a point between the first resistor and the capacitor.

2. An intervalometer comprising:

a. a series of release stations, each station including a launch relay having set and reset terminals and a transistor switch feeding the relays;

b. a source of voltage having one terminal connected to the set terminal and the other to the reset terminal of each of the relays;

c. means for applying the voltage to the first launch relay of the series of stations;

d. time control means connected to the launch relays for automatically activating successive stations following the first station, said means being connected to the launch relay and including selectable banks of resistors and capacitors with one terminal of the resistors being selectably connected to the voltage source and the other terminal to the bank of capacitors;

e. a switch driver connected to the transistor switches of the second and succeeding stations;

f. a series of clamping circuits connected to the third and succeeding transistor switches, the clamping voltage being fed from the reset terminal of the preceding station; and

g. means for doubling the time between launchings of successive stations including,

1. a rotary doubler switch having a single fixed contact and a plurality of fixed contacts connected to one each of the launching stations;
2. a first transistor having an emitter connected to the voltage source;
3. a second transistor having the base connected to the rotary terminal of the doubler switch;
4. a third transistor having the collector connected to the base of the second transistor;
5. a fourth transistor having the base connected to the collector of the first transistor;
6. a multivibrator including fifth and sixth interconnected transistors, the emitter and collector of the fourth

transistor being connected respectively to the emitter and collector of the fifth transistor;
7. a seventh transistor having the emitter and collector connected to the emitter and collector of the sixth transistor respectively;
8. an eighth transistor having the collector connected to the voltage source and the emitter connected to the emitter of the second transistor;
9. a capacitor having one terminal connected to the collector of the eighth transistor;
10. a diode connecting the other terminal of the capacitor to the base of the seventh transistor;
11. a ninth transistor having the base connected to the collector of the second transistor;
12. a 10th transistor having the base connected to the collector of the ninth transistor; and
13. a switch driver transistor having the base thereof coupled to the collector of the 10th transistor.

3. An intervalometer comprising:

a. a series of release stations, each station including a launch relay having set and reset terminals and a transistor switch feeding the relays;

b. a source of voltage having one terminal connected to the set terminal and the other to the reset terminal of each of the relays wherein the reset terminals of the final relay are connected to the voltage source for distribution to the intervalometer and the set terminals connect the source of voltage to the output terminals of the intervalometer;

c. means for applying the voltage to the first launch relay of the series of stations;

d. time control means connected to the launch relays for automatically activating successive stations following the first station, said means being connected to the launch relay and including selectable banks of resistors and capacitors with one terminal of the resistors being selectably connected to the voltage source and the other terminal to the bank of capacitors; a switch driver connected to the transistor switches of the second and succeeding stations; and

f. a series of clamping circuits connected to the third and succeeding transistor switches, the clamping voltage being fed from the reset terminal of the preceding station.