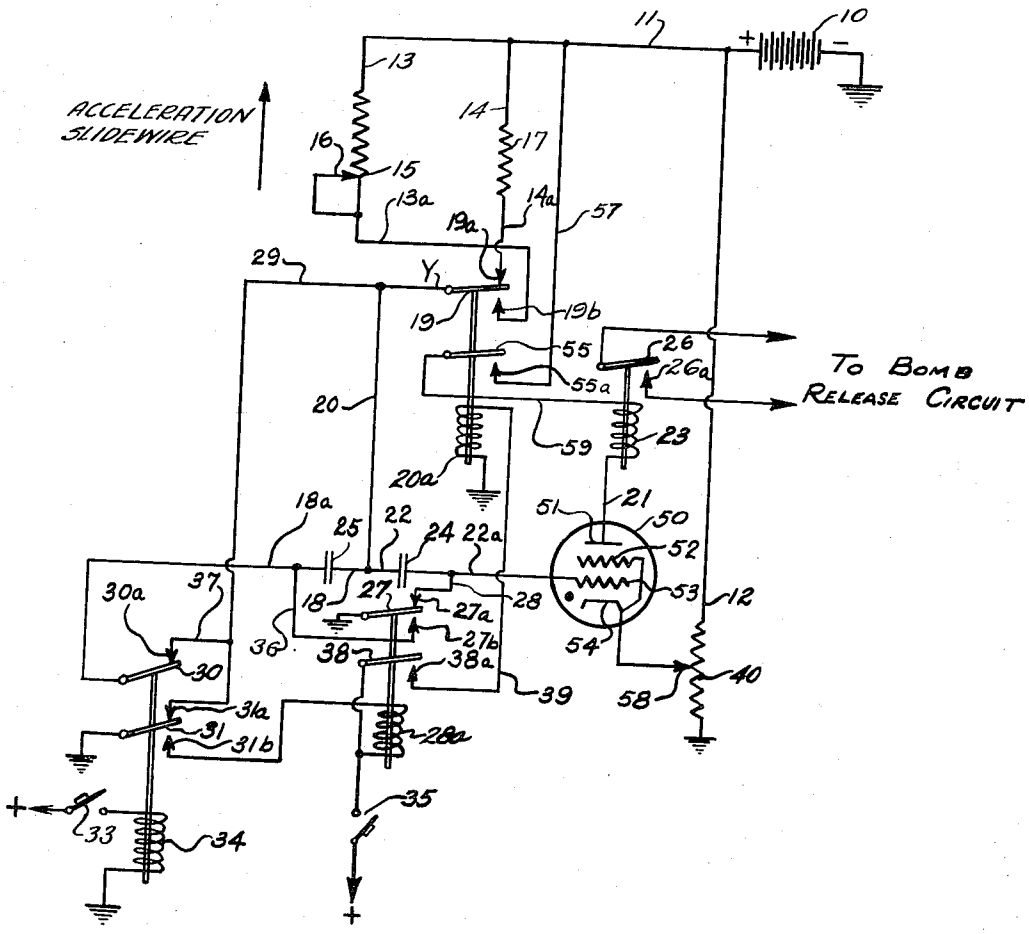
Aug. 14, 1956

W. B. McLEAN ET AL

2,758,511

BALANCED CAPACITOR INTEGRATOR

Filed April 17, 1951



INVENTORS
WILLIAM B. McLEAN
WILLIAM L. WHITSON
BY
A. O. O'Brien
AND
R. Baxter Warner
ATTORNEYS

United States Patent Office 2,758,511 Patented Aug. 14, 1956

2,758,511

BALANCED CAPACITOR INTEGRATOR

William B. McLean, Inyokern, Calif., and William L. Whitson, Washington, D. C.

Application April 17, 1951, Serial No. 221,494

2 Claims. (Cl. 89—1.5)

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

The present invention relates generally to electrical timing devices, and more particularly to a balanced capacitance electrical timing device especially adapted to controlling the release of bombs in a toss bombing attack.

A toss bombing attack is accomplished by the attacking plane approaching the target on a substantially level flight and then maneuvering into a downward glide or dive course, the plane being directed for collision with the target, moving or stationary, until the attacking plane is within a desired range of the target. Whereupon, the pilot maneuvers so as to pull out of his downward glide or dive and into an upward course. During this latter maneuver, the pull-up operation, the bomb, or stick of bombs, or the like is released. The present timing device is particularly adapted to such operations for controlling the release of a bomb at the proper point on the pull-up arc to provide a hit on the target.

Considering the present invention generally in its application to bomb release control during a toss bombing attack, a condenser is charged by a fixed potential source, through a resistance during a predetermined fraction of the dive run of the toss bombing attack, and if this dive run is accomplished at a uniform velocity, the potential established across said condenser is a measure of the time required to traverse the entire distance to collision with the target. Upon the completion of the established fraction of the dive run, a second condenser is charged from the same potential source through a resistance while the charge established on the first condenser is held thereon. Since the fraction of the above-described timing run with respect to the entire distance to collision with the target is known, the values of the second condenser and the resistance through which it is charged may be so chosen that the second condenser attains a potential difference thereacross equal to the potential across the first condenser in the remaining time required for collision with the target, if the plane were to continue on its course at the same velocity until such collision occurred. Also included in this circuit is a trigger mechanism, such as a thyratron tube or the like, which operates to control a bomb release mechanism in response to the potentials of said condensers. In the case of a thyratron tube, the potentials impressed on the plate and cathode thereof are so chosen and the condensers above-mentioned are so connected to the control grid thereof that the tube is biased against conduction until the potential across the second condenser becomes equal to that across the first; whereupon, the tube becomes conductive from its cathode to its plate and operates a bomb release control mechanism in its plate circuit. Thus, if at a determined altitude on the dive run charging of the first condenser is initiated and continued during the predetermined fraction of the dive run on collision course with the target, and after traversing this fraction the first condenser is disconnected from its charging source and the second condenser is charged, the potential across the second condenser would become equal to that across the first condenser upon collision with the target if the plane were maintained on its collision course, and at that time the thyratron tube would become conductive or the trigger mechanism would be operated to release the bombs. However, the toss bombing attack is accomplished by the plane pulling out of the dive at some point before collision with the target but after traversing the timing fraction of the distance to collision. The present device is therefore provided with an acceleration responsive means, which operates in response to the pull-up acceleration at the start of the pull out maneuver as the plane course is reversed into a substantially upward course, to decrease the resistance in the second condenser's charging circuit in accordance with this pull-up acceleration. Thus, the time required for the second condenser to obtain such a charge as would place thereacross a potential equal to that established on the first condenser is reduced in accordance with the magnitude of the pull-up acceleration, and the thyratron tube becomes conductive to release the bombs at some point on the pull-up maneuver. With the proper potentials impressed upon the plate and cathode of the thyratron tube, the proper values chosen for the several elements comprising the present circuit, and with the pull-up acceleration responsive mechanism providing the appropriate decrease in the second condenser's charging resistance, the bombs are released at that point on the pull-up arc which obtains a hit on the target, provided the dive course of the plane is established for collision with the target.

It is, therefore, one object of the present invention to provide a bomb release control circuit for a toss bombing attack which releases the bomb at an appropriate point during the pull-up maneuver to obtain a hit on the target.

Another object of the present invention is to provide a bomb release control circuit for a toss bombing attack which releases the bomb at the proper point during the pull-up maneuver to obtain a hit on the target, wherein the control is effectuated by the cooperation of two bucking condensers operating to control the action of a trigger mechanism.

Another object of the present invention is to provide a bomb release control circuit for a toss bombing attack which releases a bomb at a desired point on the pull-up maneuver to obtain a hit on the target, wherein the time of flight to collision with the target is represented by a potential across one condenser connected to bias a thyratron tube or the like against conduction, and the potential impressed across a second condenser, whose charging rate is affected by the acceleration during the pull-up maneuver, is so applied to said first condenser and thyratron tube as to balance the potential established across the first condenser to permit the thyratron tube to become conductive at the desired point during the pull-up maneuver, current flow through the plate circuit of the thyratron tube operating to release the bomb.

Still another object of the present invention is to provide a balanced capacitance timing circuit which operates substantially independently of the temperature, variations in the value of the operating voltage supply, and variations in the values and characteristics of the elements comprising the circuit, provided they are constant during a particular operational run of the circuit.

A still further object of the present invention is to provide a balanced capacitance timing circuit wherein one condenser is charged to a reference potential through a charging circuit over a known timing interval, and a second condenser is charged to an equal potential through a second charging circuit, the interval for charging said second condenser being related to the interval for charging said first condenser by a known ratio as established by the

resistance-capacitance values of the two condenser charging circuits.

Still another object of the present invention is to provide a balanced capacitance timing circuit wherein one condenser is charged to a reference potential over a known timing interval and a second condenser is charged during a measured interval, the interval for charging said second condenser being related to the interval for charging said first condenser in accordance with the ratio of potentials thus obtained across said condensers and the ratio of the resistance-capacitance values of the condenser charging circuits during the charging of the condensers.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description thereof, made in conjunction with the accompanying drawing which is a wiring diagram of the present electrical timing circuit, illustrating an embodiment particularly adapted to control the release of bombs during a toss bombing attack.

Referring to the drawing, the embodiment there shown of the present timing circuit comprises a bomb release control tube **50**, preferably of the gas filled or thyratron type, having the plate **51**, the screen grid **52** connected to the cathode **54**, and the control grid **53**. The plate circuit of this tube comprises lead **21**, the relay coil **23**, lead **59**, the switch arm **55** controlled by the relay coil **30***a*, the contact point **55***a* for said switch arm, lead **57**, and a portion of lead **11** connected to the positive side of the voltage supply **10**. The cathode **54** of this tube is also connected to the voltage supply **10** through the variable tap connection **58**, the potentiometer **40**, and the lead **12**. Thus, if the switch arm **55** is moved from its normally biased open position, as shown in the drawing, into engagement with its contact **55***a*, as is accomplished by energization of the relay coil **20***a*, and if the control grid **53** of the tube **50** is biased to permit conduction through the thyratron tube for the potential difference existing between plate **51** and cathode **54**, electron current flows from the cathode to the plate and through the plate circuit. Energization of relay coil **23**, as results from current flow through the plate circuit, causes the switch arm **26** to move from its normally biased open position shown in the drawing into engagement with its contact **26***a*, thereby closing a bomb release circuit, not shown, which operates to release a bomb, or a stick of bombs, or the like upon the closure thereof.

As previously indicated and as is apparent from the drawing, the bias on the control grid **53** of thyratron tube **50** is determined by the potentials across the condensers **24** and **25**. When the switch arm **27** is in the position shown in the drawing, in engagement with its contact **27***a*, the condenser **24** is charged through its charging circuit comprising the voltage source **10**, a portion of lead **11**, lead **14**, resistor **17**, lead **14***a*, switch arm **19** when this arm is in engagement with its contact **19***a*, its normally biased position, lead **20**, lead **22**, condenser **24**, lead **28**, contact **27***a*, switch arm **27**, and thence to ground. The potential thus impressed across the condenser **24** over a given time interval is a function of the R. C. value of this circuit. However, it is to be noted that with the circuit in the condition as shown in the drawing, condenser **24** is shorted by means of leads **22**, **20**, and **29** and switch arm **31**, shown in its normally biased position in engagement with its contact **31***a*, connected to ground, while the other side of condenser **24** is also connected to ground through lead **28**, and switch arm **27** in engagement with contact **27***a*. However, upon the closure of switch **33** a current is applied to the relay coil **34**, which operates to break switch arm **31** from engagement with its contact **31***a* and to bring it into engagement with its contact **31***b*, thereby breaking the ground connection across the condenser **24** and enabling the condenser to become charged through its charging circuit described above. After the lapse of a time interval, a potential is established across

condenser **24** in accordance with the value of resistor **17**, the value of the voltage source **10**, and the capacitance of the condenser **24**. Upon the subsequent closure of switch **35** relay coil **28***a* is energized, the flow of current therethrough being enabled by the closure of switch arm **31** to its contact **31***b* and its connection to ground, as effected by the operation of relay coil **34** described above. The energization of relay coil **28***a* causes the switch arm **27** to break from its contact **27***a* and to engage its contact **27***b*. This action traps the charge on condenser **24** and closes the charging circuit for condenser **25** comprising the voltage source **10**, leads **11** and **13**, rheostat **15**, lead **13***a*, switch arm **19** when in engagement with its contact **29***b*, lead **29**, lead **18**, condenser **25**, lead **36**, switch arm **27** now in engagement with its contact **27***b*, and thence to ground. It is to be noted, however, that in the circuit condition shown in the drawing condenser **25** is shorted to ground, one side thereof being connected to ground through leads **18**, **20**, and **29**, contact **31***a*, and switch arm **31** connected to ground, and the other side also being connected to ground through lead **18***a*, switch arm **30** in engagement with its contact **30***a*, its normally biased position, lead **37**, a portion of lead **29**, contact **31***a*, and switch arm **31**. Thus, in the nonoperating state of the circuit both sides of both condensers **24** and **25** are at ground potential. However, energization of relay coil **34** operates similarly on switch arm **30** as on switch arm **31**, causing arm **30** to break from its contact **30***a* into open position to place condenser **25** in chargeable state as is done to condenser **24**.

The energization of relay coil **28***a* affects switch arm **38** in the same manner as switch arm **27**, causing it to move from its normally biased open position, as shown in the drawing, into engagement with its contact **38***a*, enabling current to flow therethrough and through lead **39**, relay coil **20***a*, and thence to ground. The resultant energization of coil **20***a* operates to move both switch arms **19** and **55** from their normally biased positions, as shown in the drawing, so as to bring arm **19** into engagement with its contact **19***b* and arm **55** into engagement with its contact **55***a*, thus simultaneously operating to close the charging circuit for condenser **25** and the plate circuit of the thyratron **50**, both described above. The condenser **25** charges at a rate as determined by the voltage source **10**, the rheostat **15**, and the capacitance of condenser **25**. The charging of condenser **24** through its charging circuit and the trapping of the charge thereon by the breaking of switch **27**, from engagement with its contact **27***a*, results in a negative potential on its grid connected plate and on the grid **53**. As condenser **25** is charged through its charging circuit, with the switch arm **27** in engagement with its contact **27***b*, the increase in potential thereacross bucks the potential across condenser **24** and causes the reference point of the potential across the condenser **24** to become correspondingly more positive, thereby causing the control grid to become less negative or more positive in accordance therewith until such time as the potential on grid **53** attains such a value as to enable tube **50** to become conductive from its cathode **54** to its plate **51**. Whereupon, the relay coil **23** in the plate circuit of tube **50** is energized to bring switch arm **26** into engagement with its contact **26***a* and hence close the bomb release circuit.

If, for example, the characteristics of tube **50** and the potential applied to its plate **51** and cathode **54** are so chosen that tube **50** becomes conductive when its control grid **53** is at ground potential, it is apparent that immediately upon the closure of switch **33**, with switch arms **19**, **27**, and **55** in the positions as shown in the drawing and with switch arms **30** moved into open position and **31** moved into engagement with its contact **31***b*, the charging circuit for condenser **24** is closed and the control grid **53** is maintained at ground potential; but the tube **50** does not fire because its plate circuit is open, switch arm **55** being out of engagement with its contact **55***a*, and

the circuit may be readily modified to charge both condensers 24 and 25 through the same resistor, fixed or variable, but set to a determined value for a given operational run. By such a modification, the ratio of the timing interval, during which condenser 24 is charged to carry a reference potential thereacross, to the interval to be measured, during which condenser 25 is charged to obtain an equal potential thereacross, is equal to the ratio of the capacitance values of condenser 24 to condenser 25. Also, even when the present invention is intended to operate in response to acceleration as in the embodiment shown in the drawing, the circuit may be likewise modified to employ only one charging resistor, the rheostat 15; and resistor 17 and switch arm 19 may be eliminated. The full resistance value of rheostat 15 would then be employed in charging condenser 24 during the timing interval, and the condenser 25 would be charged through this rheostat by operation of switch arm 27 in the same manner as indicated in the above-detailed description. Further, it is apparent that although here described in its application to toss bombing, the present invention is not limited to a downward to upward reverse acceleration but is applicable to reverse accelerations generally.

For many timing operations using the present circuit, it would not be necessary to actually provide for equal potentials across the two condensers; but the ratio of the timing interval to the measured interval would, in general, be a function of the ratio of the potential obtained across condenser 24 to that obtained across condenser 25 and the ratio of the R. C. value of the charging circuit for condenser 24 to that of the charging circuit for condenser 25. Regardless of in which manner the circuit is employed, other trigger or voltage indicating means than the thyratron tube may be used, as may be considered suitable for the particular use and operation of the device.

Because of the balancing type operation of the present circuit, it is apparent that when the balanced potential method of operation is employed the variables which are normally difficult to control in an electrical timing device affect the voltage obtained across both condensers proportionately and are thus canceled out when the voltages are equated, provided there is no variation during an operational run or timing cycle. Variations in charging voltage except during a charging cycle do not affect the results obtained, and similarly variations in the values of resistances or capacitances, as may be caused by aging or cycling, are balanced out if the initial elements are matched, for ratios of the elements remain constant.

Other uses of the present invention, and other modifications thereof within the spirit and scope of the teachings herein set forth and as defined by the appended claims, will be apparent to those skilled in the art.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A computing circuit for determining the proper instant for releasing a bomb from an aircraft performing a dive bombing attack comprising a first capacitor, first

circuit means coupled to said first capacitor for charging said first capacitor at a known rate during a predetermined portion of said dive bombing attack to produce a first voltage thereon which is proportional to the time required for a released bomb to reach said target, a second capacitor, second circuit means coupled to said second capacitor for charging said second capacitor to a second voltage, switch means coupling said first and second circuit means for causing said first circuit means to cease charging said first capacitor after said predetermined portion of said dive bombing attack has been made and for causing said second circuit means to commence charging said second capacitor upon the cessation of the charging of said first capacitor whereby said second voltage has a portion thereof which has an instantaneous magnitude which is proportional to the distance traversed by the aircraft toward the target, acceleration responsive means coupled to said second circuit means for increasing the rate of charging of said second capacitor, said acceleration responsive means being responsive to the pull-up acceleration of said dive bombing aircraft when it departs from a collision course with said target whereby said second voltage has a portion thereof which is proportional to the upward velocity of said aircraft, means coupled to said first and second capacitors for producing a signal when said first and second voltages bear a predetermined relationship to each other which signifies the proper time for bomb release, and means coupled to said last mentioned means for releasing said bomb.

2. A circuit for providing a signal at the proper instant for releasing a bomb from an aircraft performing a dive bombing attack, said circuit comprising: a first capacitor, a first charging circuit coupled to said first capacitor and having a switch when closed for completing a circuit to cause said first capacitor to commence charging through said first charging circuit, a second capacitor, an acceleration responsive slide wire variable resistor, a second charging circuit connected with said acceleration slide wire variable resistor for charging said second capacitor through said variable resistor, switch means operatively connected into said first and second charging circuits for substantially simultaneously causing said second capacitor to commence charging through said second charging circuit and for causing said first charging circuit to open and cease the charging of said first capacitor, and means responsive to the voltages on said first and second capacitors for producing a signal when the voltages on said first and second capacitors bear a predetermined relationship to each other.

References Cited in the file of this patent

UNITED STATES PATENTS

1,997,208	Dimond	Apr. 9, 1935
2,090,224	Noble	Aug. 17, 1937
2,177,569	Jorgenson et al.	Oct. 24, 1939
2,236,157	Rea	Mar. 25, 1941
2,459,632	Engstrom	Jan. 18, 1949
2,478,670	Skellett	Aug. 9, 1949
2,545,257	Bryan et al.	Mar. 13, 1951
2,658,141	Kurland et al.	Nov. 3, 1953