Nov. 19, 1946. G. W. PONTIUS, 3D 2,411,290

MACHINE GUN SYNCHRONIZER

Filed Feb. 2, 1940 5 Sheets-Sheet 1

Fig. 1

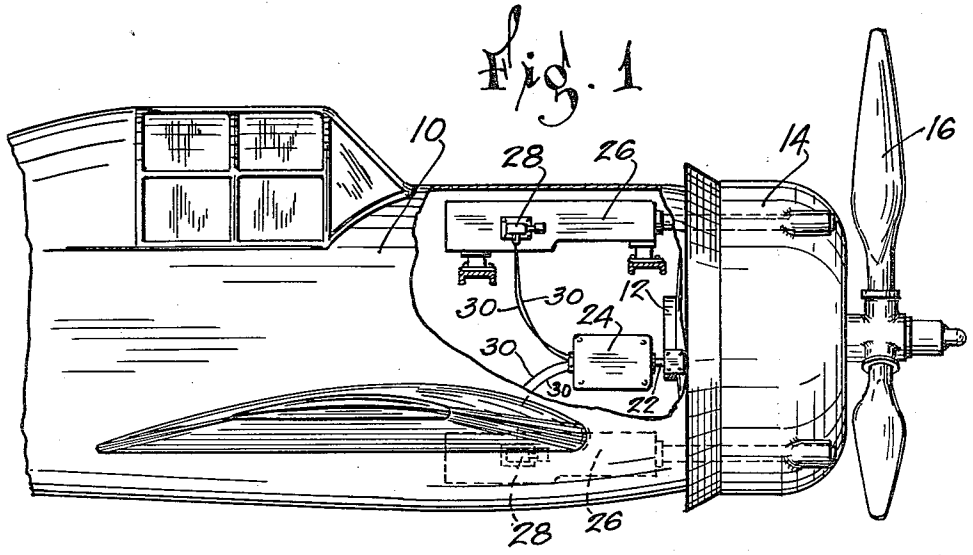
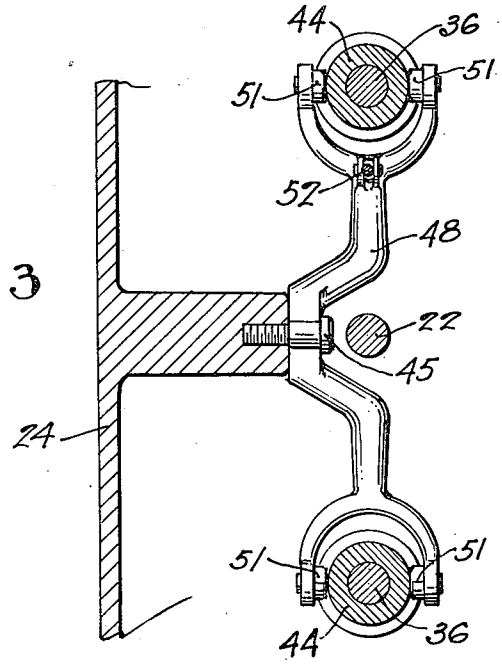


Fig. 3



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MACHINE GUN SYNCHRONIZER

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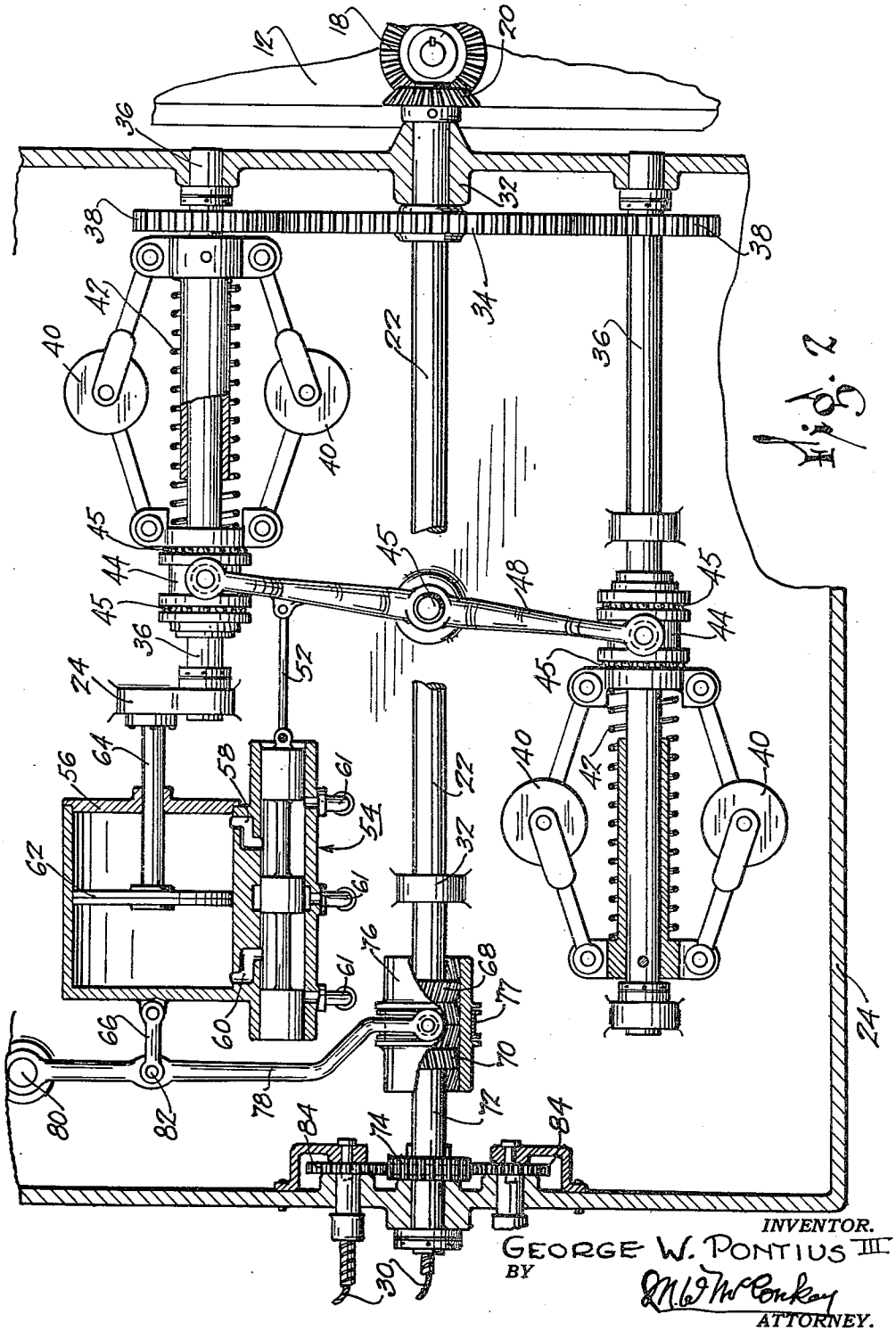


Fig. 2

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MACHINE GUN SYNCHRONIZER

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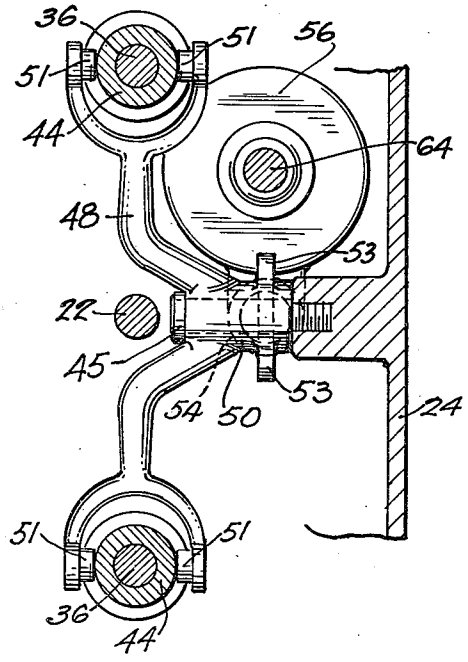


Fig. 4

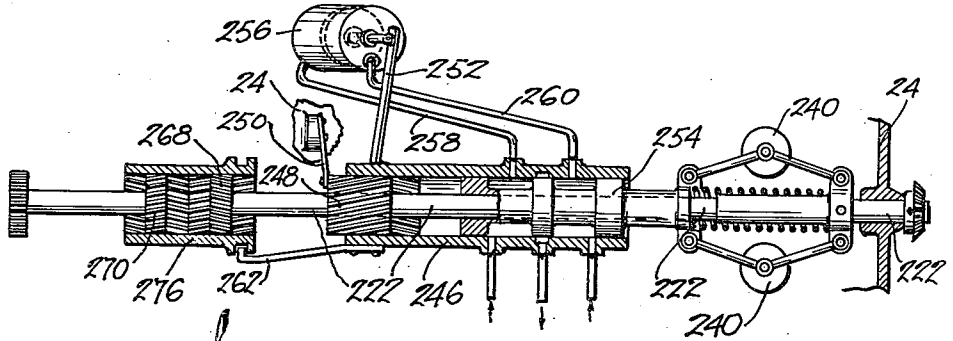


Fig. 5

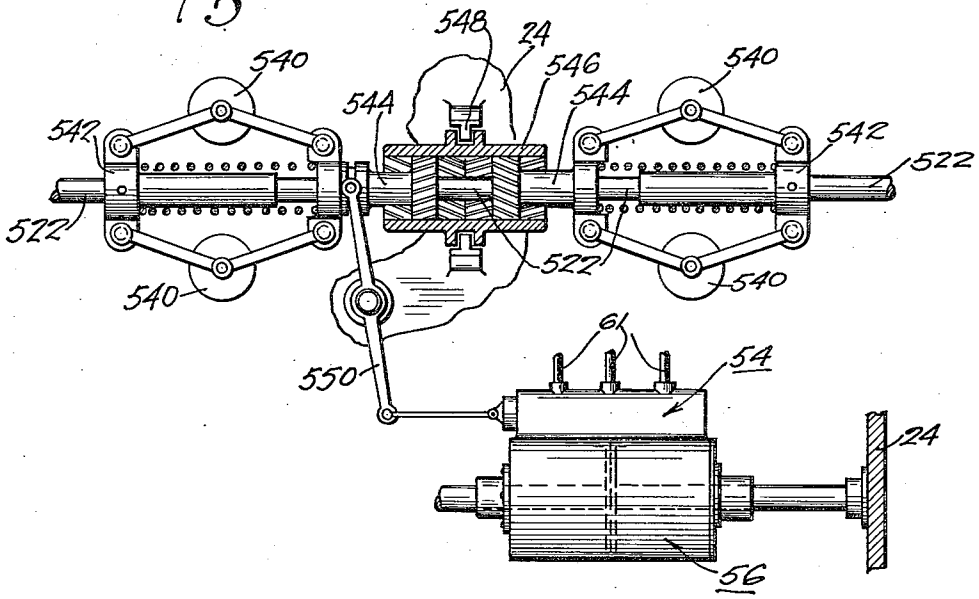
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MACHINE GUN SYNCHRONIZER

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Fig. 6



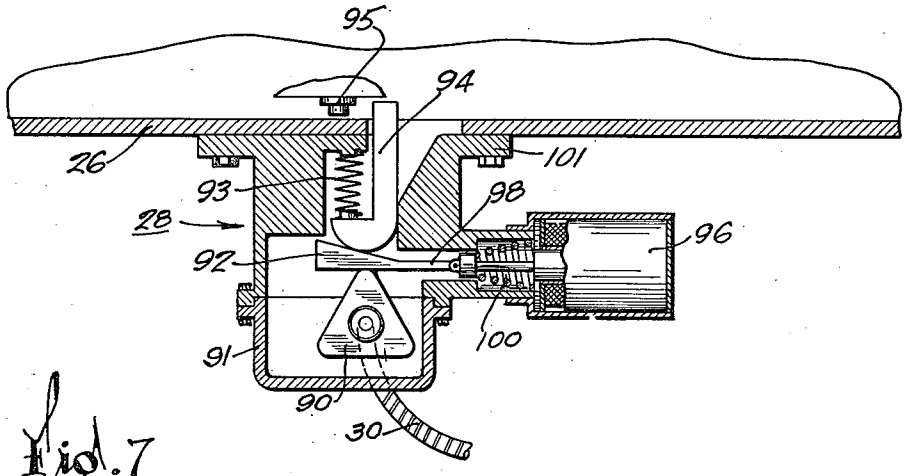


Fig. 7

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MACHINE GUN SYNCHRONIZER

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Fig. 8

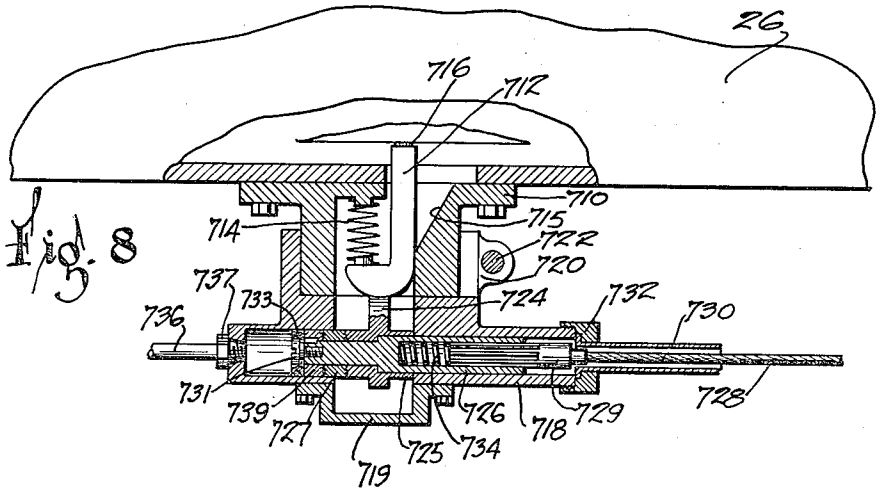
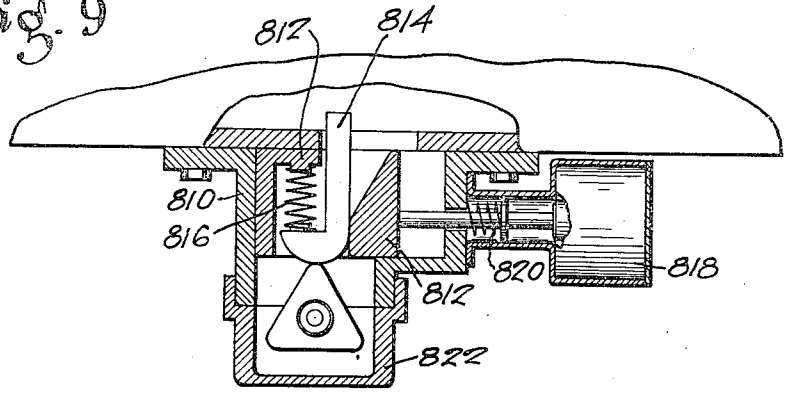


Fig. 9



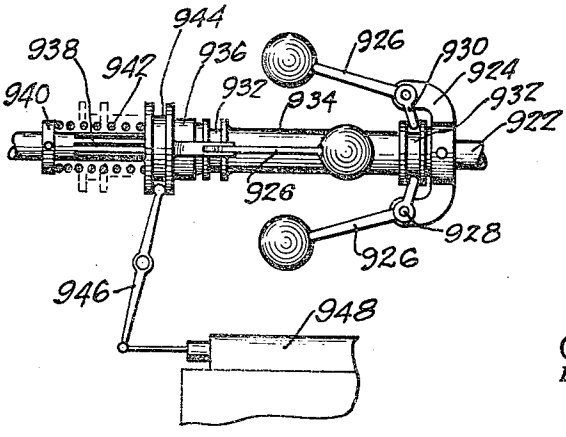


Fig. 10

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UNITED STATES PATENT OFFICE

2,411,290

MACHINE GUN SYNCHRONIZER

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Application February 2, 1940, Serial No. 316,999

18 Claims. (Cl. 64—25)

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This invention relates to a synchronizer for firing a machine gun through the propeller of an airplane and to actuating mechanisms for firing a gun.

In military aircraft, although guns may be mounted in the wings, it is also desirable to mount guns on the fuselage to fire forward in the direction of flight of the aircraft. This means in the case of a single motored airplane that the guns must be fired through the arc of the propeller of the airplane, necessitating synchronization of fire with the propeller to prevent the propeller from being hit. In firing a gun through a propeller, account must be taken of the time required for a bullet to reach the propeller zone from the instant of firing pin actuation. The adjustment of firing to engine rotation which is proper for low speeds of propeller rotation may be entirely wrong at advanced speeds of rotation when the propeller blade may possibly be in the path of the bullet before the bullet reaches the propeller zone. This defect of adjustment is especially true when three and four bladed propellers are used.

This condition is not so much of a problem when a two bladed propeller is used, because the speed of emergence of a bullet is such in relation to propeller rotation that a fixed firing point on the propeller arc will in most cases give ample clearance at all propeller speeds. However, the use of three and four bladed propellers makes the available firing arc so small with relation to the speed of emergence of a bullet that a fixed firing instant cannot be used, and a variable firing instant must be employed for varying propeller speeds.

Centrifugal adjusters have been used to advance the impulse generator shaft over the driving shaft. However, these centrifugal adjusters are affected not only by the speed of propeller rotation but by the load which the adjustment must transmit. Thus where the propeller is operating at a high speed, the centrifugal adjusters will assume a corresponding position. But when the machine guns are fired, the work of trigger actuation must pass through the centrifugal adjuster, which then assumes a position dependent upon the load transmitted and the propeller speed. This condition is accentuated by the large numbers of machine guns now used at times on a single airplane, which may be four or more.

It is therefore an object of this invention to provide a synchronizer which advances firing impulse generators in proportion to the engine speed alone, and which is independent of the load transmitted. Another object is to provide a synchronizer employing a controlled power unit to advance the impulse generator.

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It is an object of this invention to provide a centrifugal control for such a power unit, and further, to provide a centrifugal control free from the influences of acceleration or deceleration of the aircraft in which the synchronizer is mounted.

A further object is to provide a new type of trigger motor for machine gun actuation. Also it is an object to provide flexible drive means for said trigger motor. Still another object is to provide a novel lockout and engagement device for machine gun trigger motors.

It is a feature of the invention that the trigger motors may be mounted on the gun at any angle thereto according to the most beneficial method of leading the impulse transmitting mechanism to the trigger motors.

Other objects and features of the invention will be apparent in the following description and claims, best understood when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a view in elevation of an airplane with a part broken away to show machine guns actuated by apparatus constructed according to the invention;

Figure 2 is an enlarged sectional view of the automatic timing and advance mechanism shown at 24 in Figure 1;

Figure 3 is a detail view of the rocker arm 48 of Figure 2;

Figure 4 is a view of an alternative cam means for valve actuation;

Figure 5 is a sectional view in elevation of a modified form of synchronizer;

Figure 6 is a view in vertical section of a modified form of compensated governor control;

Figure 7 is a detail sectional view of a modified form of trigger motor employing a wedge lockout mechanism;

Figure 8 is a detail sectional view of a modified form of trigger motor with a slidable cam actuated by a hydraulic motor;

Figure 9 is a detail sectional view of a modified form of trigger motor with a movable tappet for a lockout; and

Figure 10 is a detail view in elevation of another form of compensated governor control.

The invention is shown in Figure 1 as applied to an airplane 10. A radial motor 12 covered by a cowling 14, drives a propeller 16. At the rear of the engine, a power take-off shaft acts through matching bevel gears to drive a shaft 22 which actuates the automatic timer mechanism en-

closed in a housing 24. The power take-off shaft is geared to the crankshaft of the engine, which drives the propeller.

The airplane is equipped with a plurality of machine guns 26, arranged symmetrically on either side of the engine. Mounted on the sides of the guns are trigger motor units 28 driven by rotary flexible shafts 30 which are driven from the synchronizer unit 24. Since the fuselage of the airplane is smaller than the arc of the propeller, the guns must fire through the arc of the propeller, being mounted to shoot on a longitudinal line through the airplane fuselage, which is the direction of straight line flight.

The means which I provide to advance the firing instant in accordance with the speed of the propeller is the automatic timing and advance unit shown at 24 in Figure 1. This synchronizer unit is shown in detail in Figure 2. A bevel gear 18 on a power take-off shaft driven by the engine 12 meshes with a bevel gear 20 secured to a drive shaft 22, which in turn operates the synchronizer unit. The drive shaft 22 is mounted in bearings 32 secured to the housing 24. Near the forward bearing 32 a gear 34 is secured to a drive shaft 22 and drives gears 38 which rotate two parallel governor shafts 36. The governor shafts 36 are mounted in suitable bearings attached to the housing 24. Mounted on the governor shafts are flyball governor units 40, stretched by springs 42. Each shaft 36 has a rotatable collar 44 which rides the free end of each of the flyball governors, and is held axially by ball bearings 45.

A rocker arm 48, shown in detail in Figure 3, contacts collars 44 through yokes on either end. The rocker arm 48 is pivoted on bolt 45 at its mid section, secured to casing 24. Fingers 51 on the yokes of rocker arm 48 contact collar 44 of the flyball governors 40, and cause rocker arm 48 to pivot on its bolt 45 as the flyball governors 40 assume different positions. A connecting rod 52 is pin jointed to the rocker arm 48 and to a hydraulic valve 54. The movement of the rocker arm 48 responsive to the governors 40 causes connecting rod 52 to actuate hydraulic valve 54 which controls and operates the power unit for the system, which unit will be later described.

I provide means to advance an impulse generator for firing the guns, to secure an advanced firing instant as the propeller speeds increase. This advancing means is in the form of an adjustable cam connection between a driving shaft and a driven shaft. The inward end of the drive shaft 22 is enlarged and cut to form a helical gear 68. Coaxially, and a short distance therefrom is a helical gear 70 with a reverse helix. Gear 70 is attached to a shaft 72 to which is secured a generator gear 74. A sleeve 76, cut internally with helices to fit the helical gears 68 and 70, is fitted over the gears 68 and 70. As this sleeve 76 is moved axially in either direction along the drive shaft, the gear 70 will change its relative rotary position with respect to gear 68. The sleeve 76 is moved axially in either direction by a yoke member 78, pivoted to the housing 24 at 80. The yoke fits a groove on a collar 77 rotatably mounted on sleeve 76, and thereby moves the sleeve along the drive shaft axis. The yoke member 78 is moved about its axis by a power unit which will next be described.

The power unit is a piston-cylinder unit operated by hydraulic fluid under pressure. A piston rod 64 is securely fastened to the casing 24, and retains a piston 62 on the other end. A floating cylinder 56 is mounted on the piston rod 64 and slides thereon. An integrally formed valve 54 controls the flow of fluid to the cylinder 56 and is connected to the cylinder through passages 60 and 58 at either end. Hydraulic fluid at times enters the valve 54 through three flexible conduits 61, the two outside ones being pressure lines and the middle one being an exhaust line. The valve 54 is connected to speed responsive rocker arm 48. The power cylinder 56 is pin jointed at 82 to the pivot arm 73 by a link 66. As the power cylinder 56 moves back and forth on its piston rod 64, it causes the yoke member 78 to move about its pivot 80 and thereby causes the sleeve 76 to move axially.

I also provide means for converting the rotary motion of driven shaft 72 into firing impulses to fire the guns 26. Spaced about the generator gear 74 are motor gears 84 which drive axially flexible shafts 30 in a 1–1 ratio. These shafts pass through the housing 24 to their respective guns to actuate the trigger motors 28. If there were only one gun, its flexible shaft could be directly connected to shaft 72. One of the trigger motors is shown in detail in Figure 7. Each trigger motor 28 comprises a base 101 rigidly secured to its gun 26 opposite the position of a sear pin 95 of the gun 26. The base 101 retains a solenoid 96 for control of a lockout mechanism and is adapted to retain a turret top 91 which retains a cam 90. The turret top 91 may be turned in any direction which is most suitable for placement of the rotary shafts 30. The cams 90 are driven by the flexible shafts 30 and are retained in bearings of any suitable kind in the turret top 91. The number of lobes on the cam should correspond to the number of blades on the airplane propeller. The cam 90 acts through a wedge 92 to actuate tappet 94 which actuates the sear pin 95 of the gun trigger mechanism. The tappet 94 is urged outward by spring 93 to return it to a perpendicular position if it should be encountered in a firing position by sear pin 95 upon counter recoil.

I provide means associated with the trigger motor for stopping the fire of the gun, which means I refer to as a lockout mechanism. The lockout mechanism comprises means for moving the wedge 92 forward and backward or right and left respectively with reference to Figure 7. When the wedge is pulled forward, the cam 90 acts through the wedge 92 to fire the gun. But when the cam is in its rearward position the cam cannot actuate the tappet 94, and the gun does not fire. The wedge may be moved by a solenoid, or a hydraulic piston, but is illustrated as moved by a solenoid unit 96 acting through rod 98 to move the wedge. A spring 100 returns the wedge to the no-firing position when the actuation is released. The controls for the unit 99 are in the pilot's cockpit.

In operation, the airplane engine 12 turns shaft 22 through gears 18 and 20, and through the gears 34 spins the flyball governor units 40, which assume definite positions for a given engine speed. The rocker arm 48 follows the movement of the governors and pulls on rod 52 causing the valve member to pull out, and valve 54 then passes high pressure liquid to the forward, or right hand, part of cylinder 56. Piston rod 64 being fixed, the cylinder moves to the front (or right) and since the valve 54 is integral with it, the valve casing moves also. This movement will finally close the valve and bring the cylinder to a stop by cutting off the source of fluid. By using a liquid under pressure as the power fluid, there

is no tendency to continue movement after the fluid is cut off.

Meantime the cylinder has acted through rod 66 to move the yoke arm 78 and cause sleeve 76 to move axially to the front. This movement acts through the driving gear 68 to shift the driven gear 70 relative thereto and advance the generator gear 74 with relation to the drive shaft 22. The motor gears will now cause the trigger motors 28 to fire at an advanced point and thus prevent the bullets hitting the propeller as the speed of the propeller increases.

If the airplane motor should now slow down, the springs 42 move the collars 44, causing rocker arm 48 to reverse its direction of angular motion. Connecting rod 52 then pushes the valve member inward. This causes valve 54 to pass fluid to the left or rear part of the cylinder 56, causing it to move rearward. In doing so, the valve casing 54 moves with it until the valve is closed. Meantime the rod 66 acts on lever 78 to shift sleeve 76 to change the relative positions of gears 68 to 70, according to the engine speed and retard the generator gear 74 and flexible shafts 30 relative to shaft 22. The trigger motors now fire at a more retarded point on the arc of the propellers and thereby effectively relate the firing to propeller speed.

The operation of the trigger motor described in connection with the synchronizer unit and shown in Figure 7 is as follows: The generator gear 74 of the synchronizer unit (Figure 2) drives gears 84 which are fastened to flexible rotary shafts 30, which lead to trigger motors 28. The relation of these parts is shown in Figure 1, wherein the synchronizer unit is represented by 24. At the trigger motor, the triangular cam 90 is fastened to the end of the flexible shaft and is rotated by it. The cam acts through the wedge 92 to reciprocate tappet 94 against the compression of spring 93. The tappet 94 strikes sear pin 95 and fires the gun in synchronism with the propeller, the lobes of the cam 90 corresponding in number and arrangement to the blades of the propeller 16 of the airship. To stop fire, the pilot of the airship opens the switch to solenoid 96, and spring 100 pushes the wedge 92 to the left, reducing the stroke of the tappet 94 so that it cannot fire the gun 26.

The dual system of flyball governors is used to eliminate the effects of acceleration and deceleration of the aircraft, especially important in maneuvering. As the craft decelerates, the forward flyball governor will tend to pull the rocker arm toward it. At the same time the rearward flyball governor will tend to push the rocker arm away from it, setting up equal and opposite forces in the rocker arm and neutralizing the effect of the deceleration. The forces in acceleration act in the same manner to neutralize the adjustment at the position for the respective rotative speeds. In this manner the effects of acceleration and deceleration, such as would affect a single flyball governor, are eliminated. Acceleration and deceleration in planes transverse to the fuselage will have no effect on the governors since the flyballs are revolving in those planes.

By using a power medium to advance the generator shaft, the centrifugal governor will reflect only the rotative speeds of the aircraft engine and will not be influenced by load factors. Thus the synchronizer can be made to operate very accurately and give definite assurance of faithful service.

The use of rotary flexible shafts to drive trigger motors results in freedom of placement of the guns and simplicity of installation of the firing mechanism. The rotary cam of the trigger motor may have more or fewer lobes or multiples thereof, depending upon the number of blades in the propeller. This type of trigger motor is simple and reliable as well as being light in weight, all prime factors in aircraft.

An alternative means of actuating the valve 54 is shown in Figure 4. The rocker arm 48 is mounted on a rotatable cam shaft 50 secured to the synchronizer casing 24 by bolt 45. The drive shaft 22 passes through the centerline of rocker arm 48. A cam 53 is integrally formed on the camshaft 50 and is adapted to contact the valve 54 (shown by a dotted line in Figure 4). As the rocker arm is rotated by the governors, the shaft 50 causes cam 53 to actuate the valve 54. A spring mounted in the valve may be used to keep the valve member in contact with the cam 53.

The operation of the modification shown in Figure 4 is as follows. Varying positions of rocker arm 48 according to engine speeds, turn shaft 50 and cause cam 53 to actuate the valve. The spring urged valve member may be used to keep contact with cam 53. The follow-up motion of the valve and the synchronizer actuation are the same as in the other embodiments of the system.

A variation of centrifugal governors compensated for bodily acceleration and deceleration of the system is shown in Figure 6. Mounted on a shaft 522, driven by the engine, are centrifugal governors 540 driven through collars 542 attached to the shaft. The free ends of the governors terminate in members 544 having reversed helices and which are driven by the governors. The members 544 are connected by a unitary member 546 which mates the helices of each member 544. The connecting member is free to rotate but not move axially, being held by guide 548 acting in a groove on connection 546. A yoke member 550, riding a groove in one of the members 544 actuates a proper power unit such as valve 54 and cylinder 56, and is movable according to rotative speed.

In operation, variation of speed causes the governors 540 to fly outward or contract, which pulls and pushes helices 544 in and out of connection 546, spinning connection 546 or decelerating it, according to the axial direction of movement. When the system is bodily decelerated or accelerated, one helix will try to pull out of the connection 546 and the other will try to push in. The movement of each will tend to twist the connection 546 to resist movement of the other, keeping the governors in their rotation responsive position, the axial inertia force of the system being taken through support 548. It will be appreciated that the governors need not rotate coaxially; all that is required are substantially parallel axes with the governors connected by an idler gear of proper matching shape for the helices.

Another embodiment of centrifugal governor controls is shown in Figure 10. A drive shaft 922 is connected to the engine drive of the aircraft. Pinned to this shaft 922 is a governor bracket 924, which retains two spaced, single arm flyball members 926, pivoted at 928. Arms 930, depending from flyball members 926, contact a circumferential groove 932 in an axially movable sleeve 934. At the other end of the sleeve 934 is another governor bracket 936, splined to shaft 922 by splines 938 and free to move axially. Two flyball units 926 are mounted in a similar manner as those at-

tached to bracket 924 and contact rear or left groove 932 of sleeve 934. The pairs of flyball governors are preferably mounted so that the flyball units are interfitting to shorten the axial length of the unit. A collar 940 holds a spring 942 against bracket 936, forcing it toward bracket 924. A groove 944 in bracket 936 moves lever 946, which controls a suitable power unit 948, which is used to advance and retard the driven shaft in relation to the driving shaft of the synchronizer unit.

In operation, the aircraft engine rotates shaft 922, rotating flyballs 926. The forward flyballs 926 fly outward and force sleeve 934 to the left. Meantime the rear or left flyballs 926 fly outward and press against sleeve 934, but being axially movable they move bracket 936 toward the rear against spring 942. In this manner, bracket 936 moves axially twice as far as would be the case with one flyball group, represented by the axial movement of sleeve 934. The movement of bracket 934 actuates lever 946 and this in turn operates power unit 948. The effect of deceleration or acceleration of the aircraft on the synchronizer system is neutralized by cooperation of the pairs of flyballs.

Many modifications of power units can be used in the system. One modification is shown in Figure 5, wherein a centrifugal governor controls a valve coaxial with the drive shaft. A governor 240 is mounted coaxially on the drive shaft 222. This governor unit could be compensated for bodily acceleration and deceleration of the system as in Figure 2, by a connection to a non-axial governor unit, but is shown as an uncompensated governor unit. The movable end of the governor is attached to a coaxial valve member 254 adjusting it according to the rotative speed. An actuator member 246 contains internal helical grooves which fit the helical grooves on a coaxial stationary member 248 attached to casing 24 by support 250.

The actuator member 246 has an arm 252 extending from it. Between the casing 24 and the arm 252 is a power cylinder 256 having its piston rod attached to arm 252. The cylinder is attached to casing 24 at its other end. Flexible conduits 260 and 258 connect the power cylinder with the valve passages. As the power cylinder acts on arm 252, actuator member 246 is rotated on helically grooved member 248 to advance the actuator member axially. Through an extension 262, a collar 276 is moved relative to the helical gears 268 and 270, advancing gear 270 relative to gear 268 thus advancing gear 270. This advances the instant of firing through a firing motor mechanism not shown.

In operation, the governor 240 pulls valve member 254 outwardly, causing fluid to flow to the power cylinder drawing arm 252 toward the casing 24. This advances member 246 on the shaft, eventually cutting off the fluid supply. As the member 246 advances, collar 276 is drawn with it, advancing the generator shaft over the drive shaft 222.

Many modifications of trigger motors can be used in the system. One modification of the trigger motor is shown in Figure 8. A base 710 is mounted on the gun 26. The base 710 retains a tappet 712 urged outwardly by a spring 714. The tappet is adapted to actuate the sear 716 of the trigger mechanism of the gun. The base 710 is round toward the outer side, so that the actuating mechanism may be mounted at any angle to the gun.

The actuating mechanism is enclosed in a housing 718, having a removable cover 719, fastened to base 710 by a split collar 720 tightened by bolt 722.

A rotary shaft 728, having a splined end 729, is protected by a casing 730, which is fastened to housing 718 by a nut 732. Fastening casing 730 to housing 718 retains shaft 728 in the housing 716. A shaft 726 is recessed and internally splined at one end and reduced at the other. This shaft fits over the splined member 729, compressing a spring 734 between them and rotates in housing 718. A cam 724, mounted on an offset sleeve 725, fits over shaft 726. The sleeve 725 is radially and regularly notched at the end of small internal diameter, and mates a similarly notched sleeve 727 having different numbers of regular, radial notches on the other face. Another notched sleeve 739 is splined or keyed to shaft 726 and has notches matching this other face of sleeve 727. A bolt 731 screws into shaft 726 and tightens the sleeves 739 and 727 against the offset of sleeve 725, the cam being driven through the key of sleeve 739. A piston packing 733 is attached to the outer end of sleeve 739. A hydraulic tube 736 is held in housing 718 by a tube nut 737.

In operation, in a non-firing position, the spring 734 urges the cam 724 to the left, where it rotates without striking tappet 712. The gun at this time is not firing because the trigger mechanism is not actuated. When the pilot of the aircraft desires to fire the gun, he opens a hydraulic valve electrically or manually, allowing fluid to flow through conduit 736 and into housing 718. This fluid then acts against packing 733 to compress spring 734, and force the cam 724 into operating position. Release of the fluid pressure causes the cam 724 to return to a non-operating position. This cam engaging mechanism could be a solenoid.

If, during operation, the tappet 712 should be depressed in the firing position, and the breech bolt should be in counter recoil, the sear 716 would contact the tappet 712. If the tappet did not yield, the sear 716, being resisted, would fire the gun, thus giving an unsynchronized shot. To avoid this, the base 710 is recessed as at 715 so that sear 716 will force tappet 712 forward. When cam 724 turns past the firing position, the spring 714 will return the tappet 712 to a firing position opposite sear 716. Then the next impulse from cam 724 will fire the gun.

The sleeves 739 and 727 with their differently numbered notches are provided in order to get a very close and accurate adjustment of the cam 724 on the driving shaft 728. By removing tube screw 737, a screw driver may be inserted into casing 718, and screw 731 can be unscrewed, allowing sleeves 727 and 725 to be turned relative to sleeve 739. This is done by removing cover plate 719 and setting the airplane propeller at the proper position with relation to the gun to be fired, and then placing cam 724 so that the tappet 712 is depressed or about to be depressed. Having secured this desired position, screw 731 is now tightened and the three sleeves locked in place with relation to shaft 726. The different numbers of notches on the sleeves allows a micrometer or vernier adjustment of the cam which is very sensitive. Because of the accessibility of the parts, this adjustment may be made very simply and readily.

Another embodiment of a trigger motor is shown in Figure 9. A base plate 810 retains a tappet block 812 containing a tappet 814 and a spring 816. A spring biased solenoid 818 moves block 812 backward against spring 820 and spring 820 moves it to a non-firing position upon release of the solenoid. The cam actuation is enclosed

in a turret housing 822. When it is desired to fire the gun, the solenoid 818 is energized pushing block 812 into position and the cam motor fires the gun through tappet 814. Deenergizing solenoid 818 allows spring 820 to return block 812 to the non-firing position.

Although the invention has been described with reference to particular embodiments of the invention, it is not limited to such embodiments, nor limited in any other manner, except by the terms of the following claims.

I claim:

1. In a device of the class described, a driving member, a driven member, a longitudinally movable spiral cam connection for connecting the driving member to the driven member for rotative movement and for advancing or retarding the driven member with respect to the driving member, fluid power means for moving spiral cam connection, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of flyball mechanisms responsive to the angular velocity of the driving member and non-responsive to the longitudinal acceleration of the driving member, and including a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

2. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the connecting means axially for retarding or advancing the driven shaft, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of opposed flyball mechanisms, and including a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

3. In an aircraft gun synchronizer, a driving shaft, a driven shaft, a longitudinally movable spiral cam connection for connecting the driving shaft to the driven shaft for rotative movement and for advancing or retarding the driven shaft with respect to the driving shaft, fluid power means for moving the connection axially for retarding or advancing the driven shaft, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of opposed flyball mechanisms, and including a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

4. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, said power means including a stationary piston and a cylinder movable in follow-up in accordance with the position of said valve, a control for said valve and power means including a pair of opposed flyball mechanisms, and including a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

5. In a device of the class described, a driving member, a driven member, means for connecting the driving member to the driven member for rotative movement and movable to advance or retard the driven member with respect to the driving member, fluid power means for moving said means, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of parallel shafts drivably connected to the driving member, a flyball mechanism mounted on each shaft in opposed relation and responsive to the angular velocity of the driving member and non-responsive to the longitudinal acceleration of the driving member, and a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid to the fluid power means.

6. In an aircraft gun synchronizer, a driving shaft, a driven shaft, a longitudinally movable spiral cam connection for connecting the driving shaft to the driven shaft for rotative movement and for advancing or retarding the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of parallel shafts drivably connected to the driving shaft, a flyball mechanism mounted on each shaft in opposed relation, and a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

7. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the connecting means axially for retarding or advancing the driven shaft, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of parallel shafts drivably connected to the driving shaft, a flyball mechanism mounted on each shaft in opposed relation, and a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

8. In an aircraft gun synchronizer, a driving shaft, a driven shaft, a longitudinally movable spiral cam connection for connecting the driving shaft to the driven shaft for rotative movement and for advancing or retarding the driven shaft with respect to the driving shaft, fluid power means for moving the spiral cam connection for retarding or advancing the driven shaft, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of parallel shafts drivably connected to the driving shaft, a flyball mechanism mounted on each shaft in opposed relation, and a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid to the fluid power means.

9. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, said power means including a stationary piston and a cylinder movable in follow-up in accordance with the position of said

valve, a control for said valve and power means including a pair of parallel shafts drivably connected to the driving shaft, a flyball mechanism mounted on each shaft in opposed relation, and a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid to the fluid power means.

10. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, a control for said valve and power means including a pair of opposed centrifugal mechanisms secured to the driving shaft and each having an axially movable part terminating in a helix of opposite hand from that of the other, a rotatable but longitudinally stationary coupling matching and connecting said helixes, and a member movable in response to the axial movement of one of the centrifugal mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

11. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, said power means including a stationary piston and a cylinder movable in follow-up in accordance with the position of said valve, a control for said valve and power means including a pair of opposed centrifugal mechanisms secured to the driving shaft and each having an axially movable part terminating in a helix of opposite hand from that of the other, a rotatable but longitudinally stationary coupling matching and connecting said helixes, and a member movable in response to the movement of the flyball mechanisms for opening the valve to admit fluid under pressure to the fluid power means.

12. In a device of the class described, a driving member, a driven member, means for connecting the driving member to the driven member for rotative movement and movable to advance or retard the driven member with respect to the driving member, a servo motor for moving said means, a valve for controlling said servo motor, a centrifugal control for said valve and servo motor, said control comprising a governor shaft driven by said driving member, an axially movable sleeve mounted on the governor shaft, a first flyball mechanism secured to the governor shaft and operative to move the sleeve axially, an axially movable second flyball mechanism rotatably connected to said governor shaft operative to tend to move said sleeve in the opposite direction, biasing means for urging the second flyball mechanism toward the first flyball mechanism, and a member movable in response to the movement of the second flyball mechanism for opening the valve to admit fluid to the servo motor.

13. In an aircraft gun synchronizer, a driving shaft, a driven shaft, means for connecting the driving shaft to the driven shaft for rotative movement and movable to advance or retard the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, a centrifugal control for said valve and power means, said control comprising a driving shaft, an axially movable sleeve mounted on said driving shaft, a first flyball mechanism secured to the driving shaft and operative to move the sleeve axially, an axially movable second flyball mechanism rotatably connected to said driving shaft operative to tend to move said sleeve in the opposite direction, biasing means for urging the second flyball mechanism toward the first flyball mechanism, and a member movable in response to the movement of the second flyball mechanism for opening the valve to admit fluid under pressure to the fluid power means.

14. In an aircraft gun synchronizer, a driving shaft, a driven shaft, axially movable means for connecting the driving shaft to the driven shaft for rotative movement and for advancing or retarding the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, a centrifugal control for said valve and power means, said control comprising a governor shaft driven by said driving shaft, an axially movable sleeve mounted thereon, a first flyball mechanism secured to the governor shaft and operative to move the sleeve axially, an axially movable second flyball mechanism rotatably connected to said governor shaft operative to tend to move said sleeve in the opposite direction, biasing means for urging the second flyball mechanism toward the first flyball mechanism, and a member movable in response to the movement of the second flyball mechanism for opening the valve to admit fluid under pressure to the fluid power means.

15. In an aircraft gun synchronizer, a driving shaft, a driven shaft, axially movable means for connecting the driving shaft to the driven shaft for rotative movement and for advancing or retarding the driven shaft with respect to the driving shaft, fluid power means for moving the first said means, a valve for admitting fluid under pressure to the power means, said power means including a stationary piston and a cylinder movable in follow-up in accordance with the position of said valve, a centrifugal control for said valve and power means, said control comprising a driving shaft, an axially movable sleeve mounted on said driving shaft, a first flyball mechanism secured to the driving shaft and operative to move the sleeve axially, an axially movable second flyball mechanism rotatably connected to said driving shaft operative to tend to move said sleeve in the opposite direction, biasing means for urging the second flyball mechanism toward the first flyball mechanism, and a member movable in response to the movement of the second flyball mechanism for opening the valve to admit fluid under pressure to the fluid power means.

16. A speed responsive device comprising a rotatable shaft, a centrifugal governor driven by the shaft and having a member axially movable upon variations in the speed of said shaft, a second centrifugal governor driven by the shaft and having a member axially movable upon variations in the speed of said shaft, a control element, and means operatively connecting said members to the element to move it in response to a given change in speed of said shaft but ineffective to move the element in response to change in acceleration of the speed device.

17. A speed responsive device for use on a vehicle comprising a rotatable shaft, a pair of centrifugal governors driven by the shaft, and a

control element operatively connected to said governors to be moved thereby in response to variations in shaft speed, said governors being so disposed relative to each other and to the element that acceleration of the vehicle will tend to move one of the governors to a position corresponding to an increased shaft speed and will tend to move the other governor to a position corresponding to a decreased shaft speed.

18. A speed responsive device for use on a vehicle comprising a rotatable shaft, a pair of centrifugal governors driven by the shaft, a control element, and means connecting the governors to the element to operate said element, said governors and means being so arranged that inertia effects of one governor resulting from change in velocity of the vehicle tend to move the element in one direction and the inertia effects of the other governor tends to move the element in the opposite direction.

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