

Aug. 27, 1940.

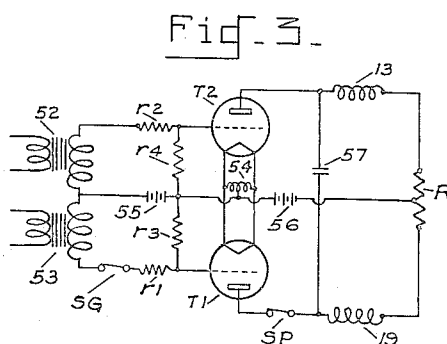
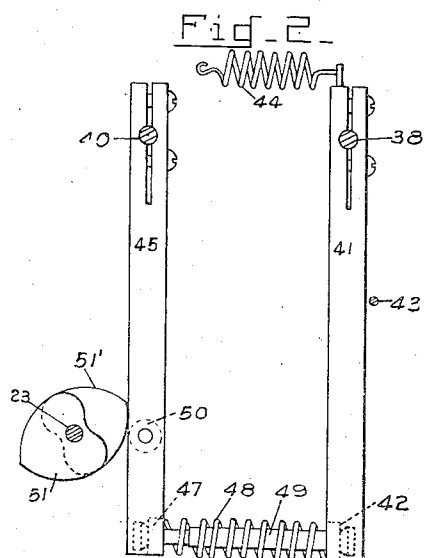
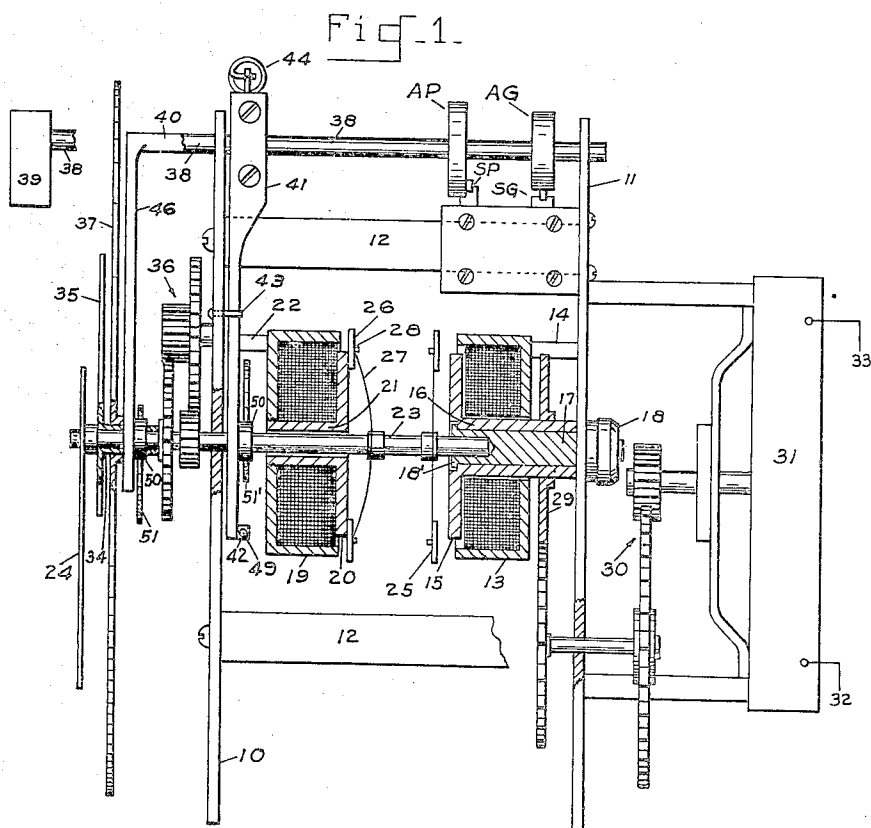
L. P. DORSETT ET AL

2,212,981

CHRONOGRAPH

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3 Sheets-Sheet 1



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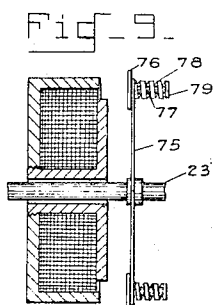
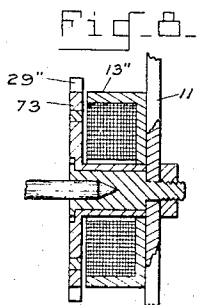
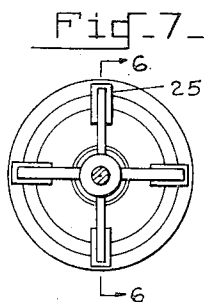
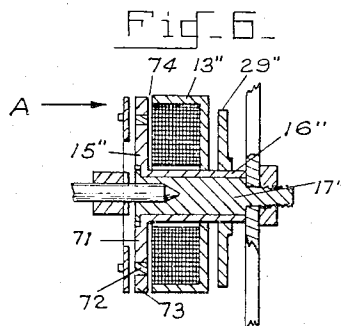
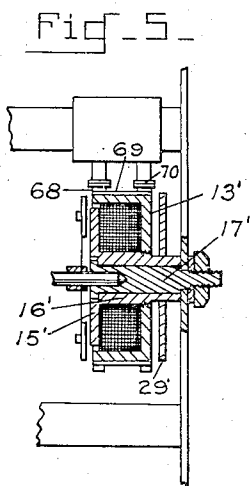
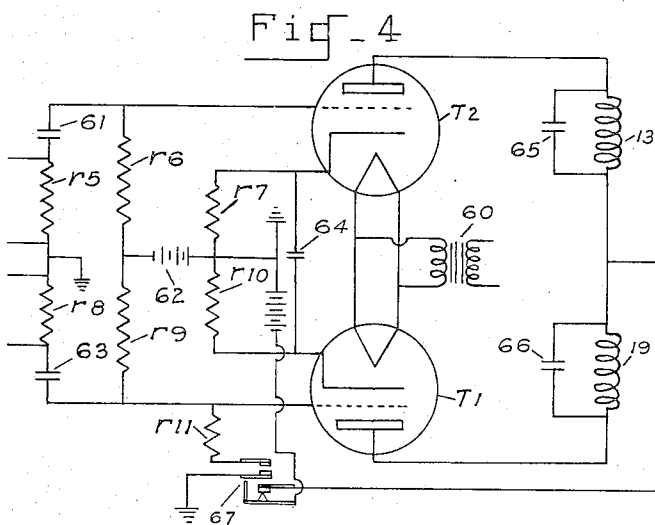
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CHRONOGRAPH

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3 Sheets-Sheet 2



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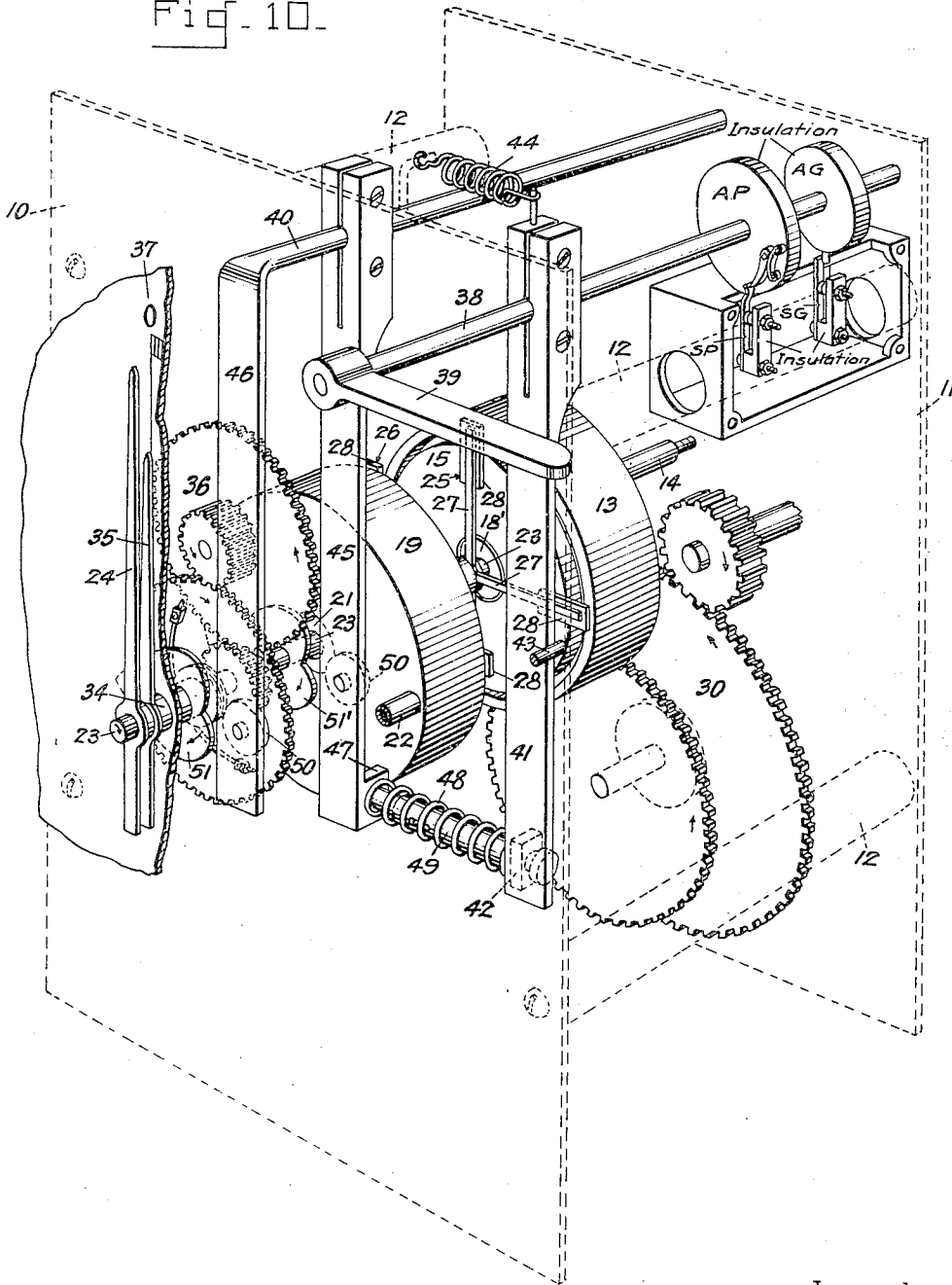
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CHRONOGRAPH

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Fig. 10.



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UNITED STATES PATENT OFFICE

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CHRONOGRAPH

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4 Claims. (Cl. 161--15)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

5 This invention relates to improvements in chronographs and more particularly to electrically actuated chronographs adapted to measure and record time intervals of integral and very small fractional second values.

10 Heretofore in the art it has been common practice in electrically actuated chronographs to employ sliding clutch plates, sliding shafts or similar movable members to connect the recording indicators with the clockwork train or similar mechanism driven at known speed, and to use
15 electromagnets for effecting engagement or disengagement of the movable members with the clockwork train. We have found, however, that movable members of the character above described are necessarily of such mass that their motions are retarded considerably through their inertias and that corresponding inaccuracies in the recording of the chronograph are introduced because of this time lag.

25 It is therefore, an object of this invention to provide an electrically actuated chronograph wherein moving parts operable in accordance with an electric signal or similar impulse have been altogether eliminated or so employed that
30 their masses may be much less than required in the movable members above referred to.

It is a further object of the invention to provide electromagnets for directly and positively initiating and effecting cessation of movement of the recording indicators by the clockwork train or similar mechanism driven at known speed,
35 concurrently and respectively with suitable signals indicating the beginning and termination of the interval of time to be measured.

40 It is still a further object of the invention to provide a suitable thermionic relay for controlling the action of the electromagnets in proper sequence and with minimum time lag.

The specific nature of the invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings in which:

50 Fig. 1 is a side elevation partially in section of a chronograph constructed in accordance with the invention;

Fig. 2 is a fragmentary elevation of a part of the structure shown in Fig. 1;

55 Fig. 3 illustrates schematically one embodiment of a thermionic relay circuit adapted to

control the electromagnetic arrangement shown in Fig. 1;

Fig. 4 is a schematic illustration of a modified embodiment of thermionic relay circuit adapted for use with the chronograph;

Fig. 5 is a sectional view of a modified form of electromagnet suitable for use in the chronograph;

Fig. 6 is a sectional view taken on the line G—G of Fig. 7 of still another modification of an electromagnet that may be used in lieu of the ones shown in Fig. 1 or 5;

Fig. 7 is an elevation of the structure shown in Fig. 6 looking in the direction of arrow A.

Fig. 8 illustrates an alternate method of driving the rotatable pole piece and securing the electromagnet to the frame;

Fig. 9 illustrates an alternate method of arranging the movable armatures;

Fig. 10 is a perspective view of the chronograph with parts broken away and other parts omitted to clearly show the zeroizing and switch mechanisms.

Referring now to the drawings by characters of reference there is shown in Fig. 1 a chronograph mounted in a supporting frame comprising a front plate 10 and rear plate 11 joined to each other in spaced parallel relation by spacers 12 of any suitable design. An annular electromagnet 13 is secured to the rear plate 11 of the frame in spaced substantial parallel relation therewith by means of spacers 14 and is provided with a rotatable pole piece 15 secured to an annular core 16 journaled on a stub shaft 17 of non-magnetic substance. The shaft 17 may conveniently be secured at one end to the rear plate 11 in fixed relation by any desirable securing means, such as shown at 18, and flanged, upset or otherwise formed at its opposite end 18' to retain the core 16 in proper bearing relation thereon. Another annular electromagnet indicated at 19 and provided with a stationary pole piece 20 and annular core 21 is secured in spaced substantial parallel relation to the front plate 10 by spacers 22. A rotatable shaft 23 is journaled at its rear end within a suitable bore in the stub shaft 17 and intermediate its ends in the front plate 10. The shaft 23 extends through the annular core 21 of electromagnet 19 and has affixed to its front end an indicator 24. Intermediate the electromagnets 13 and 19 the shaft has affixed thereon for rotatable movement therewith armatures 25 and 26 adapted to cooperate respectively with the pole pieces 15 and 20. Each armature is comprised of substantially identical

structure and includes a plurality of flat springs 27 secured at one of their ends to the shaft 23 in any appropriate manner and secured at their opposite ends to a segmental or annular armature member 28. It will be observed that in this manner of attachment of the armatures that they may move in directions parallel with the axis of the shaft 23 independent of the shaft and that the only inertia to be overcome in effecting their movement is due to the relative slight masses of the armature constructions. The rotatable core 16 secured to the pole piece 15 projects to the rear of the electromagnet 13 and carries a gear 29 rigidly thereon and constituting one of the gears of a gear train 30 of any desired driving ratio driven by a small synchronous motor 31. Conductors 32 and 33 connect the motor 31 with any convenient source of alternating current. At its forward end the shaft 23 has sleeved thereover a sleeve 34 carrying a second indicator 35 which is driven through the sleeve and a suitable gear train 36 driven by shaft 23 so as to be driven at a preselected ratio with respect to the shaft 23 and indicator 24. A dial 37 graduated in any appropriate units of time interval is suitably positioned in rear of the indicators 24 and 35 from which a measured time interval may be directly read as indicated by the indicators.

When the chronograph has functioned to measure and record an interval of time it is of course necessary that the indicators 24 and 35 be reset to zero or zeroized before the chronograph is in condition for subsequent measurement by direct reading and for this purpose the resetting or zeroizing device more particularly shown in Figs. 1 and 2 is provided which comprises a rotatable shaft 38, having at its forward end a cranked arm 39, mounted in the frame plates 10 and 11 for rotation. A shaft 40 similar to shaft 38 is mounted in the frame plates 10 and 11 for rotation on an axis parallel with and contained in substantially the same horizontal plane as the latter. The axis of shaft 40 is also substantially parallel with the axis of shaft 23 and is disposed to one side of the vertical plane containing the axis of shaft 23 a suitable distance as shown in Fig. 2. At its upper end a depending lever 41 is frictionally or otherwise suitably secured to the shaft 38 and is provided at its lower end with a perforated spring abutment 42. The lever 41 is normally held in engagement with a stop 43 on the frame plate 10 by resilient means 44 initially tensioned so as to bias the lever in a counterclockwise direction away from shaft 23 as viewed in Fig. 2. Shaft 40 is provided with two longitudinally spaced depending levers as indicated at 45 and 46 respectively, in both Figs. 1 and 2. The lever 45 depends to a position in substantial horizontal alignment with the lower end of lever 41 and is provided with a perforated spring abutment 47 which cooperates with the abutment 42 on lever 41 to support a compression spring 48 interposed between the two abutments and held under initial compression by a telescopic member 49 extended through the perforations of opposed abutments. The telescopic member is of such length in extended position and so secured to the abutments as to normally restrain the levers 41-45 to a position of parallelism under the influence of spring 48 but will permit slight relative movement of lever 41 toward lever 45. Each of the levers 45 and 46 have a roller 50 mounted thereon in substantial horizontal alignment with the axis of shaft 23 to cooperate

with heart shaped cams 51' and 51 mounted respectively on the shaft 23 and sleeve 34. As will be seen hereinafter depression of arm 39 will rotate shaft 38 and lever 41 in a clockwise direction as viewed in Fig. 2 and such rotation will be imparted to lever 45 through the spring 48 and to lever 46 through the shaft 40 to cause the rollers 50 to engage the heart shaped cams 51' and 51 and rotate the shaft 23 and sleeve 34 to a position where the indicators 24 and 35 indicate zero on the graduated dial 37.

In order to control the thermionic circuit hereinafter described during the zeroizing of the indicators 24 and 35 a switch box housing switches SP and SG is mounted for convenience on the frame plate 11 and actuators of non-conducting material, indicated respectively at AP and AG are mounted on the shaft 38 and so arranged as to open the switches SP and SG in proper sequence upon rotation of the shaft 38 in clockwise direction as viewed in Fig. 2.

A relay circuit of the thermionic type suitable for effecting energization and deenergization of the electromagnet coils 13 and 19 in proper sequence in measuring a time interval is shown schematically in Fig. 3. As shown means 52, which may be a transformer with its primary connected in the starting signal circuit is arranged to be generally affected by any suitable signal initiating the interval of time to be measured and 53 is similar means arranged to be operably affected by any suitable signal indicating the termination of the time interval measured. A pair of gaseous triodes T1 and T2 having input and output circuits are arranged to have their outputs regulated by the means 52 and 53 through the input circuits. The cathodes of the triodes are heated by any suitable source of power such as 54 and include in common in their input circuits any suitable grid biasing source 55. The input circuit of triode T2 comprises the grid resistor r2 leak resistor r4 and secondary of the transformer included in means 52 and likewise the input circuit of triode T1 comprises the grid resistor r1 leak resistor r3 secondary of the transformer of means 53 and in addition the switch SG hereinbefore mentioned. The output circuit of both triodes include in common the anode current source 56. The output circuit of triode T2 comprises the electromagnet 13 and one-half of the resistance R and the output circuit of triode T1 includes the electromagnet 19, one-half the resistance R and switch SP hereinbefore referred to. The condenser 57 is disposed in parallel with the electromagnets as shown.

The operation of the system thus far described is as follows:

During the zeroizing operation of the indicators 24 and 35 to be hereinafter more fully set forth, the switch SG is momentarily opened which changes the grid bias on triode T1 to such an extent that the triode becomes conducting and initiates flow of current in the plate circuit through the electromagnet 19. The electromagnet 19 upon being energized by flow of current in the plate circuit of triode T1 attracts armature 26 to stationary pole piece 20 and restrains shaft 23 against movement thereby holding indicators 24 and 35 in the zero position. Flow of current in the plate circuit of triode T1 induces a charge on condenser 57 because of the potential drop across the resistance of electromagnet 19 and one-half of resistance R. The system is now conditioned to measure an interval of time and upon the impression of an electric signal in-

dicating the commencement of the time interval to be measured on the primary of the transformer included in means 52 an E. M. F. will be induced in the secondary of the transformer and so modify the grid bias of the input circuit of triode T2 that this triode will become conducting and a plate current will flow in the output circuit. Flow of current in the output circuit of triode T2 will energize the electromagnet 13 attracting the armature 25 to the pole piece 15. Simultaneously with flow of current in the output circuit of triode T2 the condenser 57 discharges through triode T2 because of the change in potential of this plate circuit with respect to the plate circuit of triode T1 and the plate of triode T1 becomes momentarily more negative than its cathode thereby causing the current flow in the output circuit of triode T1 to cease with accompanying deenergization of electromagnet 19 and retraction of the armature 26 by springs 27 to release shaft 23 for rotation. The pole piece 15 is rotated by the synchronous motor 31 energized from a suitable A. C. source through conductors 32 and 33 and it will of course be understood that motor 31 has been brought to synchronous speed prior to the impression of a starting signal on means 52. The indicators 24 and 35 are driven by the motor 31 through the train gear 30, rotating pole piece 15, armature 25, shaft 23, and gear train 36 at known speed until the expiration of the time interval whereupon a signal is impressed on means 53 to induce an E. M. F. in the secondary of the transformer of this means and modify the bias on the triode T1 grid so as to start flow of current in the plate circuit of this triode. When current again flows in the output circuit of the triode T1 the condenser 57, which was charged when electromagnet 19 was deenergized as above described in a sense opposite to that in which it was charged prior to discharging through triode T2 will discharge through triode T1 rendering triode T2 non-conducting with accompanying deenergization of electromagnet 13 and release of shaft 23 from driven relation with the rotating pole piece 15 and electromagnet 19 will be energized attracting armature 26 and stopping rotation of shaft 23. The time interval measured may now be read directly from the dial 37 as indicated by the indicators 24 and 35.

When the measured time interval has been read from the dial 37 the indicators are reset to zero to condition the system for subsequent operation by direct reading and this is done through the zeroizing mechanism. It is of course obvious that when current is flowing in the plate of triode T1 that the shaft 23 will resist rotation since armature 26 is strongly attracted by electromagnet 19 and therefore the indicators cannot be set to zero without first deenergizing electromagnet 19. This is done when resetting crank 39 is depressed to rotate shaft 38 which causes the actuator AP on the shaft 38 to open the switch SP during initial movement of the shaft and thereby break the plate circuit of triode T1 to deenergize the electromagnet 19. Further rotation of shaft 38 will close the switch SP which conditions triode T1 to conduct when the bias on its grid is suitably changed. Deenergization of electromagnet 19 will permit the indicators 24 and 35 to be returned to zero, therefore continued depression of resetting crank 39 and rotation of shaft 38 will cause the lever 41 through the spring connection 48 to rotate the levers 45 and 46 so as to bring the rollers 50 into engagement

with the cams 51' and 51 to rotate the same to position the indicators to zero in a manner well understood in the art. When the indicators have been returned to zero the rollers 50 will engage in the depressions of the heart shaped cams 51' and 51 and further rotation of shaft 38 will cause spring 48 to compress so that lever 41 will move relative to the levers 45 and 46 and this additional rotation of shaft 38 will cause the actuator AG to open switch SG in the grid circuit of triode T1 and so change the grid bias on this triode that it will become conducting as above set forth and energize the plate circuit and electromagnet 19 so that the indicators will be held in the zero position. Upon release of the reset crank 39 the spring 44 returns the levers 41, 45 and 46 to their initial positions without opening switch SP and closing switch SG and the system is again in condition for operation as above described.

In Fig. 4 a modified form of thermionic relay circuit is shown suitable for use in the chronograph system which eliminates the necessity of employing a zeroizing mechanism such as shown in Figs. 1 and 2. In this form of relay a pair of gaseous triodes T1 and T2 of the separate heater type are shown. The cathodes of the triodes are heated through any suitable source of power such as 60. The input circuit of triode T2 comprises the starting signal means including resistance r5, the resistances r6 and r7, condenser 61, and biasing source 62. The input circuit of triode T1 comprises the stopping signal means including resistance r8, the resistances r9 and r10, condenser 63 and biasing source 62. The condenser 64 is connected to the cathodes of the triodes in parallel with resistances r7 and r10. The output circuits of the triodes include a common source of power for the anodes of the triodes T2 and T1 and the electromagnets 13 and 19, respectively. Condensers 65 and 66 are placed in parallel with the electromagnets 13 and 19, respectively, and are chosen to have a minimum time constant in switching the current in the output circuits of the triodes from one electromagnet to the other.

A depressible reset switch 67 is arranged in the plate circuits of both triodes and in the grid circuit of triode T1 so that upon initial depression of the switch the grid of triode T1 will be grounded through resistance r11 and thereafter upon further depression will open the plate supply circuit.

The operation of the thermionic relay shown in Fig. 4 in the chronograph system is as follows:

The reset switch 67 is depressed which first grounds the grid of triode T1 and then opens the plate circuits of both triodes T1 and T2 to deenergize the electromagnets 13 and 19 which then permit zeroizing of the indicators 24 and 35 through the use of the levers 41, 45, 46 and heart shaped cams 51' and 51 as hereinbefore described or in any other suitable manner.

Upon release of the reset switch the plate circuits of the triodes are closed before the grid of triode T1 is ungrounded and this renders triode T1 conducting and effects a current flow through the output circuit thereof to energize electromagnet 19 and attract armature 26, which prevents shaft 23 from rotating with consequent displacement of the indicators from zero position. After the plate circuits are closed further release of the reset switch from its depressed position ungrounds the grid of triode T1 and condenser 64 is charged by the drop in potential across re-

sistance r_{10} . The system is now in condition to measure an interval of time and when a signal indicating initiation of the interval of time to be measured is momentarily applied across the resistance r_5 of the starting means the pulse will be transmitted across condenser 61 raising the potential of the grid in triode T2 to the extent that the triode becomes conducting. Current will then flow through the output circuit of this triode and energize electromagnet 13 thereby attracting the armature 25 attached to shaft 23 to the pole piece 15 being rotated by the synchronous motor 31 and displace the indicators 24 and 35 accordingly. Simultaneously with initiation of current flow in the output circuit of triode T2 condenser 64 will discharge through triode T2 momentarily raising the cathode potential of triode T1 above the plate potential to render the triode non-conducting. Current then ceases to flow in triode T1 and electromagnet 19 is deenergized to release the armature 26 and permit rotation of shaft 23. Upon expiration of the time interval being measured an electric signal will be momentarily applied across the resistance r_8 of the stopping means across the condenser 63 to the grid of the triode T1 so raising its potential that the triode becomes conducting and current is thereby switched from electromagnet 13 to electromagnet 19 to release armature 25 from the rotating pole piece 15 and stop the shaft 23 by attraction of armature 26 to the fixed pole piece 20 all in a manner similar to the one in which the starting signal affects the circuits of the triodes as above explained. The interval of time measured may now be directly read from the dial 37 indicated by the indicators 24 and 35 and the system conditioned for subsequent operation as above.

In Fig. 5 a modified form of electromagnet 13' is shown which may be used in lieu of the electromagnet 13. In this form the coil housing of annular electromagnet 13', pole piece 15' and annular core 16' are all secured together and mounted on a stud shaft 17' for rotation as a unit. The housing of the electromagnet carries the spaced annular contacts 68 insulated from each other by the insulating medium 69 and suitably connected with the terminals of the coil of the electromagnet. Brushes 70 properly connected in the output circuit of triode T1 serve to conduct an energizing current to the annular contacts 68. This electromagnet functions in the system in the same manner as electromagnet 13, being driven by the gear 29' through the gear train 30 and synchronous motor 31.

In Figs. 6 and 7 a further modification of the electromagnet 13 is shown at 13'' but this modification may with equal facility be applied to the stationary pole piece 20 of the electromagnet 19. In this modification the pole piece 15'' comprises an annular soft iron, or similar substance of high magnetic permeability, piece 71 of smaller diameter than the electromagnet coil housing, an annular piece 72 of material of non-magnetic substance, such as brass and another annular member 73 having an outside diameter substantially equal to the coil housing of the same substance as piece 71 secured to piece 72. The pole piece 15'' is secured to an annular core 16'' mounted for rotation on the stud shaft 17'' and adapted to be rotated by the gear 29''. The pole piece 15'' and core 16'' are spaced by very small air gaps 74 from the coil to permit rotation thereof and reduce the reluctance of the magnetic path to a minimum. In effect the non-magnetic ring 72 separates the pole piece 15'' into two poles thus

concentrating the magnetic force through the cooperating armatures 25 and making them cling to the pole face more securely. The gap with pole piece 15'' caused by 72 may be made relatively wide. For economy in organization it may be desirable to secure the gear 29'' directly to the periphery of annular member 73 in the form of a ring gear whereby housing 13'' may be fastened directly to the frame plate 11 as shown in Fig. 8.

As disclosed in Fig. 9 each armature assembly may consist of a light weight disc 75 secured to the shaft 23 at a predetermined distance from the cooperating pole piece and in substantially parallel relation therewith. A plurality of armature members 76 of any convenient shape and each having a polygonal shaped boss 77 projecting through a correspondingly shaped aperture in the disc are disposed around the disc and urged into contact therewith by springs 78 interposed between the disc and suitable abutments 79 on the bosses. This arrangement allows the light armature members 76 to move freely parallel to the axis of the shaft 23 between the two positions, against the pole piece and at a fixed distance from it against the disc. The bosses passing through the holes in the disc prevent any relative rotatable motion between the armature members and the disc.

Having now described our invention what we claim is:

1. In a chronograph system in combination, a rotatable shaft, an indicator having a normal zero position driven by said shaft, an electromagnet mounted adjacent the shaft, an armature flexibly secured to the shaft and adapted to be coupled with the electromagnet to restrain the shaft against rotation with the indicator in its normal zero position through energization of the electromagnet, a second electromagnet having a rotatable pole piece mounted adjacent the shaft, and a second armature flexibly secured to the shaft and adapted to be coupled with the rotatable pole piece through energization of the second electromagnet.

2. In a chronograph system in combination, a supporting frame comprising front and rear spaced plates, an electromagnet having a stationary annular core and attached pole piece secured to the front plate with the axis of its core intersecting the front plate, a second electromagnet having a rotatable annular core and attached pole piece secured to the rear plate with the axis of its core in alignment with said first recited axis, means mounting the rotatable annular core for rotation, a rotatable shaft journaled in said last recited means and front plate extending through the core of the first recited electromagnet, a pair of substantially identical armatures flexibly secured to the rotatable shaft intermediate the electromagnets and adapted to be coupled with the pole pieces of the first and second recited electromagnets respectively through energization of the latter.

3. In a chronograph system in combination, a rotatable shaft, an indicator driven by the shaft, a first electromagnet having a stationary pole piece adapted to restrain the shaft against rotation, means for driving the shaft comprising a second electromagnet having a rotatable pole piece adapted to be coupled with the shaft, starting signal means, an electronic device having an input circuit coupled with the starting signal means and an output circuit including said second electromagnet, stopping signal means, an electronic device having an input circuit coupled

with the stopping signal means and an output circuit including said first electromagnet, a condenser connected across said output circuits operable to render the output circuit of the electronic device coupled with the stopping signal means non-conducting when the output circuit of the other electronic device is conducting and vice-versa and means for resetting the indicator to zero position when current is flowing in the output circuit of the electronic device including the first electromagnet, comprising means to open and close the output circuit in sequence to stop flow of current in the output circuit, means to reset the indicator to zero position and means to initiate flow of current in the output circuit including a device operable to open and close the input circuit of said electronic device in sequence.

4. In a chronograph system, a supporting frame comprising front and rear plates, a rotatable shaft mounted in said frame, an indicator secured to the shaft, a sleeve mounted on the shaft and rotatable relative thereto, a second indicator secured to the sleeve, heart shaped cams secured to the shaft and sleeve respectively, a rotatable shaft mounted on the front and rear plates in parallel relation with said first recited rotatable

shaft, levers secured to said rotatable shaft mounted in the front and rear plates and depending to a position adjacent the heart shaped cams, rollers mounted on the levers and adapted to engage the cams, an actuator lever shaft mounted in the front and rear plates in parallel relation with said other rotatable shafts, an actuator lever secured to said actuator lever shaft and resiliently connected at its lower end with one of said first recited levers, means restraining the interconnected levers against relative movement in one direction, means biasing said levers to a normal position in the direction of restrained relative movement with the rollers out of engagement with the heart shaped cams, means for rotating the levers contra to the biasing means, electromagnetic means for restraining said first recited shaft against rotation, an electronic device having input and output circuits for controlling energization of the electromagnet means, switches in the input and output circuits, and switch actuators secured to said actuator lever shaft in cooperating relation with the switches and adapted to open and close said switches in sequence.

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