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PHOTOELECTRIC CONTROL

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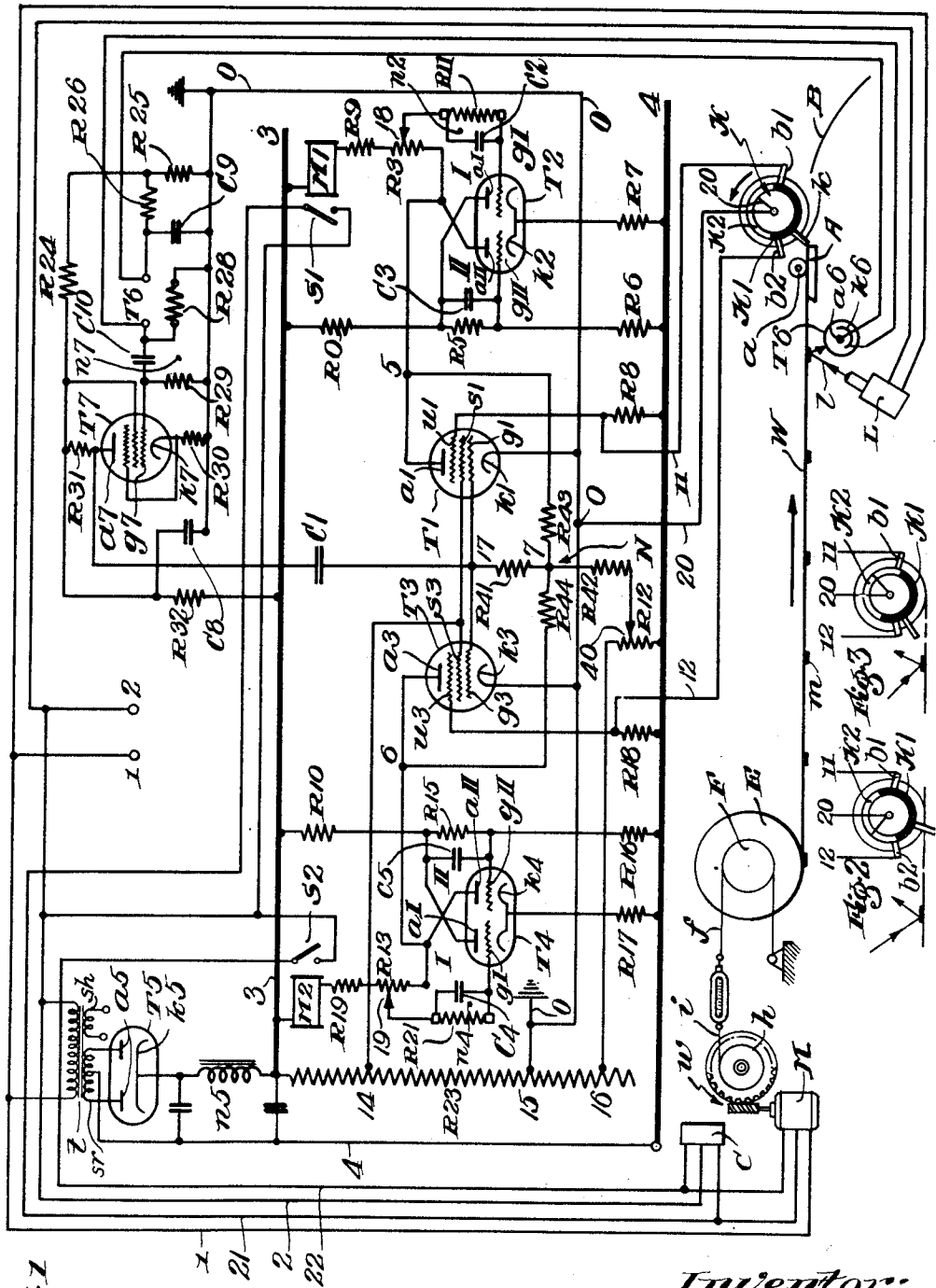


Fig. 1

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## PHOTOELECTRIC CONTROL

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This invention relates to electronic control circuits and especially to arrangements where energy impulses, derived for example from a phototube, control the correlation of an operating instrumentality with the material operated upon.

Some of the main objects of the invention are to actuate a controlling element upon the concurrent effects derived from a working operation and a supervising impulse, to move a controlling element in one sense or the other dependent upon the relative location of an impulsing mark relatively to an operating means, to provide a device for carrying out such control movements in one or the other sense in positive dependency upon the relation between impulsing mark and operating means as this relation changes correspondingly in one sense or the other, and to provide a device of this nature which permits the selection of effective impulses and of the duration of their effectiveness separately in either sense.

Other objects, as applied especially to blank severing machines, are to provide a simple registration control which supervises the direction of error in the relation of registering marks and cutting edge or similar severing instrumentality, for operating a corrective device for a suitable period of time in the proper direction. In still another aspect, the invention has the object to provide such registration control with the aid of a comparatively simple and compact electronic circuit using only standard high vacuum tubes as distinguished from the often unstable gas tubes which are also more expensive and require rather complicated controls which are not as completely electronic as might be desired.

The control circuit which is included in the invention is universally adjustable as to the duration of correction time in either direction and electronically locks out the detecting effect during the time when correction is carried out in either direction. Further, the detecting circuit according to the invention carries only very small currents so that practically no maintenance is required.

These and other objects, aspects and advantages will appear from the following description of a specific embodiment illustrating the character of my invention by way of example and referring to a drawing in which

Fig. 1 is a diagrammatical representation of a cutting machine incorporating the invention including a control circuit; and

Figs. 2 and 3 illustrate two abnormal positions of the supervising arrangement.

In the embodiment of my invention now to be

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described, a cutting mechanism is required to operate under the control of a series of registration marks applied to comparatively thin and stretchable strip material to be cut.

Fig. 1 shows a table A supporting strip material W delivered by suitable means indicated by a feed roll *a* from a supply roll E with a brake drum F carrying as a synchronization adjusting means a brake band *f*. An electromotor M is adapted to rotate by means of a transmission, for example worm gear *w*, a pulley *h* to which the brake band is fastened as indicated at *i*. The motor may be a self-starting synchronous motor with condenser pack *c* permitting it to be started in either direction by closing switch S1 or S2. The transmission is so arranged that at full speed, which motor M reaches almost instantaneously, pulley *h* rotates rather slowly, for example at the rate of one revolution per minute. The tension of strip W will depend upon the braking friction exerted by band *f*, and can be varied by tightening or releasing the stretchable band by means of the motor rotating in one or the other direction.

A knife drum K rotating at constant speed carries as operating means a knife *k* which upon striking the edge of table A severs a blank B from strip W. Fastened to drum K and rotating with it is a selector switch, for example a commutator consisting of a segment K1 of insulating material and a conducting segment K2. Two stationary brushes *b1*, *b2* are so arranged that under normal conditions both contact the insulating segment K1 at the time when the knife *k* cuts. Under abnormal conditions, to be discussed in detail hereinafter, one or the other brush may contact conducting segment K2, as shown in Figs. 2 and 3; such contact establishes an electric connection between one of the brushes and wire 20, through a slip ring or similar arrangement connecting segment K2 with wire 20, as indicated in the figures.

Registration marks *m* are applied to strip W for example in the form of dots or lines printed or otherwise applied to the strip and having light reflecting properties different from those of the strip material proper. These marks are supervised or detected by means of a lantern L directing a scanning light beam *l* towards strip W which reflects it towards a phototube T6 constituting a detecting impedance which varies proportionate to the light flux impinging thereon; this flux in turn depends upon the reflecting properties of the strip material or the marks, respectively. It will be evident that markings, as for example perforations, which are blocking or transmitting

a light beam may be used for delivering control impulses.

As will be described in detail below, changes of the relative position of marks *m* and cutting edge *k* cause the motor *M* to run in one or the other direction, thereby releasing or tightening brake band *f* and decreasing or increasing the tension and therefore setting the length between marks of the strip material to be cut, so that a predetermined spatial relation between cuts and marks is maintained, providing for example registration on the blanks of printed matter. The electric circuit controlling this operation will now be described.

A current source, for example a standard alternating current line indicated by terminals 1, 2 is connected to the primary of a transformer *t* having a rectifier secondary *sr* and an auxiliary secondary *sh* for the heater elements of the electronic apparatus of the circuit. The mid-point of the rectifier secondary constitutes one side 4 of a direct current supply system; the other side 3 of that system is connected to cathode *k5* of a rectifier tube *T5* whose anodes *a5* are in customary manner connected to the end terminals of the rectifier secondary of transformer *t*. A band elimination filter network *n5* may be connected between wires 3 and 4 for the purpose of smoothing the direct current supply.

The voltage between wires 3 and 4 is apportioned by means of potentiometer *R12* and resistor *R23*, connected in series between conductors 3 and 4 and defining predetermined voltages at terminals 14, 15 and 16 and adjustable tap 40. Terminal 15 may be connected to ground as indicated at 0, so that 3 and 14 are positive and 4, 40 and 16 negative with respect to 15.

Two actuating twin tubes *T2*, *T4* with cathodes *k2*, *k4* and each having a section I and a section II with anodes *aI*, *aII*, and control grids *gI*, *gII* serve as electronic switching means and are connected as follows, it being understood that separate tubes can be used as electronic relay means for this purpose.

Two series of resistors *R0*, *R5*, *R6* and *R10*, *R15*, *R16* are connected between wires 3 and 4. Anodes *aI* of tubes *T2*, *T4* are connected between resistors *R0*, *R5* and *R10*, *R15*, respectively, and grids *gII* between *R5*, *R6* and *R15*, *R16*, respectively. Resistors *R5*, *R15* are bridged by condensers *C3*, *C5*, respectively. The cathodes *k2*, *k4* are connected to wire 4 through resistors *R7*, *R17*, respectively. Anodes *aII* of tubes *T2*, *T4* are connected to wire 3 through resistors *R3*, *R9* and relay magnet *M1*, and resistors *R13*, *R19* and magnet *M2*, respectively. Grids *gI* of tubes *T2* and *T4* are connected to adjustable taps 18, 19 of resistors *R3*, *R13*, respectively, through timing networks *n2*, *n4* consisting of resistances *R11*, *R21* and condensers *C2*, *C4*, respectively. Resistors *R11*, *R21* may be of the plug-in type in order to permit convenient adjustment of the characteristics of networks *n2*, *n4*.

Magnets *M1*, *M2* close, when energized, normally open switches *S1*, *S2* which control the connections between supply terminal 2 and motor supply leads 21, 22, respectively.

Two initiating pentodes *T1*, *T3* are connected as follows.

The cathodes *k1*, *k3* of tubes *T1*, *T3* are connected to ground wire 0 which is tied to point 15 of potentiometer *R23*; the control grids *g1*, *g3* are joined to point 17 of network *N* (to be described below); screen grids *s1*, *s3* are joined to point 14 of *R23*; suppressor grids *u1* and *u3* are

connected to negative wire 4 through resistances *R8*, *R18*, respectively, and they are also connected through wires 11 and 12 to brushes *b1* and *b2*, respectively, of the commutator arrangement indicated at *K* of the figures. The anodes *a1* and *a3* are connected between anodes *aII* and resistors *R3*, *R13* of sections II of tubes *T2* and *T4*, respectively.

The phototube detector *T6* with cathode *k6* and anode *a6* is connected in a detecting and amplifying circuit as follows.

The cathode *k7* of a photo amplifier tube *T7* is connected to wire 0 and its anode *a7* to wire 3 through load resistance *R31*. Grid *g7* of tube *T7* is connected to an impulse discriminating network *n7* consisting of condenser *C10* connected to wire 0 in series with phototube *T6*, the two sides of the condenser being joined to wire 0 through impedances *R28* and *R29*, respectively. For reasons to be pointed out below, impedance *R28* and the impedance constituted by phototube *T6* may be arranged interchangeably as indicated by adjacent terminals in Fig. 1. The output circuit of tube *T7* is coupled to network *N* and the grids *g1*, *g3* of tubes *T1*, *T3* through condenser *C1*. Condensers *C8*, *C9* and resistors *R24*, *R25*, *R26*, *R30* and *R32* are inserted for supplying the proper voltages to the elements of pentode *T7* and to provide filtering action where necessary, in conventional fashion.

The initiating or control network *N* includes grid resistor *R41* connected between points 7 and 17, and resistor *R42* between 7 and tap 40 of potentiometer *R12*. To point 7, intermediate *R41* and *R42*, are connected on the one side resistor *R43* leading to point 5 on anodes *aII* of tube *T2* and *aI* of tube *T1*, and on the other side resistor *R44* leading to point 6 on anodes *aII* of tube *T4* and *a3* of tube *T3*.

The above-described embodiment of the invention operates as follows:

The actuating tubes *T2*, *T4* conduct under normal conditions through sections I because in sections II the voltages of grids *gII* are lower than those of cathodes *k4* and *k2* due to the current flowing in resistors *R0*, *R5*, *R6* and *R10*, *R15*, *R16*—resistances *R5*, *R6*, *R15*, *R16* being substantially equal and small as compared to *R7*, *R17*.

If for a reason to be discussed below, one of the initiating tubes, for example *T3*, becomes conductive, current will flow through

0—*T3*—6—*R13*—*R19*—*M2*—3

For reasons likewise to be discussed below, the voltage of tap 19 and hence of grid *gI* will be depressed sufficiently below the critical value to render section I non-conductive, and section II conductive.

Still assuming that *T3* and section II became conductive, condenser *C4* of timing circuit *n4* will charge due to the grid current in nonconducting section I, and magnet *M2* will be energized. When condenser *C4* has discharged through its network *n4*, grid *gI* will become again sufficiently positive to transfer conductivity back to section I, whereupon *M2* becomes again deenergized. Condensers *C3* and *C5* help in transferring conductivity back to sections I since they bridge resistors *R5*, *R15*, short circuiting them for sudden loads so that the grid potential can quickly assume the plate potential.

It will be noted that, after the voltage of tap 19 and grid *gI* has once been lowered due to conductivity of tube *T3*, section I will remain non-conductive until condenser *C4* is sufficiently dis-

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charged, regardless of the condition of the initiating tubes. It will be further noted that in tubes T2, T4 transfer of conductivity from sections I to sections II will be initiated independently for each tube by tubes T1, T3, respectively, whereas the transfer of conductivity back from sections II to sections I depends only on the timing circuits n2, n4, regardless of the conditioning of T1, T3. Still further it will be noted that the voltage of cathodes k2, k4 will be substantially constant since tubes T2, T4 always conduct, either through sections I or sections II. Thus the actuating tubes T2, T4 are each in a pulse generator circuit furnishing a substantially rectangular current pulse (through section II) for actuating the relays M1 and M2.

The initiating tubes T1, T3 are with their suppressor grids u1, u3 normally connected to negative wire 4 through high value resistances R8, R18. The voltage of 4 is sufficiently negative to prevent these tubes from conducting so long as this voltage is applied to the suppressors; however, if a suppressor is connected to the wire of cathode voltage, the respective tube is unlocked. These connections can take place through selector switch brushes b1 or b2. For example, if the selector is in the position shown in Fig. 2, suppressor grid u3 of tube T3 is connected to cathode voltage through brush-suppressor circuit u3-12-b2-K2-20-0-k3, and T3 is free to become conductive so soon as the voltage of its control grid g3 is sufficiently positive.

The phototube T6 is subject to changes of illumination of its cathode k6 causing corresponding variations of its impedance and of the charge on condenser C10. If these variations are sufficiently slow, as for example caused by changes of ambient illumination, the condenser charges will dissipate in network n1 before control grid g1 of photo amplifier T7 is affected. If however an instantaneous energy impulse such as caused by a mark m moving into the light beam l of lantern L is transmitted to condenser C10, the latter cannot discharge quickly enough and will lower the voltage of grid g1. Tube T7 will become less conductive, the voltage drop across resistor R31 will decrease and hence the voltage of point 17 become more positive.

If phototube T6 is connected as shown in Fig. 1, sudden decreases of the illumination of T6, as passing of a mark m through beam l, are effective to supply an initiating impulse to tubes T1 and T3; if T6 and R28 are exchanged, sudden increases of illumination are similarly effective.

The initiating network N controls the voltage of point 7 which is normally, that is with sections I conducting, determined by the position of tap 40 on potentiometer R12, which is so set that the voltage of grids g1 and g3 of tubes T1 and T3, respectively, is low enough to keep these tubes non-conductive.

The above-mentioned change towards the positive of point 17, effected by phototube T6, will raise the potential of grids g1 and g3 sufficiently to permit the tubes to become conductive. If unlocked by operation of the brush-suppressor circuit, one of the initiating tubes will become conductive. Due to their magnetic circuit, relay magnets M1 and M2 act as high impedances for sudden or steep impulses. Since the becoming conductive of one of the initiating tubes is such an impulse, M1 or M2 thereupon act as high impedance load on T1 or T3; this causes considerable voltage drop on tap 18 or 19 and hence on grids g1 of sections I, and transfer of the con-

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ductivity of tube T2 or T4 from section I to section II.

The voltage drop in R3-R9-M1 or R13-R19-M2, now in the anode circuit of sections II, reduces the voltage of point 5 or 6, and hence the voltage of points 7 and 17 will be correspondingly lowered, reducing the voltage on grids g1 and g3 to a value so low that impulses from photo amplifier T7 are no longer effective. This voltage drop is in the form of a substantially rectangular pulse similar to and caused by the afore-mentioned current pulse through sections II.

In this connection it will be noted that tubes T1, T3 may advantageously be high mu pentodes which should work into a high plate impedance in order to have sufficient gain, whereas tubes T2, T4 work well with a comparatively low load impedance, promoting a plate current sufficiently high to operate the relay magnets. These requirements are met by magnets M1, M2 which are in the anode circuits of both types of tubes and have a high impedance for short load impulses of the initiating tubes T1, T3, whereas they have a comparatively low resistance in the direct current load circuit of the actuating tubes T2, T4.

It will also be noted that either none or only one of tube groups T1, T2 or T3, T4, respectively, can be affected in this manner; this is due to the fact that either none of brushes b1, b2 (Fig. 1) or only brush b2 (Fig. 2) or only brush b1 (Fig. 3) can connect the respective suppressor of the initiating tubes T1, T3 to the cathode wire for the unlocking of the respective tube.

Assuming, for example, that initiating tube T3 has become conductive with brush b2 in the position of Fig. 2, and an impulse transmitted through photo amplifier T7 raising the voltage of point 17, the conductivity of tube T4 will be transferred from section I to section II and magnet M2 will be energized as above described, closing switch S2 and starting motor M in a given direction. Upon M2 becoming energized, the voltage of point 6 drops due to the current in

3-M2-R19-R13-T4-R17-4

the voltage of points 7 and 17 drops accordingly, the grid bias of g1 and g3 increases, and the sensitivity of initiating tubes T1, T3 is reduced.

Impulses arriving from T7 are now unable to render T1, T3 conductive, and hence unable to affect the condition of either actuating tube during the time when S1 or S2 is switched or during the time when sections II are kept conductive, before condenser C2 or C4 has sufficiently discharged. After C2 or C4 has sufficiently discharged to return sections I to conductivity, as above described, tubes T2 and T4 are now ready to receive another impulse from T6 through photo amplifier T7, network N and one of the initiating tubes, effective to energize M1 or M2, respectively.

It will be noted that the above-described lock-out function through reduced sensitivity of the initiating tubes T1, T3 and reduced voltage of point 7 is completely separate from the suppressor lock-out of the same tubes due to positioning of brushes b1, b2.

Summing up the complete cycle of operation it may be assumed that strip material W is conveyed as indicated by the arrows of Fig. 1 and slightly tensioned by brake f. In this connection it should be noted that the normal distances of the marks between rolls E and a, corresponding to the path of the cutting device, will be somewhat

longer than the correct length of the severed blank, in order to compensate for this initial stretch.

If the machine functions normally, brushes b1 and b2 will be in position Fig. 1 at the time when the marks pass the light beam 1, suppressors u1 and u3 are connected to negative wire 4 and block the initiating tubes, the impulse arriving from T6 through T7 and N is therefore ineffective, S1 and S2 remain open and motor M stands still.

If the cuttings should become too long due to a shift in the phase relation of the cutting cycle and the registering cycle, the register marks strike the beam too late, that is, after knife k has performed the cut and the commutator is in position Fig. 2, brush b2 establishes connection between wires 12 and 20 and unlocks T3, and the impulse arriving from T6 through T7 renders T3 conductive and switches conductivity of T4 from section I to II. Switch S2 thereupon closes, and motor M turns drum h in clockwise direction releasing the tension of strip W and therefore rectifying the defect by decreasing the distance between markings.

If the cuttings become too short, brush b1 will go into position Fig. 3 and unlock tube T1, the scanner impulse will energize magnet M1 in the manner described above for magnet M2, switch S2 will close and motor M will rotate drum h in counter-clockwise direction tightening the brake and increasing the marking distance until normal condition prevails whereupon both switches S1 and S2 open and the motor comes to a standstill.

During the time period when condenser C2 or C4 discharges in network n2 or n4, magnet M1 or M2 will remain energized regardless of the unlocking of tubes T1, T3 or of incoming scanner impulses. This time period is adjustable as mentioned above so that the machine can be set for a speed of correction dependent upon the material handled, the conveying speed, the size of cuttings and other controlling characteristics. Full correction need not be accomplished in response to a single impulse but may extend through several cutting operations.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. Electric control apparatus comprising cyclically effective operating means, registering means delivering a series of impulses normally effective in synchronism with said operating means, setting means adapted to vary the phase relation between the cycle of said operating means and said registering means, electronic initiating means having suppressor screen means and control grid means, means associated with said suppressor means for locking said initiating means during periods in fixed time relation to the cycle of said operating means, means associated with said control grid means for rendering said initiating means conductive during periods in fixed time relation to said impulses, and electronic pulse generator means for generating a substantially rectangular pulse of electric current of a predetermined time duration in substantially immediate response to an initiating impulse of any lesser duration applied to an electrode of said generator means; said initiating means providing said initiating impulse immediately upon the concurrent unlocking and rendering conductive

of said initiating means through said suppressor means and said grid means under control of said operative means and said registering means; said rectangular pulse actuating said setting means for its entire duration, but not longer.

2. Electric control apparatus comprising cyclically effective operating means, registering means delivering a series of impulses normally synchronized with the cycle of said operating means, setting means operative in two senses for varying the phase relation between the cycle of said operating means and said registering means, two electronic initiating means, means associated with each of said initiating means for varying the conductivity of its initiating means in fixed time relation to the cycle of said operating means, means associated with each of said initiating means for varying said conductivity in fixed time relation to said impulses, said conductivity varying means being normally alternately effective, and electronic pulse generator means for generating a substantially rectangular current pulse of a predetermined time duration to actuate said setting means in one sense or the other for said time duration in response to an initiating impulse of any lesser duration applied to an electrode thereof; one or the other of said initiating means furnishing said initiating impulse immediately upon said conductivity varying means being simultaneously effective thereon; said pulse generator means then furnishing to said setting means a pulse to actuate said setting means to restore said normally synchronized condition.

3. Electric control apparatus comprising cyclically effective operating means, registering means delivering a series of impulses normally synchronized with the cycle of said operating means, setting means operative in two senses for varying the phase relation between the cycle of said operating means and said registering means, two electronic initiating means each having a first and a second control electrode means, means associated with each of said first electrode means for varying the conductivity of its initiating means in fixed time relation to the cycle of said operating means, means associated with each of said second electrode means for varying said conductivity in fixed time relation to said impulses, said conductivity varying means being normally alternately effective, two substantially inertialess electronic relay means for actuating said setting means in one sense or the other, means for establishing an actuating conductivity condition of said relay means immediately upon the overlapping in one sense or the other, respectively, of the effect thereon of said operating means and said registering means, and means for maintaining said actuating condition during a period which is independent of the condition of said initiating means.

4. Electric control apparatus comprising means adapted to deliver a first and a second series of impulses; means adapted for adjusting the synchronization of said impulse series by varying the impulse intervals of one of said series; a discharge device having an output circuit and two control electrodes associated with said impulse-delivering means, one control electrode affecting the conductivity of said device in synchronism with said first series and the other control electrode affecting said conductivity in synchronism with said second series; an electronic pulse generator for generating a substantially rectangular pulse of electric current of a predetermined time duration in substantially immediate response to

an initiating impulse of any lesser duration applied to an electrode thereof; said discharge device output circuit providing said initiating impulse immediately upon concurrence of impulses of each of said first and second series to render said device conductive; and said rectangular pulse energizing said adjusting means.

5. Electric control apparatus comprising means adapted to deliver a first and a second series of impulses; means adapted for adjusting the synchronization of said impulse series by varying the impulse intervals of one of said series; a discharge device having an output circuit and two control electrodes associated with said impulse delivering means, one control electrode affecting the conductivity of said device in synchronism with said first series and the other control electrode affecting said conductivity in synchronism with said second series; an electronic pulse generator for generating simultaneously a substantially rectangular pulse of electric current of a predetermined time duration and a substantially rectangular voltage pulse of substantially identical duration, both said pulses being initiated in substantially immediate response to an initiating impulse of any lesser duration applied to an electrode of said generator; said discharge device output circuit providing said initiating impulse immediately upon concurrence of impulses of each of said first and second series to render said device conductive; said current pulse energizing said adjusting means; and said voltage pulse being applied to one of said control electrodes in such fashion as to maintain said device non-conductive for the duration of said pulses.

6. Electric control apparatus comprising means adapted to deliver a first and a second series of impulses; means adapted for adjusting the synchronization of said impulse series by varying the impulse intervals of one of said series; a discharge device having an output circuit and two control electrodes associated with said impulse delivering means, one control electrode being adapted to affect the conductivity of said device in synchronism with said first series and the other control electrode being adapted to affect said conductivity in synchronism with said second series; and an electronic switching means including two anodes and two grids each grid controlling one of said anodes with the second one of said anodes being operatively connected to said adjusting means, connections from each of said anodes to the grid controlling the other anode, a bias controlling means associated with said output circuit of said discharge device and a condenser and a resistance bridging said condenser in said connection to said second anode, said bias controlling means being adapted to transfer conductivity from the first anode to said second anode whereupon discharge of said condenser transfers conductivity back to said first anode after a time predetermined by its time constant; said switching means being adapted to energize said adjusting means immediately upon impulses of each of said first and second series concurrently affecting the conductivity of said discharge device.

7. Electric control apparatus comprising means for delivering operating impulses, means for delivering control impulses, means for synchronizing said operating impulses and said control impulses, control initiating means of variable conductivity including electron discharge means having two electrodes for controlling said conductivity, means for applying to one of said electrodes a control potential varying in fixed time relation

with said operating impulses, means for applying to the second electrode a control potential varying in fixed time relation to said control impulses, and electronic pulse generator means for generating a substantially rectangular pulse of electric current of a predetermined time duration in substantially immediate response to an initiating impulse of any lesser duration applied to an electrode thereof, said electron discharge means providing said initiating impulse immediately upon concurrent effect of said operating and control impulses on said respective control electrodes to cause variation in the same sense of said conductivity, and said rectangular pulse actuating said synchronizing means.

8. Electric control apparatus comprising cyclically effective operating means, registering means delivering a series of impulses normally synchronized with the cycle of said operating means, setting means adapted to vary the phase relation between the cycle of said operating means and said registering means, control initiating means of variable conductivity including electron discharge means having two electrodes for controlling said conductivity, means for applying to one of said electrodes a control potential varying in fixed time relation with said operating cycle, means for applying to the second electrode a control potential varying in fixed time relation to said registering impulses, and electronic pulse generator means for generating a substantially rectangular pulse of electric current of a predetermined time duration in substantially immediate response to an initiating impulse of any lesser duration applied to an electrode thereof, said electron discharge means altering its conductivity and providing said initiating impulse immediately upon the concurrent effect of said operating means and said registering means upon said initiating means, and said rectangular pulse actuating said setting means.

9. Apparatus in accordance with claim 2 in which said pulse generator means furnishes a second substantially rectangular pulse simultaneously with said current pulse and of like duration for rendering both said initiating means substantially ineffective for the duration of said rectangular pulses and hence during the actuation of said setting means.

10. Electric apparatus for controlling the phase relation of cyclically effective operating means and registration means furnishing a series of impulses normally in synchronism with said operating means, comprising: switching means conducting in synchronism with said operating means only during control periods prior to and after, respectively, the effectiveness of said operating means; setting means for varying said phase relation; said registration means including a phototube and a network for furnishing said series of impulses; two initiating tubes each having a suppressor normally supplied with a voltage locking the conductivity of the respective initiating tube and adapted for connection to its cathode through a respective one of said switching means and each initiating tube having a control grid connected to said network and tending to render its initiating tube conductive in response to said impulses; two electronic relay means for operating said setting means in one sense and the other, respectively, and means for restoring said relay means to inoperative condition after a predetermined time period, said relay means being adapted to be rendered operative by corresponding ones of said initiating tubes upon the concur-

rent effect thereon of said operating means and said impulses upon coincidence of one or the other of said control periods and one of said impulses and maintained operative by said restoring means during said time period.

11. Electric apparatus for controlling the phase relation of cyclically effective operating means and registration means furnishing a series of impulses normally in synchronism with said operating means, comprising: switching means conducting in synchronism with said operating means only during control periods prior to and after, respectively, the effectiveness of said operating means; setting means for varying said phase relation; said registration means including a phototube and a network for furnishing said series of impulses; means for excluding from said network impulses having a slow rate of change; two initiating tubes each having a suppressor normally supplied with a voltage locking the conductivity of the respective initiating tube and adapted for connection to its cathode through a respective one of said switching means, and each initiating tube having a control grid connected to said network and tending to render its initiating tube conductive in response to said impulses; two electronic relay means for operating said setting means in one sense and the other respectively, the operativeness of said relay means being controlled by corresponding ones of said initiating tubes upon the concurrent effect thereon of said operating means and said impulses upon coincidence of one or the other of said control periods and one of said impulses, and means including a timing condenser for terminating said operativeness of said relay means independently of the condition of said initiating tubes.

12. Electronic control apparatus of the class described comprising: an electronic pulse generating device adapted to furnish a current pulse of substantially rectangular shape and of predetermined time duration in response to a relatively sharp initiating pulse of shorter duration applied to a control electrode thereof; a relay coil in an anode-cathode circuit of said device adapted to be energized by said current pulse, said coil providing relatively low impedance to the flow of said current pulse there-through, but a relatively high impedance to said initiating pulse, said coil being so connected in said circuit that its impedance to said initiating pulse serves to accentuate the effect of said initiating pulse on said control electrode; an electronic switch for providing said initiating pulse including an electron discharge device having at least a first and a second control electrodes and adapted to provide said initiating pulse only when a pair of controlling pulses applied one to each of said electrodes occur simultaneously; a controlled device adapted to produce one and a supervising device adapted to produce the other of said controlling pulses, said devices normally producing said controlling pulses alternately; and means rendered operative by said relay coil when energized by said current pulse to restore the normal relationship between said controlling pulses.

13. Apparatus in accordance with claim 12 in which said pulse generating device furnishes a second substantially rectangular pulse simultaneously with said current pulse and of like duration, for rendering that control electrode of said electronic switch which is controlled by said supervising device substantially ineffective for the duration of said rectangular pulses, and

hence during the time when said restoring means is operative.

14. Electronic control apparatus comprising cyclically effective operating means, registering means delivering a series of impulses normally synchronized with the cycle of said operating means, setting means operative in two senses for varying the phase relation between the cycle of said operating means and said registering means, two electronic initiating means each having a first and a second control electrode means, means associated with each of said first electrode means for varying the conductivity of its initiating means in fixed time relation to the cycle of said operating means, means associated with each of said second electrode means for varying said conductivity in fixed time relation to said impulses, said conductivity varying means being normally alternately effective, and two substantially inertialess electronic relay means for actuating said setting means in one sense or the other, means for establishing an actuating conductivity condition of said relay means immediately upon the overlapping in one sense or the other, respectively, of the effect on said initiating means of said operating means and said registering means, and means for maintaining said actuating condition during a period which is independent of the condition of said initiating means.

15. Electronic control apparatus comprising cyclically effective operating means, registering means delivering a series of impulses normally synchronized with the cycle of said operating means, setting means operative in two senses for varying the phase relation between the cycle of said operating means and said registering means, two electronic initiating means each having a first and a second control electrode means, means associated with each of said first electrode means for varying the conductivity of its initiating means in fixed time relation to the cycle of said operating means, means associated with each of said second electrode means for varying said conductivity in fixed time relation to said impulses, said conductivity varying means being normally alternately effective, and two electronic pulse generator means for generating each a substantially rectangular pulse of electric current of a predetermined time duration for actuating said setting means in one sense or the other for said duration, and means for initiating one of said rectangular pulses to actuate said setting means in one sense or the other immediately upon the overlapping in a corresponding sense of the effect on said initiating means of said operating means and said registering means.

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#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name           | Date          |
|-----------|----------------|---------------|
| 2,002,374 | King           | May 21, 1935  |
| 2,031,503 | Rainey         | Feb. 18, 1936 |
| 2,052,255 | Shoults        | Aug. 25, 1936 |
| 2,169,026 | Gulliksen      | Aug. 8, 1939  |
| 2,052,263 | Whiteley       | Aug. 25, 1936 |
| 2,250,209 | Shoults et al. | July 22, 1941 |
| 2,195,006 | Gulliksen      | Mar. 26, 1940 |
| 2,249,820 | Gulliksen      | July 22, 1941 |
| 2,262,362 | Gulliksen      | Nov. 11, 1941 |
| 2,348,862 | Sorkin         | May 16, 1944  |