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CODED TRACK CIRCUITS FOR RAILROADS

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FIG. 1.

FIG. 2.

FIG. 3.

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CODED TRACK CIRCUITS FOR RAILROADS

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This invention relates to railway track circuits of the pulsating uni-directional current coded type, and more particularly to a relay controlled by such pulsating current for applying code impulses of such pulsating current to the track circuit.

It has been found that pulsating current, under certain conditions of track ballast and the like, is preferable to alternating current or continuous direct current in the track circuit and this pulsating current is preferably obtained by rectifying out the current pulses of one polarity from an alternating current from a suitable alternating current source. Since coded track circuits require the track circuit current to be applied and removed intermittently at rates of from 75 impulses per minute to 180 or more impulses per minute, or even at higher rates, the problem of intermittently applying the current and interrupting the same without undue burning of the contacts due to sparking has arisen. It may be pointed out that not only sparking tends to occur when the contacts are broken while current flows therein, but a great deal of sparking tends to occur upon closing of such movable contacts due to bouncing and vibration of the movable contact as it first comes into engagement with the stationary contact. It is not practical to make and break the energized track circuit by contacts emersed in oil in view of the extremely low voltages that must be used in track circuits. Track circuits therefore present a special problem.

In view of the foregoing problems and other considerations it is proposed in accordance with the present invention to employ a specially constructed code applying relay for controlling the application of the pulsating uni-directional current and to control this relay by the pulsating current. This relay is preferably constructed to either close the circuit between two successive pulses of current, to open the circuit between two successive pulses of current or to both close and open the circuits only during the "off" period between successive pulses of the pulsating current depending upon whether some or all of the features of the relay are incorporated. This relay is proposed to be controlled from the same pulsating current source the current of which it is to control and is to perform these functions irrespective of the time of closure of its energizing circuit with respect to the pulses of such pulsating current. One of the objects of the present invention is to construct the special code applying relay so that the armature of the relay is very quick acting when it has once started to move, and to so time its actuation with the pulses of current pulses applied thereto that its contacts will be closed in the first "off" period after the first full pulse of current applied thereto has transpired and will open its contacts during the second "off" period after the last full pulse of current that was applied thereto has flowed. This latter feature of not opening the contact until the second "off" period after the last full pulse flows in its winding is necessary in order for the relay to remain in its energized condition between successive pulses of the pulsating current. That is, to avoid chattering of the relay. In accordance wtih one form of the present invention, it is proposed to employ a spring for biasing the armature of the relay to its normal inactive position and in accordance with another form of the present invention it is proposed to employ magnetic flux from a permanent magnet to bias such armature to its normal inactive position. It is also proposed to employ a hold-down feature which in one form is provided by the permanent magnet and in another form is provided by a hold-down magnetic circuit of restricted cross-section. Another feature of the present invention resides in the provision of a sustaining means for delaying the operation of the relay back to its normal inactive position for a predetermined time after deenergization thereof in order to prevent dropping of the relay between successive impulses of the pulsating current applied to its control winding and also to cause it to drop away during an "off" period of the pulsating current.

Other objects, purposes, and characteristic features of the present invention will appear as the description thereof progresses in the light of the accompanying drawing in which:

Fig. 1 illustrates one embodiment of the present invention;

Fig. 2 shows a modified form of the present invention; and

Fig. 3 shows graphically a time chart for illustrating the functioning and time characteristics of the code applying relays shown in Figs. 1 and 2.

Referring to Fig. 1, it will be seen that the track rails 100 of a railway system have been shown divided into blocks by insulating joints 101 of which a single block N only has been illustrated. At the entrance end to this block is provided a signal S for governing traffic from left to right into the block in the normal direction of traffic as indicated by the arrow 102. This signal S is preferably controlled through the medium of decoding apparatus 103, which is con-

trolled by a code following track relay TR, located at the entrance end of such block N and controlled in accordance with coded current in the track rails. The signal S may be of any suitable construction but, as shown, is preferably a multiple aspect light signal having light projecting units G, Y and R for transmitting green, yellow and red light beams signifying clear, caution and danger, respectively. At the exit end of this block N is preferably provided code applying apparatus including a code repeater relay CP to which codes of current are applied in accordance with traffic conditions in advance of the block and this code repeater relay through the medium of its front contact 105 controls a special code repeater relay CPR through the medium of pulsating current. This special code repeater relay CPR is constructed to close and open its contacts during the "off" periods between current impulses irrespective of the time its control circuit is closed or opened. This pulsating current is preferably derived through a rectifier r from alternating current supplied by a transformer T, and a relay of this construction is employed in order to avoid sparking at the contacts of the relay when the track circuit is made and broken respectively.

In accordance with the invention illustrated in Fig. 1 this special code repeater relay CPR is of rather special construction and consists of a three-legged core C of the general shape illustrated of which one outside leg L^1 is of reduced cross section as compared with the other two legs L^2 and L^3. This construction is resorted to in order to cause this one leg L^1 to become saturated long before the current in the winding W contained on the middle leg L^2 reaches its maximum. The other outside leg L^3 which is of much larger cross sectional area will allow the magnetism therethrough to build up much faster and to a much higher value as a result of which the magnetic pull produced by leg L^3 eventually exceeds that of the magnetic pull produced by leg L^1 and movement of the armature A is started. For each increment of movement of the armature A flux shifts from the leg L^1 to leg L^3 and this shift of flux causes very fast and snappy movement of the armature A to its actuated position as indicated at 110 (see Fig. 3), that is, makes the relay snap acting toward the actuated position. This excess of magnetic flux passing through the legs L^2 and L^3 over that existing in the magnetic circuit including legs L^1 and L^2 does not occur unless substantially a full wave of pulsating current has passed through the winding W contained on the middle leg L^2 of the relay CPR. A partial pulse of the pulsating current will, therefore, not start movement of the armature. The armature has secured thereto but insulated therefrom a contact B by insulators 106. This contact B is included in series with the track circuit for the block N and when closed allows pulsating current rectified by the rectifier r and derived from the secondary winding of the transformer T to flow. The primary winding of this transformer is connected to a source of alternating current A. C. of commercial or special frequency herein assumed to be 60 cycles per second.

Since the winding W when energized is energized by pulsating current wherein the current pulses are separated by substantial periods of deenergization, conveniently called "off" periods, suitable means must be provided to delay the starting of the movement of the armature A toward its retracted position. This is necessary in order to prevent chattering of the armature or opening of the contacts B between pulses of the pulsating current. To provide this hold-over feature to hold the armature against the leg L^3 of the core C during the "off" period of the pulsating current a slug or bucking coil H has been provided on the leg L^3. This bucking coil may constitute a single short circuited turn of copper but preferably constitutes a coil of insulated copper wire short circuited through a rectifier $r1$ so poled that current induced therein by an increase of flux from the winding W will be blocked by the rectifier but current induced therein due to a reduction in this flux is free to flow. In other words, the bucking coil acts to allow the free build-up of flux but counteracts the dropping of flux and retards the dropping of the armature A. That is, the bucking coil H does not in any way delay the operation of the armature toward its actuated position but does delay the dropping of the armature. The extent to which this bucking coil H delays the dropping of the armature A can, of course, be varied by changing the internal resistance of the rectifier $r1$ or by changing the relation of the number of turns in the coil H as compared with the ohmic resistance of this coil. Since the magnetism in the airgap between armature A and leg L^3 changes rather rapidly as the armature starts to move, this armature is caused to move to its normal non-actuated position very quickly when movement is once started as indicated at 111 (see Fig. 3). By comparing the widths of rackets 110 and 111 of Fig. 3, it is readily seen that the armature A moves to its actuated position in substantially half the time required for it to return to its non-actuated position.

Stating it briefly the relay CPR is of a construction so that the application of current to the relay winding will not start movement of the armature until saturation or substantial saturation of the reduced section leg L^1 of the core C has taken place. When movement of the armature once starts it moves very quickly and is not delayed at all by the presence of the bucking coil H on leg L^3 because the rectifier $r1$ prevents the flow of any bucking current therein when the flux in leg L^3 is increased. The lag in the flux behind the voltage by reason of the inductance of coil W and the hold-down armature function of the relay performed by the magnetic path through leg L^1 is sufficient to cause the armature to be operated to its actuated position during the first "off" period following a full "on" pulse of such pulsating current. In this connection it should be understood that if the circuit to the relay winding is closed later than the beginning of a current pulse to any appreciable extent the current and magnetism will not rise to the critical value where movement of the armature starts in which event the effect of the entire current pulse will be lost.

The bucking coil H is provided to delay the dropping of the relay to an extent so as not to drop between successive full pulses of the pulsating current and to prevent chattering of the armature of the relay. To obtain these results the earliest dropping of the armature that could occur if the relay energizing circuit is opened at the end of a current pulse, or in fact anywhere in an "off" period of the current, would be near the end of the next current pulse time. Therefore, this retarding effect to delay dropping of the armature has been made still a little more pronounced so that the dropping of the armature

will occur near the end of the second "off" period. By this construction the armature will drop in the second "off" period even though the last impulse was not quite a full impulse.

Operation Fig. 1.—Let us assume that the coding contact **105** of the relay CP is intermittently closed at the rate of either 75 or 180 times per minute, the periods of "on" and "off," that is periods of closed and open contact, being substantially the same. Referring now to Fig. 3 where the pulses of the pulsating current have been shown by solid lines above the dotted line X—Y whereas the portions of the alternating current blocked out by the rectifier *r* of Fig. 1 or Fig. 2 have been shown by dotted half-waves below this dotted line X—Y. The alternating current source A. C. is presumed to deliver 60 cycle current so that the distance between adjacent vertical lines on the dotted line X—Y represents one-six hundredth of a second which for convenience will be called one "increment" of time throughout this specification.

Let us now assume that the contact **105** closes anywhere between the 12th and 22nd line, namely between the end of the 12th increment and the end of the 22nd increment, that is anywhere in the time embraced by the bracket **114**. Even though the contact **105** closed as early as the end of the 12th increment an insufficient portion of the pulse of the current will flow to reach the critical point where movement of the armature starts and this current pulse **116** will therefore be ineffective. If the contact **105** closes anywhere between the end of the 12th increment and the end of the 21st increment the current pulse **116** is ineffective whereas the current pulse **117** is effective. The time at which the magnetism is fully built up to its actuating value in leg L^3 for the pulse **117** will of course vary a little depending upon at what time between points **12** and **21** the contact **105** was closed but this discrepancy, since it is small, will be disregarded. We may therefore assume that irrespective of where contact **105** is closed between the increment **12** and the end of increment **21** the armature A will start to move at approximately the same point in the time chart. If we assume that the delay due to current and flux lag is fairly represented by the time indicated by bracket **113**, a fair assumption, then the armature A starts to move at approximately the end of the 25th increment of time and the contact B closes approximately at the end of the 26th increment of time, the 26th increment of time being consumed by the actual movement of the armature. It is thus seen that the contact B closes during the "off" period of the pulsating current irrespective of in what part of the pulsating current cycle the coding contact **105** is closed.

Referring again to Fig. 3 the right-hand portion of the time chart shown therein shows how the contact B is caused to open during the "off" period of the pulsating current irrespective of the time of opening of the contact **105** of relay CP with respect to the cycles of the pulsating current. If the contact **105** is opened anywhere between the ends of the 42nd and 52nd increment (see bracket **122**) the effect of the opening is about the same because the pulse **119** will be fully effective whereas the pulse **120** will, at best, be substantially ineffective. If the contact **105** is opened to break the energizing circuit for the winding W of the relay CPR at any time in the 43rd, 44th or 45th increment the current will in each instant fall from the maximum value and the effect irrespective of the actual time of opening of the contact B will be substantially the same. If the contact **105** is opened anywhere between the end of the 45th increment and the end of the 50th increment the effect is substantially the same because substantially no current is flowing at this time. If the contact **105** is opened during either the 51st or the 52nd increment the effect of the 120th pulse is substantially nil. Summarizing these considerations the opening of contact **105** anywhere between the end of the 42nd increment and the end of the 52nd increment will render the pulse **119** effective and render the pulse **120** ineffective so that the period of lag imposed due to the sustaining coil H will begin and end substantially at the points indicated by bracket **123**. The dropping of the armature A and the opening of its contacts B is less snappy than the lifting of this armature and the closing of its contacts, and assuming its speed of movement to be half as fast for opening of the contact B as compared with its closing, two increments of time as indicated by bracket **111** (see Fig. 3) will be consumed during the opening of contact B as compared with closing operating time of one increment as indicated by bracket **110**. If the contact **105** opens at the end of increment **45** as compared with the end of increment **42** the sustaining time effected by coil H will start and end later, that is the bracket **123** will be shifted slightly toward the right and this will shift the actual time of opening of contact B more nearly to the middle of the "off" period existing between pulses **120** and **121**.

It is thus seen that in response to both closing and opening of contact **105** and irrespective of the time of such closing and opening of this contact **105** with respect to pulses of the pulsating current the relay CPR will respond thereto after a period of delay such that the contact B will both close and open during an "off" period of such pulsating current. Also, that the closing of the contact B will occur during the first "off" period after the first fully effective wave of pulsating current and this contact B will open during the second "off" period after the last fully effective wave of such pulsating current.

Fig. 2 structure.—The structure of Fig. 2 differs from that of Fig. 1 by the employment of a permanent magnet PM for performing the function of both the spring **104** and the restricted leg L^1, in the placing of the energizing winding W1 on the right-hand leg L^3 instead of the middle leg L^2 and in the placing of the bucking coil H1 and its rectifier *r*2 on the middle leg instead of the right-hand leg. For this reason like parts of Fig. 2 have been designated by the reference characters as corresponding parts in Fig. 1.

Operation of Fig. 2.—In this Fig. 2 structure the permanent magnet PM produces an armature hold-down effect temporarily at least preventing operation of the armature A to its actuated position. This effect must be overcome by a dominating electro-magnetic force, that is, the winding W1 is poled, as shown by the arrow, so that it will not demagnetize the permanent magnet PM but will if anything strengthen its holding effect. When, however, the pull produced by the leg L^3 overpowers that of the pull produced by the permanent magnet PM the armature will, by very fast or snap action, be operated to its actuated position. It will be observed that the building up of electro-magnetic flux by the winding W1, which has its north pole N at the bottom, will cause the magnetism in the middle leg to first be bucked out and then to be reversed. This

bucking down and reversal of the magnetism in the middle leg will not be opposed or retarded by the bucking coil H1 by reason of the blocking action of the rectifier r2 included in series therewith. This winding W1 also does not oppose the permanent magnet PM because this winding W1 and permanent magnet PM are poled in the same direction in the magnetic circuit in which they are magnetically included in series.

Upon opening of contact 105 of the Fig. 2 structure and the deenergization of the winding W1 of the relay CPR1 the delay in the dropping of the armature A1 by the sustaining coil and its rectifier r2 is substantially the same as that of relay CPR of Fig. 1 so that the timing chart shown in Fig. 3 applies equally as well to Fig. 2 as it does to Fig. 1. In other words, the functioning of the two relays CPR and CPR1 is substantially the same for both the picking up and the dropping of these relays and the description of the operation of relay CPR of Fig. 1 given by referring to the time chart of Fig. 3 applies equally as well to the relay CPR1 shown in Fig. 2.

Having thus illustrated and described two embodiments of the present invention, it should be understood that these embodiments have been selected to disclose the nature of the invention, the functions performed thereby and how the invention may be applied in practicing the same and it should also be understood that various changes, modifications and additions may be made in practicing the inventions without departing from the spirit and scope of the invention except as demanded by the scope of the following claims.

What we claim as new is:

1. In a relay controlled by a circuit and controlling another circuit to at times energize it by pulsating unidirectional current, the combinations with a three-legged core, biasing means, an armature biased by said biasing means to bridge one pair of the three legs of said core, an energizing winding on one of the legs of another pair of the three legs of said core to act on said armature to an extent to overcome said bias only after a pulse of said current in said winding has almost reached its maximum value and to thereby actuate said armature to its actuated position during the first "off" period after such pulse of said pulsating current, a closed circuit linking the magnetic path through said another pair of said three legs, and a rectifier in said circuit poled for delaying the operation of said armature toward its biased position until after the second "off" period following the last full pulse of pulsating current applied to said winding, whereby said relay is operated in both directions during an "off" period of said pulsating current and is held in its energized position during an "off" period between two successive pulses of pulsating current applied to said winding.

2. In combination; a pulsating current source; a circuit; and a relay controlled by pulsating current from said source for controlling the flow of current in said circuit from said source comprising, a three-legged core, biasing means, an armature biased by said biasing means to bridge one pair of the three legs of said core, an energizing winding located to produce magnetism in another pair of the three legs of said core so as to act on said armature to an extent to overcome said bias only after a pulse of current from said source in said winding has almost reached its maximum value and to thereby actuate said armature to its actuated position during the first "off" period following said pulse of said pulsating current, a closed circuit linking the magnetic path through said another pair of legs of said three-legged core, and a rectifier in said circuit poled so as to delay the operation of said armature toward its biased position until after the second "off" period following the last full pulse of pulsating current applied to said winding, whereby said relay is operated in both directions during an "off" period of said pulsating current and is held in its energized position during an "off" period between two successive pulses of energizing current applied to said winding.

3. In combination; a pulsating current source; a circuit; and a relay controlled by pulsating current from said source for controlling the flow of current from said source in said circuit comprising, a three-legged core, biasing means, an armature biased by said biasing means to bridge one pair of the three legs of said core, an energizing winding located to produce magnetism in a magnetic circuit including another pair of the three legs of said core so as to act on said armature to an extent to overcome said bias only after a pulse of current from said source flowing in said winding has almost reached its maximum value, and means to further delay the movement of said armature toward its actuated position to an extent to actuate said armature to its actuated position during the first "off" period following said pulse of said pulsating current and to also delay its movement toward its biased position so as not to drop during the "off" period between two successive pulses of said current whereby said relay is operated to its actuated position during an "off" period of said pulsating current and is held in its energized position during an "off" period between two successive pulses of energizing current applied to said winding.

4. In a relay controlled by one circuit and controlling another circuit to at times energize it by pulsating unidirectional current, the combination with a three-legged core, biasing means, an armature biased by said biasing means to bridge one pair of the three legs of said core, an energizing winding located so as to produce magnetism in another pair of the three legs of said core to act on said armature to an extent to overcome said bias only after a pulse of said current flowing in said winding has almost reached its maximum value and to thereby actuate said armature to its actuated position during the first "off" period after such pulse of said pulsating current, a closed circuit linking the magnetic path including said another pair of said three legs poled for delaying the decay of magnetic flux and the operation of said armature toward its biased position to an extent so as not to allow the armature to drop away between two successive pulses of said current applied to said winding, whereby said relay is operated to its actuated position during an "off" period of said alternating current and is held in its energized position during an "off" period between two successive pulses of energizing current applied to said winding.

5. In a relay, the combination with a three-legged core including a middle leg, an armature pivoted adjacent the middle leg of said core so as to close a magnetic path through said middle leg and one or the other of the remaining legs as said armature assumes its deenergized and its energized position respectively, means for biasing said armature toward said one leg, a winding located so that when energized it produces magnetic flux through said middle leg and said other leg of said core, a closed circuit linking the mag-

netic path including said middle and said other leg, and a rectifier in said linking circuit so poled as to retard the decay of flux originally produced by said winding.

6. In a relay, the combination with a three-legged core having its legs arranged in a row, an armature pivoted adjacent the middle leg of said core so as to close a magnetic path through said middle leg and one or the other of the remaining legs as said armature assumes its deenergized and its energized position respectively, means for biasing said armature toward said one leg to cause a predetermined retardation in the operation of said armature toward said other leg, a winding so located on said core that when energized it produces magnetic flux through said middle leg and said other leg of said core, a closed circuit of low resistance linking the magnetic path including said middle and said other leg, and a rectifier in series in said closed circuit so poled that current induced in said circuit by decreasing flux originally produced by unidirectional current in said winding is permitted to flow freely, the said closed circuit having a resistance to cause a predetermined retardation in the operation of said armature back toward said one leg.

7. In a relay, the combination with a three-legged core of which the middle leg and one of the outside legs are of large cross-sectional area and said other leg is of small cross-sectional area, an armature pivoted adjacent said middle leg which in its actuated and non-actuated positions engages said one leg and said other leg respectively, means for biasing said armature toward said other leg, a control winding on said middle leg, and a retarding winding on said one leg.

8. In a relay, the combination with a three-legged core of which the middle leg and one of the outside legs are of large cross-sectional area and said other leg is of small cross-sectional area, an armature pivoted adjacent said middle leg which in its actuated and non-actuated positions engages said one leg and said other leg respectively, means for biasing said armature toward said other leg, a winding on said middle leg, and a closed circuit linking said one leg, and a rectifier in said circuit poled to retard the decay of flux originally produced by said winding.

9. In a relay, the combination with a three-legged core of which the legs are parallel and arranged in a row, an armature pivoted adjacent said middle leg which in its actuated and non-actuated positions engages one outside leg and the other outside leg respectively, means for biasing said armature toward said other leg, a winding on said middle leg, a closed circuit of low resistance linking said one leg, and a rectifier in said closed circuit so poled as to allow current due to falling flux to flow when said winding is deenergized after having been energized by current of a particular polarity.

10. In a relay, the combination of a three-legged core in which the legs are parallel and arranged in a row and of which one outside leg constitutes a permanent magnet and the other two legs and the back yoke are constructed of soft iron, an armature pivoted near its middle and adjacent the middle leg and biased by magnetism derived from said permanent magnet toward said permanent magnet, a winding on the other of said outside legs, a closed circuit of low resistance linking said middle leg, and a rectifier in said circuit poled to delay the decay of magnetic flux produced by said winding.

11. In a relay, the combination of a three-legged core in which the legs are parallel and arranged in spaced relation in a row and of which one outside leg constitutes a permanent magnet and the other two legs and the back yoke are constructed of soft iron, an armature pivoted near its middle and adjacent the middle leg and biased by a magnetic field emitted from said permanent magnet and toward said permanent magnet, a winding on the other of said outside legs at times energized by current of a particular polarity, a closed circuit of low resistance linking said middle leg, and a rectifier in said closed circuit of low resistance poled to delay the decay of flux in said other outside leg originally produced by said current.

12. In a relay, the combination of a three-legged core in which the legs are parallel and arranged in spaced relation in a row and of which one outside leg constitutes a permanent magnet and the other two legs and the back yoke are constructed of soft iron, an armature pivoted near its middle and adjacent the middle leg and biased by magnetism derived from said permanent magnet toward said permanent magnet, a winding on the other of said outside legs, a closed circuit of low resistance linking said middle leg, and a rectifier in said closed circuit of low resistance so poled that current induced in said closed circuit due to rising flux from said permanent magnet is free to flow.

13. A relay for controlling a circuit at times energized by uni-directional pulsating current and controlled by uni-directional pulsating current from the same source, the combination with a three-legged stationary core and a movable armature pivotally connected to the middle leg and magnetically bridging the middle and one and the other of the outside legs as the armature is moved to its normal and its actuated position respectively, means including a winding on the magnetic circuit including said middle and said other outside leg for actuating said armature toward its actuated position in response to current from said source, means for biasing said armature toward its normal position to an extent to allow it to assume its actuated position during an "off" period of said uni-directional pulsating current source irrespective of the time of closure of the energizing circuit including said winding and said source with respect to the pulses of said pulsating current source, and means for retarding the movement of said armature toward its non-actuated position upon deenergization of said winding including a circuit linking the said magnetic circuit and including a rectifier so poled as to retard the decay of flux originally produced by said winding so as to allow the armature to be returned to its non-actuated position during an "off" period of said uni-directional pulsating current irrespective of the time of opening of the energizing circuit for said winding with respect to the pulses of said pulsating current source.

14. In a coder; the combination with a source of uni-directional pulsating current; a coding contact; a code repeater relay comprising, a magnetic structure having a magnetic circuit, an armature in said magnetic circuit, biasing means for biasing said armature to its deenergized position, a winding on said magnetic structure and controlled from said source and through the medium of said coding contact, and a normally open front contact for applying current from said source to a circuit to be coded; said code repeating relay including means for delaying the oper-

ation of said armature and the closing of its associated front contact until during the first "off" period following the first "on" period of said pulsating current source comprising, an armature hold-down magnet including a magnetic circuit receiving its magnetism from said winding and acting on said armature in the same direction as said biasing means, which latter magnetic circuit has a limiting flux carrying capacity such that its effect becomes sub-ordinate to the full effect of the first mentioned magnetic circuit including said armature to thereby cause such delaying action; whereby said front contact is always closed during an "off" period of said unidirectional pulsating current source.

15. In a coder, the combination with a source of pulsating current, a coding contact, a core of magnetic material having two magnetic paths, an armature so associated with said core that magnetism in one magnetic path tends to operate said armature to one position and magnetism in the other magnetic path tends to operate said armature to the other position, biasing means tending to operate said armature to the other position, a winding on said core for producing magnetism in both of said magnetic circuits, a circuit for said winding including said source of pulsating current and said coding contact, and a contact operated by said armature and closed when said armature assumes said one position for applying current from said source to the circuit to be coded, said other magnetic path having a reluctance and saturation point such that substantially a whole current pulse is required to operate said armature and so that operation of the armature and closing of its contact is delayed until during the first "off" period following the first "on" period of said pulsating current applied to said winding, whereby said contact is always closed during an "off" period of said pulsating current source.

16. In a coder, the combination with a source of pulsating current, a coding contact, a core of magnetic material having two magnetic paths, an armature so associated with said core that magnetism in one magnetic path tends to operate said armature to one position and magnetism in the other magnetic path tends to operate said armature to the other position, biasing means tending to operate said armature to the other position, a winding on said core for changing the magnetism in both of said magnetic circuits, a circuit for said winding including said source of pulsating current and said coding contact, and a contact operated by said armature and closed when said armature assumes said one position for applying current from said source to the circuit to be coded, said other magnetic path including a permanent magnet of a strength such that substantially a whole current pulse is required to operate said armature and so that operation of the armature and closing of its contact is delayed until during the first "off" period following the first "on" period of said pulsating current applied to said winding, whereby said contact is always closed during an "off" period of said pulsating current source.

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