

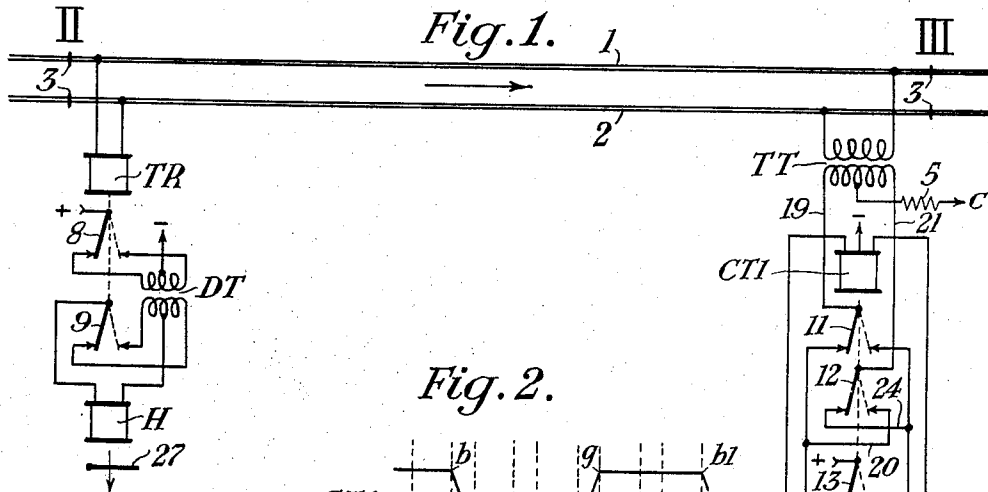
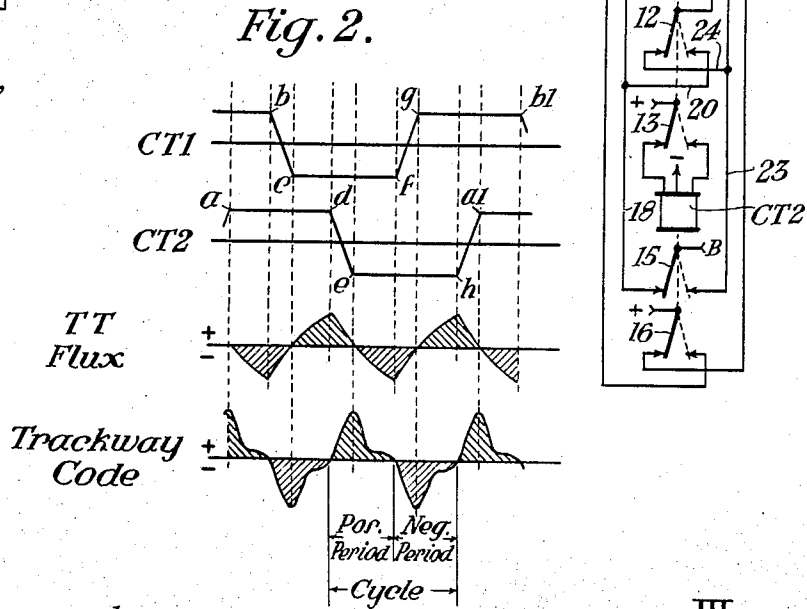
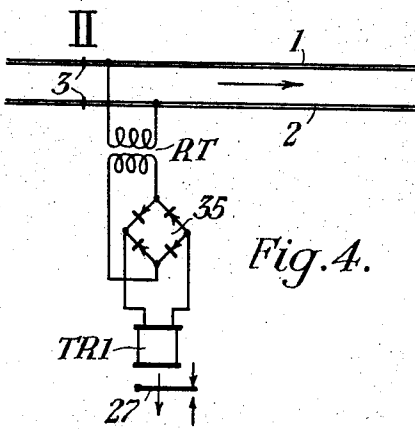
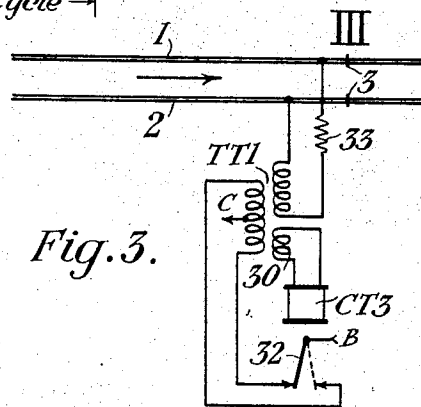
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CODED TRACK CIRCUITS FOR RAILWAY TRAIN DETECTION

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CODED TRACK CIRCUIT FOR RAILWAY
TRAIN DETECTION

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My invention relates to coded track circuits for detecting the presence of railway trains and it has special reference to the employment by such track circuits of coded energy pulses that have positive and negative polarities in alternating sequence and that are of relatively short individual duration.

Generally stated, the object of my invention is to improve the design and broaden the utility of coded track circuits of the "polar impulse" type just described.

A more specific object is to provide improved energy supply facilities for polar impulse track circuits of the "single code" type.

Another object is to derive the polar impulse energy from non-track battery sources and to supply the pulses of that energy at code frequencies which are much higher than those of customary direct current codes.

A further object is to provide code generating facilities which are of new and simplified character and which incorporate self-starting and other desirable features.

In practicing my invention I attain the above and other objects and advantages by deriving the trackway energy from a direct current source of twelve volt or other conventional control potential; by interposing an impulse transformer between this source and the track rails; and by providing code generating apparatus which causes this transformer to receive from the source relatively short pulses of exciting current that recur several times each second and that have positive and negative polarities in alternating sequence.

I shall describe representative forms of "polar impulse" coded track circuits which embody my invention and shall then point out the novel features thereof in claims. These illustrative embodiments are disclosed by the accompanying drawing in which:

Fig. 1 is a diagrammatic representation of a "single code" track circuit that incorporates the improvements of my invention and that is of the "detection only" type;

Fig. 2 shows the "Trackway code" for the circuit of Fig. 1 and indicates the manner in which that code is produced;

Fig. 3 illustrates a modified form of code generating apparatus which may be employed at the exit end of the Fig. 1 track section; and

Fig. 4 shows a modified form of code detecting apparatus which may be employed at the entrance end of the Fig. 1 track section.

In the several views of the drawing, like reference characters designate corresponding parts. Referring first to Fig. 1, characters 1 and 2 designate the conductors of a control circuit which normally is capable of transmitting energy between its two ends but which at times is ren-

dered incapable of such transmission. As shown in Fig. 1, these control circuit conductors take the form of the two rails of a section of railway track II—III which is separated from adjoining sections by the customary insulated joints 3 and through which it will be assumed that traffic moves in the single direction indicated by the arrow. Such movement, of course, makes location II the section entrance end and location III the section exit end.

At this exit end III there is provided an impulse transformer TT having an output winding that is continuously connected with the section rails and an input winding that has one center and two end terminals; a source of direct current exciting energy for this transformer which has first and second terminals B and C and which may take the form of a twelve volt control battery (not shown) or the like; an impedance 5 which continuously connects source terminal C with the center terminal of transformer TT's input winding; and coder relays CT1 and CT2 which repeatedly connect source terminal B first with one and then with the other of that input winding's two end terminals and which thereby cause the transformer TT to supply the section rails with recurring pulses of output potential that have positive and negative polarities in alternating sequence.

At the section entrance end II there is provided a track relay TR of the code following type which has its winding connected across the rails and which holds contacts 8—9 to the left during each positive polarity pulse of winding received energy and to the right during each negative pulse of received energy; a decoding transformer DT which receives primary current under the control of the pole changing contact 8 of the track relay; and a code detecting relay H which is of the direct current delayed release type and which is energized from the decoding transformer secondary over a rectifying contact 9 of the track relay.

Two-relay coder apparatus of Fig. 1

The exit end or location III apparatus just described for the Fig. 1 track section will first be examined in greater detail. Each of the coder relays CT1 and CT2 is of the magnetically toggled code following type having a delayed response of the short character later described. Looking at device CT1, when the left portion of its winding is energized the relay holds it contacts 11—12—13 in the left or "normal" position; when, however, the right portion of the relay winding is energized contacts 11—12—13 then are shifted to the right or "reverse" position.

Once, moreover, either of these positions is established, the contacts there remain continuously until the relay winding is energized in the

opposing direction. Relay CT2 performs in exactly the same manner. When the left portion of its winding is energized it holds contacts 15—16 in the left or "normal" position; when, however, the right portion of the relay winding is energized these contacts 15—16 are shifted to the right or "reverse" position.

In the illustrative organization shown, current for operating the first coder relay CT1 is supplied over contact 16 of the companion relay CT2 while the current for operating that companion coder device CT2 is supplied over contact 13 of the first coder relay CT1. As will be seen: (1) relay CT2's energizing circuits cause CT2's contacts 15—16 to go to their left or normal position following each normal positioning of relay CT1's control contact 13 and to their right or reversed position following each reverse positioning of that control contact; and (2) relay CT1's energizing circuits cause CT1's contacts 11—12—13 to go to their right or reversed position following each normal positioning of CT2's control contact 16 and to their left or normal position following each reversed positioning of that control contact.

By these uniquely arranged energizing circuits, the two coder relays CT1 and CT2 are caused repeatedly to shift the positioning of their contacts in the cyclic manner which Fig. 2 represents. In the diagram of that figure, the elevated portions of the "CT1" pattern designate a "normal" or left closure of contacts 11—12—13, while the depressed portions of that pattern designate a "reverse" or right closure of the same contacts. Similarly, the elevated portions of the "CT2" pattern designate a "normal" or left closure of contacts 15—16, while the depressed portions of the pattern designate a "reverse" or right closure of the same contacts.

From this Fig. 2 diagram, it will be seen that: (1) if the contacts of coding device CT2 reach their left or normal position at point *a*, then the contacts of device CT1 will begin movement from their normal to their reverse position at the later point *b*; (2) if relay CT1's contacts reach their right or reversed position at point *c*, then relay CT2's contacts will begin movement from their normal to their reverse position at the later point *d*; (3) if CT2's contacts reach their right or reversed position at point *e*, then CT1's contacts will begin movement from their reverse to their normal positions at the later point *f*; (4) if those CT1 contacts reach their normal position at point *g*, then the CT2 contacts will begin movement from their reverse to their normal positions at point *h*; and (5) if the CT2 contacts again reach their normal position at point *a*, then the CT1 contacts will start to move from their normal to their reverse position at the later point *b*.

The just stated periods *a—b*, *c—d*, *e—f*, *g—h* and *a—b* of contact position overlap result from the earlier mentioned delayed response characteristics of the two coder relay CT1 and CT2. As long as proper potential continues to be applied to the operating circuit terminals "plus" and "minus" the sequence of actions diagrammed by Fig. 2 continues to repeat itself on the four period basis already indicated. The various time intervals in the sequence are, of course, dependent upon the response speeds of coder devices CT1—CT2.

For reasons to be made clear presently, it is preferable to arrange that these periods *a—b*, *c—d*, *e—f* and *g—h* of contact register recur at the rate of several times each second.

In the complete organization of Fig. 1, each one of those four periods defines the completion of a circuit through which the input winding of impulse transformer TT is supplied with a pulse of exciting current from direct current source B—C. The first of these circuits extends from source terminal B through normal contact 15 of device CT2, conductor 18, normal contact 11 of device CT1, conductor 19, the left half of transformer TT's input winding, and impedance 5 back to source terminal C. By it, transformer TT receives positive polarity exciting energy for the time interval *a—b* of Fig. 2.

The second exciting circuit for the transformer extends from source terminal B through normal contact 15 of device CT2, conductors 18 and 20, reverse contact 12 of device CT1, conductor 21, the right half of transformer TT's input winding and impedance 5 back to source terminal C. By this second circuit, the transformer receives negative polarity exciting current during the time interval *c—d* of Fig. 2.

The third exciting circuit for the transformer extends from source terminal B through reverse contact 15 of device CT2, conductor 23, reverse contact 11 of device CT1, conductor 19, the left half of transformer TT's input winding and impedance 5 back to source terminal C. By this third circuit, the transformer is supplied with positive polarity exciting current during time interval *e—f* of Fig. 2.

The fourth exciting circuit for transformer TT extends from source terminal B through reverse contact 15 of device CT2, conductors 23 and 24, normal contact 12 of device CT1, conductor 21, the right half of the transformer input winding and impedance 5 back to source terminal C. By that fourth circuit, the transformer is supplied with negative polarity exciting current during time interval *g—h* of Fig. 2.

Through their earlier described cyclic operations, therefore, the two coder relays CT1 and CT2 thus cause the impulse transformer TT to be supplied with recurring pulses of exciting current which have positive and negative polarities in alternating sequence and which produce in the transformer core magnetic fluxes having the general character designated by the "TT flux" portion of Fig. 2. The alternate reversals of flux polarity are, of course, effected by the relatively reversed directions of current flow through the left and right halves of the transformer input winding.

By those recurrently reversing core fluxes there is generated in the output winding of transformer TT a secondary potential having the general character indicated by the "Trackway code" portion of Fig. 2. As that figure shows, this trackway potential is alternating in polarity; it takes the form of positive and negative voltage pulses which follow one another in regularly recurring sequence; each of those pulses has a high "peak" or impulse value; and each pair of pulses constitutes a code cycle consisting of a positive period followed by a negative period.

Preferably, these "polar impulse" cycles recur at a code frequency which is much higher than that of customary direct current codes. Typically such customary codes have an upper limit of the order of 180 cycles per minute, or three cycles per second. In the "polar impulse" code of Figs. 1 and 2, frequencies of the order of six or more cycles per second are to be preferred and such are readily obtainable by means of coder relays

arranged in the novel manner shown at CT1—CT2 in Fig. 1.

Looking next at the entrance end or location II apparatus earlier described for the Fig. 1 track section, it will first of all be observed that track relay TR also is a code following device of the magnetically toggled or "polar stick" type. Such a relay is capable of transferring its contacts from one position to the other rather rapidly and in response to only a short application of winding energy. A positive polarity pulse of the short character indicated in Fig. 2 is therefore effective to shift the track relay contacts 8—9 to their normal or left position while a negative polarity pulse of correspondingly short duration is effective to shift the contacts to their right or reversed position.

Operation of the track relay is, therefore, exactly the same as were each of the positive pulses to be prolonged for the full duration of the "positive" code period and each of the negative pulses to be prolonged for the full duration of the "negative" code period. Even with code frequencies of the elevated order of six or more cycles per second such desired operation of the track relay continues to be achieved.

As earlier indicated, the track relay TR controls a code detector relay H in such manner that the latter relay holds its contact 27 picked up when and only when the track relay is following code. In the preferred arrangement shown, pick-up current is transmitted to the winding of relay H from control source terminals "plus" and "minus" and through decoding transformer DT. Contact 8 of relay TR serves to pole change the transformer exciting energy while contact 9 of the track relay mechanically rectifies the resulting transformer output in a manner which is disclosed and claimed by Frank E. Nicholson et al. Patent No. 2,237,788 issued April 8, 1941.

As long as the track relay TR receives recurring pulses of positive and negative polarity trackway energy and shifts contacts 8—9 between their normal and reverse positions in step with those pulses, this code detector relay H receives the code frequency pulses of unidirectional current which hold contact 27 continuously picked up. In the event, however, that contacts 8—9 stay in one position continuously, no secondary voltage is generated by transformer TT and relay H then is allowed to release contact 27.

From the foregoing description of the apparatus at exit and entrance locations III and II, the functioning of the complete "polar impulse" track circuit combination of Fig. 1 will have become apparent. Coder relays CT1 and CT2 operate continuously and cause exit end elements B—C and TT to supply the section rails with trackway energy having the "polar impulse" character represented by the lower portion of Fig. 2. Under vacant conditions of the section this energy is transmitted to entrance end track relay TR.

In responding, that relay repeatedly shifts contacts 8—9 between their normal and reverse positions and thereby causes code detecting relay H to hold contact 27 continuously picked up. This picked up condition persists, quite obviously, as long as track section II—III remains vacant. Entry of a train into the section by-passes rails 1—2 in the usual manner and thereby cuts off all energy reception by relay TR. Such cut-off causes contacts 8—9 to remain continuously in the position to which they were last energized

and thereby deenergizes code detecting relay H. As a result of that deenergization, contact 27 now releases.

As the train passes out of section II—III, transmission of the "polar impulse" energy through entrance end track relay TR is once more resumed, contacts 8—9 thereof again follow code, transformer DT once more supplies energizing current to the winding of relay H, and contact 18 of that relay again picks up.

Any suitable use of the code detector relay's contact 27 may, of course, be made and because of the diversity of such possible uses there has been no attempt to represent any particular one of them. Typically, however, they will be of the "detection only" variety wherein relay H performs the single function of distinguishing between vacant and occupied conditions of the associated track section. Such a function is, of course, required in many signaling system applications of commercially well-known character.

Single-relay coder apparatus of Fig. 3

Referring to Fig. 3, I have there shown an alternative arrangement for generating "polar impulse" code of the general character indicated by Fig. 2. In this arrangement only one polarized code following relay is used at the exit location III and it is shown in the form of a device CT3.

In these modified exit end facilities of Fig. 3, use is made of an impulse transformer TT1 which corresponds to device TT of Fig. 1 but which differs therefrom in being equipped with a second output winding 39 by which operating energy is supplied to relay CT3. That relay is provided with a single contact 32 over which direct current source B—C supplies exciting current to the input winding of transformer TT1.

When contact 32 occupies the left or "normal" position shown, the flow of exciting current is upwardly through the lower half of the transformer primary and the effect of a negative exciting pulse (see the "Flux" diagram of Fig. 2) is had. When, however, contact 32 is in the right or "reverse" position, the flow of exciting current is downwardly through the upper half of the transformer primary and the effect of a positive pulse of exciting current (again see Fig. 2) then is had.

Interposed between the main output winding of transformer TT1 and the track rails is a current limiting impedance 33 which performs the same function as does element 5 of the Fig. 1 combination, but which permits the generation of substantially full transformer output voltage even during shunted conditions of the supplied track rails 1—2.

The single coder relay CT3 of Fig. 3 has response characteristics which are generally similar to those earlier described for devices CT1—CH2 of Fig. 1. That is, flow of energizing current through the relay winding in the direction of from left to right causes contact 32 to go to the left or "normal" position; likewise, flow of relay winding current in the opposite or right to left direction causes contact 32 to go to the right or "reverse" position. Like coder relay devices CT1—CT2, moreover, this relay CT3 is of the delayed responding type.

In the code generating combination of Fig. 3, it is responsive to each pulse of output voltage that results from each establishment of an exciting connection. In the particular organization

illustrated, relay CT3 thus is caused to shift contact 32 to the opposing position a short time following each such establishment.

Looking more closely at Fig. 3, assume that contact 32 has just moved to the illustrated normal position wherein negative polarity current is supplied to the primary of transformer TT1 and positive polarity potential is as a result of such application being generated in each of the transformer's two output windings. Such generation in winding 30 flows current from the right to the left through relay CT3 and thus causes contact 32 to shift to the right or reverse position.

As a result of this shift, positive polarity exciting current is applied to transformer TT1 and as a result of such application there is generated in winding 30 a potential which flows current through relay CT3 in the direction of from left to right. This flow causes contact 32 to shift back to the left or normal position.

The cycle just described now is repeated and in this manner relay CT3 is caused to repeatedly transfer contact 32 between the normal and the reverse positions.

By such transfer, transformer TT1 is caused to impress upon rails 1-2 coded trackway energy of the "polar impulse" character represented in Fig. 2. By choosing the response characteristics of relay CT3 the frequency of such code pulse application may, quite obviously, be selected within wide limits. Preferably, however, a frequency of the order of six or more cycles per second is to be desired.

Single-relay detector apparatus of Fig. 4

Entrance end code detecting facilities of the character represented at location II in Fig. 1 are usable with code generating apparatus not only of the two relay type shown at Fig. 1's location III but also of the single relay type which Fig. 3 illustrates. Such facilities utilize, as had been seen, a code following track relay TR of conventional "polar stick" character plus a code detecting relay H and an energizing transformer DT therefor.

In Fig. 4, I have represented a simplified form of code detecting equipment wherein only a single relay TR1 is utilized. This relay is a non-code following track device which receives energy from the rails through a relay transformer RT and a full wave rectifier 35. It has a contact 27 which performs the same function as does the similarly designated element of Fig. 1, and which has slow releasing characteristics.

Reception at Fig. 4's location II of "polar impulse" trackway energy, such as the code generating apparatus of either Fig. 1 or 3 produces, causes transformer RT and rectifier 35 to impress upon relay TR1 pulses of unidirectional energizing current which recur at code pulse frequency and which are effective to hold contact 27 continuously picked up.

Entry of a train into the section of which Fig. 4's location II marks the entrance cuts off all of these energy pulses and thereby allows contact 27 to release. As the train passes out of the section, transmission of the coded "polar impulse" energy through transformer RT is once more resumed and relay TR is caused again to pick up contact 27.

This Fig. 4 arrangement is best suited for use with code frequencies of comparatively high character, such as the six or more cycles per second earlier named. With such frequencies the release period for relay TR1's contact 27 may

be reduced sufficiently to provide a very quick shunting response.

Summary

The "polar impulse" coded track circuits herein shown are alternative to a "detector only" organization which is disclosed and claimed by my copending application Serial No. 412,624 filed on September 27, 1941, for "Coded track circuits for railway traffic control." For the track circuits of the present application, therefore, the same broad advantages may be claimed as are enumerated by my copending application just identified.

These broad advantages flow from the use of the "polar impulse" principle and include a lowering of power requirements, a raising of immunity to false operation by foreign currents, an elimination of operating difficulties due to "storage" energy persistence, a lowering of code distortion effect, and an improvement in shunting sensitivity.

In addition, the novel code generating apparatus of this application broadens the utility of coded track circuits of the "polar impulse" type by: (1) improving the design of energy supply facilities for "single code" track circuits; (2) deriving the "polar impulse" energy from non-track battery sources and supplying the pulses of that energy at code frequencies which are much higher than those of customary direct current codes and which approximate the characteristics of an alternating current track circuit; and (3) permitting all of the code generating devices to be of similar design.

In each of the organizations of Figs. 1 and 3, moreover, the code generating apparatus is inherently self-starting and automatically begins to function when energy of a proper character is impressed upon the terminals of its driving circuits.

From the foregoing it will accordingly be seen that the improved "polar impulse" coded track circuits of my invention are of broad utility and that their application is by no means restricted to the "detector only" forms which are herein shown by way of illustration.

Although I have herein shown and described only representative forms of coded track circuits embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In track circuit energy supply means, in combination, a transformer having an output winding that is adapted to be connected with the rails of a section of railway track and an input winding that is provided with one center and two end terminals, a source of direct current exciting energy for said transformer having first and second terminals, means for continuously connecting the second terminal of said direct current source with the center terminal of said transformer input winding, first and second coder relays each having contacts which occupy a normal position when and after the relay is energized in one direction and which occupy a reversed position when and after the relay is energized in the opposing direction, an energizing circuit for said second relay which is controlled by a contact of said first relay and which causes the second relay contacts to go to their normal

position following each normal positioning of the first relay contacts and to their reversed position following each reversed positioning of the first relay contacts, an energizing circuit for said first relay which is controlled by a contact of said second relay and which causes the first relay contacts to go to their reversed position following each normal positioning of the second relay contacts and to their normal position following each reversed positioning of the second relay contacts, and circuits including contacts of said first and second relays over which said first terminal of said direct current energy source is repeatedly connected first with one and then with the other of said two end terminals of said transformer input winding and by which said transformer output winding is caused to supply recurring pulses of output potential that have positive and negative polarities in alternating sequence.

2. In combination, a pair of conductors, a transformer connected in energy supplying relation with said conductors, a source of direct current exciting energy for said transformer, first and second coder relays each having contacts which occupy a normal position when and after the relay is energized in one direction and which occupy a reversed position when and after the relay is energized in the opposing direction, an energizing circuit for said second relay which is controlled by a contact of said first relay and which causes the second relay contacts to go to their normal position following each normal positioning of the first relay contacts and to their reversed position following each reversed positioning of the first relay contacts, an energizing circuit for said first relay which is controlled by a contact of said second relay and which causes the first relay contacts to go to their reversed position following each normal positioning of the second relay contacts and to their normal position following each reversed positioning of the second relay contacts, and circuits including contacts of said first and second coder relays over which said transformer primary is from said source supplied with exciting current of a character that causes the transformer to supply said conductors with recurring pulses of positive polarity energy which are separated by intervening pulses of negative polarity energy.

3. In combination, current-receiving apparatus, a source of energy therefor, first and second coder relays each having contacts which occupy a normal position when and after the relay is energized in one direction and which occupy a reversed position when and after the relay is energized in the opposing direction, an energizing circuit for said second relay which is controlled by a contact of said first relay and which causes the second relay contacts to go to their normal position following each normal positioning of the first relay contacts and to their reversed position following each reversed positioning of the first relay contacts, an energizing circuit for said first relay which is controlled by a contact of said second relay and which causes the first relay contacts to go to their reversed position following each normal positioning of the second relay contacts and to their normal position following each reversed positioning of the second relay contacts, and circuits governed by contacts of said first and second coder relays over which said apparatus is from said source supplied with recurring pulses of positive polarity energy that are separated by intervening pulses of negative polarity energy.

4. In combination, current-receiving apparatus, a source of energy therefor, first and second coder relays each having contacts which occupy a normal position when and after the relay is energized in one direction and which occupy a reversed position when and after the relay is energized in the opposing direction, an energizing circuit for said second relay which is controlled by a contact of said first relay and which causes the second relay contacts to go to their normal position following each normal positioning of the first relay contacts and to their reversed position following each reversed positioning of the first relay contacts, an energizing circuit for said first relay which is controlled by a contact of said second relay and which causes the first relay contacts to go to their reversed position following each normal positioning of the second relay contacts and to their normal position following each reversed positioning of the second relay contacts, a first circuit which connects said source in positive energy supplying relation with said apparatus when the contacts of both of said relays are in their normal position, a second circuit which connects said source in negative energy supplying relation with said apparatus when the contacts of said second relay are in their normal position and the contacts of said first relay are in their reversed position, a third circuit which connects said source in positive energy supplying relation with said apparatus when the contacts of both of said relays are in their reversed position, and a fourth circuit which connects said source in negative energy supplying relation with said apparatus when the contacts of said second relay are in their reversed position and the contacts of said first relay are in their normal position.

5. In combination, current-receiving apparatus, a source of energy therefor, first and second coder relays each having contacts which occupy a normal position when and after the relay is energized in one direction and which occupy a reversed position when and after the relay is energized in the opposing direction, an energizing circuit for said second relay which is controlled by a contact of said first relay and which causes the second relay contacts to go to their normal position following each normal positioning of the first relay contacts and to their reversed position following each reversed positioning of the first relay contacts, an energizing circuit for said first relay which is controlled by a contact of said second relay and which causes the first relay contacts to go to their reversed position following each normal positioning of the second relay contacts and to their normal position following each reversed positioning of the second relay contacts, a first circuit completed over a normal contact of said second relay and a normal contact of said first relay for connecting said source in positive energy supplying relation with said apparatus, a second circuit completed over a normal contact of said second relay and a reversed contact of said first relay for connecting said source in negative energy supplying relation with said apparatus, a third circuit completed over a reversed contact of said second relay and a reversed contact of said first relay for connecting said source in positive energy supplying relation with said apparatus, and a fourth circuit completed over a reversed contact of said second relay and a normal contact of said first relay for connecting said source in negative energy supplying relation with said apparatus.

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