

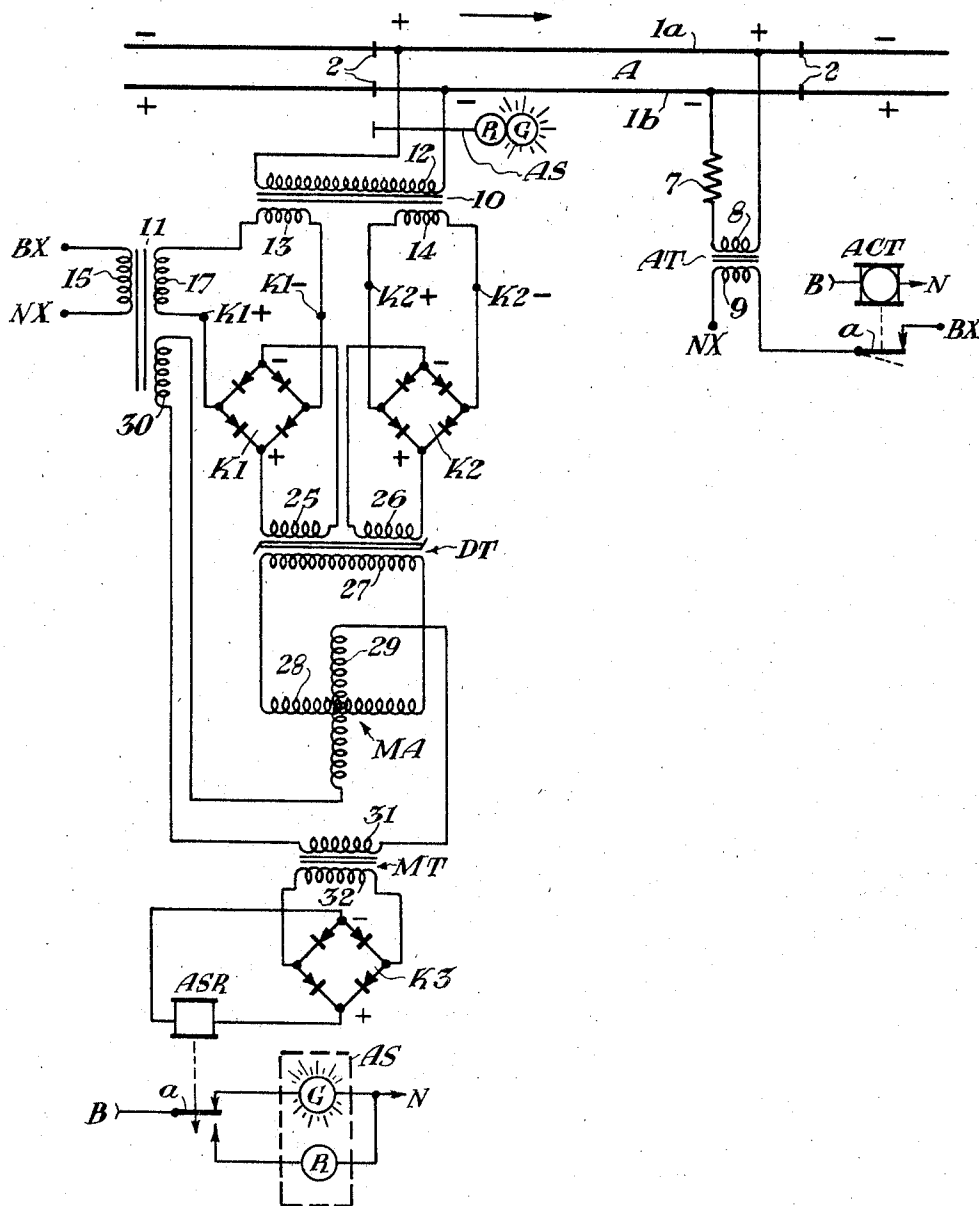
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CODE DETECTING APPARATUS

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CODE DETECTING APPARATUS

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ABSTRACT OF THE DISCLOSURE

This disclosure relates to a code detecting apparatus for railway signaling systems comprising a phase sensitive apparatus which includes a track transformer, an auxiliary transformer, and a first and a second rectifier feeding a decoding transformer. The decoding transformer is coupled to the control winding of a magnetic amplifier which has its main winding connected to the primary winding of a matching transformer. The secondary winding of the matching transformer is coupled through a third rectifier to a signal relay which is picked up when and only when the decoding transformer is oppositely and alternately energized at a preselected code rate.

Our invention relates to a code detecting apparatus for use in connection with railway signaling systems. More particularly, our invention relates to an improvement upon the code detecting apparatus shown and described in Letters Patent of the United States No. 3,046,454, issued July 24, 1962, to Crawford E. Staples.

In the above-mentioned Staples patent, there is disclosed a code detecting arrangement employing a transformer having a core with a substantially rectangular hysteresis characteristic. This transformer includes two primary and one secondary windings. A specially designed retained-neutral type of relay is electrically connected to the secondary winding. The primary windings are electrically connected either to suitable contacts of a code following relay or directly to a phase sensitive apparatus which receives coded energy from the rails of a section of railway track. The retained-neutral relay is of a double winding type and includes means for delaying the decay of flux through its cores for retaining the armature picked up during periods of pole-changing. Accordingly, the relay is so constructed and so proportioned that the armature of the relay is picked up and retained in that position when, and only when, the primary windings are alternately energized by electric pulses of opposite relative polarity above a predetermined code rate.

While such previous forms of code detecting devices have operated satisfactorily in the past, there are several features which are considered objectionable. For example, a special construction or designed relay not only materially increases the initial purchase cost of the code detecting apparatus but also proportionally increases the maintenance cost of the code detecting apparatus since additional relays must be stocked for replacement purposes. Further, the use of a code following relay not only escalates the cost factor of the code detecting apparatus but also augments the servicing requirement of this type of code detecting equipment since the movable and contact elements of this additional relay are, themselves, susceptible to the deleterious effects of mechanical and electrical wear.

Accordingly, it is an object of our invention to provide a novel and improved code detecting apparatus for railway signaling systems.

Another object of our invention is to provide a novel code detecting arrangement for a railway signaling system

which will not produce a false indication signal during an existing dangerous track condition.

A further object of our invention is to provide a unique code detecting arrangement which utilizes minimum number of movable mechanical and electrical elements thereby appreciably reducing the wear and materially increasing the life of the equipment.

A still further object of our invention is to provide a new and improved code detecting apparatus for railway signal systems which is simple in design, economical to manufacture, efficient in operation, and durable in use.

In accordance with our invention, we provide a unique code detecting arrangement which comprises a phase sensitive apparatus having a track transformer, an auxiliary transformer and a pair of full-wave bridge rectifiers. The pair of rectifiers are electrically and separately connected to a pair of primary windings of a decoding transformer, which includes a core of a material having a substantially rectangular hysteresis characteristic. The secondary winding of the decoding transformer is connected to a control winding of a magnetic amplifier which has its controlled or main winding serially interconnected to a secondary winding of the auxiliary transformer and a primary winding of a matching transformer. The secondary winding of the matching transformer is electrically connected to a full-wave bridge rectifier which has its direct current terminals connected to a signal relay. The signal relay is picked up and retained in the picked-up position when and only when the pair of primary windings of the decoding transformer are oppositely and alternately energized at a preselected code rate by energy pulses received from the phase sensitive apparatus which ensures that the pulses have a predetermined relative polarity.

Other objects and characteristic features of our invention will become apparent as the description proceeds.

We will describe one form of the code detecting apparatus embodying our invention, and will then point out the novel features thereof in the claims.

The accompanying drawing is a diagrammatic view showing a railway signaling system including a code detecting arrangement embodying our invention.

Referring to the drawing, there is shown a section of railway track designated by the reference character A comprising rails designated by the reference characters 1a and 1b. The track section A is separated from the adjoining track sections by insulated rail joints 2 in the usual and well known manner.

Traffic normally moves through the track section in a direction indicated by the arrow, that is, from left to right as viewed in FIG. 1, and the movement of traffic into the track section is controlled by a suitable signal, here designated by the reference character AS, located adjacent the entrance end of the track section A. As shown, the signal is of the color light type, although any convenient type of signal may be employed. The signal is provided with a red or stop lamp R and a green or proceed lamp G.

The track section A is provided with code detecting apparatus embodying our invention located adjacent the entrance of the section for selectively controlling the signal which, in turn, controls the movement of traffic in accordance with the prevailing conditions of the track section. The novel code detecting arrangement comprises a phase sensitive apparatus including a track transformer 10, an auxiliary transformer 11, and a first and a second rectifier K1 and K2; a decoding transformer DT; a magnetic amplifier MA; a saturable matching transformer MT; a third rectifier K3; and a relay ASR for effectively energizing the appropriate signal lamp.

The decoding transformer DT consists of a core hav-

ing a substantially rectangular hysteresis characteristic and includes two primary windings 25 and 26 and a secondary winding 27.

It is to be understood that alternate energization of the primary windings of transformer DT in opposite directions will induce in secondary winding 27 of transformer DT an alternating current of a low frequency, namely, the frequency corresponding to the track code rate, as will be described hereinafter.

The decoding transformer DT is connected to the rails of the track section A through a phase sensitive apparatus which is substantially identical to that employed in the previously mentioned United States Patent No. 3,046,454. As here shown, the primary windings 25 and 26 are connected to the direct current terminals of the full-wave bridge rectifiers K1 and K2, respectively. One of the alternating current terminals, designated K1—, of rectifier K1, is connected to one side of the secondary winding 13 of track transformer 10. The other alternating current terminal, designated K1+, of rectifier K1, is connected to one side of the secondary winding 17 of auxiliary transformer 11. The other sides of secondary windings 13 and 17 are connected together. One of the alternating current terminals, designated K2+, of rectifier K2, is connected to one side of the secondary winding 14 of transformer 10, and the other alternating current terminal, designated K2—, of rectifier K2, is connected to the other side of secondary 14 of transformer 10.

The primary winding 12 of track transformer 10 is connected to the rails of track section A, and the primary winding 15 of auxiliary transformer 11 is connected to a suitable source of alternating current energy, the terminals of which are designated BX and NX. If so desired, a suitable phase shifting means may be interconnected between the primary winding 15 and the terminal BX for adjusting the phase of current flowing through the primary winding, such as illustrated and described in Patent No. 3,046,454.

The secondary winding 27 of decoding transformer DT is connected to the control winding 28 of a transducer or magnetic amplifier MA which includes a main or controlled winding 29. It is readily apparent that by properly proportioning and designing the parts of the magnetic amplifier MA, its magnetizable core may be normally held at a given flux condition. For example, when the core becomes saturated in response to control flux created by sufficient current flowing through winding 28, the impedance of the main winding 29 assumes a relatively low value so that current of relatively high magnitude may readily flow through winding 29. When, however, control energy is not supplied to winding 28, that is, with no current flowing through winding 28, the core of the magnetic amplifier MA will assume an unmagnetized or unsaturated condition, wherein the impedance of main winding 29 greatly increases so that the flow of current through winding 29 ceases or decreases to a relatively negligible value. Now, as shown, the main winding 29 of the magnetic amplifier MA is serially connected to secondary winding 30 of the auxiliary transformer 11 and to primary winding 31 of saturable matching transformer MT. While the secondary winding 30 is employed to provide a suitable source of alternating current for the serially connected circuit, it is readily apparent that any convenient supply may be utilized for this purpose. The secondary winding 32 of matching transformer MT is connected to the alternating current terminals of a full-wave bridge rectifier K3. The direct current terminals of rectifier K3 are connected to the winding of relay ASR so that the green or proceed lamp is lighted when the relay ASR is picked up and the red or stop lamp is lighted when the relay ASR is released. The relay ASR may be any suitable or conventional slow-release type relay and need not include special construction, as was heretofore necessary.

At the exit end of track section A, rail 1a is connected

to one end of a secondary winding 8 of a transformer AT, and rail 1b is connected to the other end of secondary winding 8 through a current limiting device, here shown as a resistance and designated by the reference character 7. This resistance limits the flow of current through the transformer when the rails of the track section are shunted. One end of the primary winding 9 of transformer AT is connected, through a contact a of a coding device ACT, shown here as a relay, to the terminal BX of the source of alternating current energy. The other end of winding 9 of transformer AT is connected to terminal NX of the source of alternating current energy. This arrangement causes the track section A to be supplied with alternating current energy which is periodically interrupted at a suitable code rate which preferably is substantially less than the frequency of the alternating current source. That is, the alternating current energy is modulated in an on-off manner at a code rate or frequency determined by the code relay ACT which is alternately energized from a suitable direct current source whose terminals are designated B and N.

It is to be understood that the track sections to the left and right of track section A are furnished with apparatus similar to that shown for track section A. However, the coded currents furnished to the rails of these sections are of opposite relative phase to that of the rails of section A as designated by the positive (+) and negative (—) signs indicating the particular polarities of the track sections at a given instant.

It is to be further understood that a common source of alternating current energy is used for both ends of track section A as well as for the track sections to the left and right of track section A so that the safety and phase requirements can readily be fulfilled.

The modulated pulses of alternating current energy being supplied to the rails at the exit end of the track section via transformer 8 are transmitted through the rails and cause modulated pulses of energy to be supplied to the primary winding 12 of transformer 10 located at the entrance end of the track section. During the "on" period of the pulses, energy is induced in the secondary windings 13 and 14 of transformer 10. The energy induced in the secondary winding 13 of transformer 10 and the energy induced in secondary winding 17 of transformer 11 are so arranged as to be substantially 180 degrees out of phase with each other, that is, the two voltages induced in the secondary windings 13 and 17 oppose each other so that the resultant voltage is substantially zero. Thus, since the resultant voltage across rectifier K1 is zero substantially no current flows through rectifier K1 so that no voltage appears across the primary winding 25 of transformer DT. However, during this "on" period of the pulses, energy is supplied from secondary winding 14 through rectifier K2 and, in turn, to the primary winding 26 of the transformer DT. During the "off" period of the track circuit energy pulses, no energy is induced in either secondary winding 13 or 14 of transformer 10. However, energy is still being induced in the secondary winding 17 of transformer 11 so that energy is now being supplied only to the primary winding 25 of transformer DT. It is thus apparent that the output of the secondary winding 27 of transformer DT "follows" the pulses of energy supplied to the rails of track section A.

Now when a train enters the track section A and shunts the coded energy pulses, no energy is supplied to the primary winding 12 so that no voltages are induced in the secondary windings 13 and 14 of transformer 10. During this occupancy, the primary winding 25 of transformer DT will appear steadily energized by D.C. current being supplied by rectifier K1, which is wholly caused by the energy induced in the secondary winding 17 of transformer 11. That is, no coded energy will be induced in secondary winding 27 of transformer DT since the primary current remains unidirectional and retains the

core magnetized in one given direction, as will be described in detail hereinafter.

It should be noted that in the event the insulated joints 2 between the track section A and the next track section to the left become defective while a vehicle occupies track section A, pulses of alternating current energy may be supplied to the primary winding 12 of track transformer 10 from the track circuit energy being supplied to the rails of the track section to the left, as viewed in FIG. 1. However, as previously mentioned, this energy being induced from the left track section into the secondary windings 13 and 14 of transformer 10 will be of opposite phase or polarity to that normally induced in windings 13 and 14 from track section A. The voltage pulses induced in secondary winding 13 of transformer 10 and secondary winding 17 of transformer 11 are now "in phase," and, during the "on" period of the pulses, combine to produce a resultant voltage greater than that induced in secondary winding 14 of transformer 10. As previously mentioned, the transformer DT is preferably of a type comprising a core having a substantially rectangular hysteresis characteristic so that when the core is magnetized and saturated in a given direction by a current flowing in a primary winding of the transformer, the core remains saturated in the given direction, due to residual magnetism, until the direction of the primary current flow is reversed. This current flow change must be made in order to produce any sizeable output from the secondary of the transformer. Accordingly, since the energy being supplied to winding 25 of transformer DT is greater than that being supplied to winding 26 of transformer DT during the "on" period, the core of the transformer DT is magnetized and substantially saturated in a given direction. As is readily apparent, during the "off" period of the coded energy pulses, current is only supplied to winding 25 from energy induced in secondary winding 17. Since the directional flow of this latter mentioned current is the same as during the "on" period the core remains magnetized and saturated in the given direction so that no energy is induced and no output is produced in the secondary winding 27 of transformer DT at this time. Accordingly, the decoding transformer DT is incapable of "following" the coded energy pulses transmitted to track section A from the left-hand track section for producing false operation.

While it would be desirable to directly employ the output from the secondary winding 27 to energize and control relay ASH such a utilization is not practical on account of high value of A.C. ripple produced by rectifiers K1 and K2 which could result in a false signal indication. For example, during a period of train occupancy or during a period of an insulated joint failure, it is not only necessary but also mandatory that the red lamp of signal AS be illuminated to display a stop indication in order to indicate to an approaching train that a condition of danger exists. While as mentioned above no coding action takes place during either of these periods since current is only permitted to flow in one given direction through the primary windings of transformer DT, it will be appreciated that relatively high A.C. ripple components normally accompany the rectified currents which flow through the primary windings of transformer DT. Accordingly, since these A.C. ripples are transformer coupled to the secondary winding 27 of transformer DT, special precautions must be employed for preventing these ripple pulses from energizing the signal relay whereby a false signal indication may be produced. While various methods have been devised for handling this problem, each was possessed of certain disadvantages. For example, in United States Patent No. 3,046,454, a special constructed relay was employed to prevent false indications by the A.C. ripple component. However, this method is not wholly acceptable since these special types of relays not only result in a high fabricating cost of such an arrangement but also result in a high maintenance ex-

pense of such an arrangement due to the fact that a relay is normally shortlived in comparison to the other elements of the system. Accordingly, it is advantageous to utilize a simple inexpensive relay since the inherent relatively frequent replacement of this element. Similarly, an L-C filtering arrangement is generally not acceptable since a short-circuited inductor or an open-circuited capacitor would allow the A.C. ripple to energize the relay thereby resulting in the production of a false signal indication.

Accordingly, we have devised a new and improved arrangement which is economical to manufacture, relatively inexpensive to maintain, and efficient and reliable in operation. In the present invention, the secondary winding 27 of the decoding transformer DT is connected to the control winding 28 of the magnetic amplifier which has its main winding 29 being supplied from the secondary winding 30 of auxiliary transformer 11. It will be appreciated that the ripple frequency is approximately forty (40) times the code rate frequency so that the relative impedance of the control winding 28 with reference to the A.C. ripple is proportionately larger than the code rate impedance. This relatively large impedance prevents any A.C. ripple from saturating the core of the magnetic amplifier MA so that the relay ASR is incapable of being falsely operated during train occupancy or during failure of the insulated joints.

In explaining the operation of our invention, it will be assumed that the apparatus is operating properly and in its normal condition as shown in the drawing, that is, the code transmitter ACT is supplying coded energy to the track section A at the exit end of the track section and the primary windings 25 and 26 of the decoding transformer DT are being alternately energized in opposite directions at the entrance end of the track section. This alternate energization of the primary windings induces in the secondary winding 27 of transformer DT an alternating current of a low frequency, the frequency corresponding to the code rate of relay ACT. As previously mentioned, the supply of coded or low frequency current to winding 28 causes the core of the magnetic amplifier MA to be magnetized which, in turn, causes the main winding 29 to assume a low impedance condition. This lowering of the impedance of winding 29 of the magnetic amplifier MA permits the free flow of current supplied to secondary winding 30 to primary winding 31 which, in turn, results in energy or voltage being induced in the secondary winding 32. The alternating current energy induced in secondary winding 32 is rectified by bridge rectifier K3 and, in turn, applied to the winding of relay ASR. The energization of relay ASR causes the front contact *a* to be closed so that a circuit is completed from battery terminal B through front contact *a* and the filament of the green lamp to the battery terminal N. Thus, the signal AS displays a green or proceed aspect indicating that it is safe for a train to proceed past the signal.

Now let us assume that the track section A is shunted by the presence of a railway vehicle so that the coded energy from transmitter ACT is not being received at the entrance end of the track section. Under this condition, the corresponding alternating output is not available at the secondary winding 27 of the decoding transformer DT since the primary winding 25 is steadily energized by the unidirectional current from rectifier K1. Accordingly, with no energy induced in secondary winding 27 no current flows through the control winding 28 so that the core of the magnet amplifier MA becomes demagnetized. The demagnetization of the core of the magnetic amplifier MA causes the impedance of the main winding 29 to greatly increase to effectively reduce and stop the flow of alternating current supplied by secondary winding 30 of transformer 11. As a result, no transformer action takes place within transformer MT so that relay ASR is released, and a circuit is established from the battery terminal B through the back contact *a* and the filament of the red lamp to the

battery terminal N. Accordingly, the signal AS now displays a stop or red aspect thereby indicating to a train approaching the track section that a condition of danger exists. Upon departure of the railway vehicle from track section A, coded energy will again be received at the entrance end of this track section so that the apparatus will resume its normal condition of operation. That is, relay ASR will be picked up so that the red lamp signal circuit will be opened and the green lamp signal circuit will be closed thereby indicating that it is now safe to proceed.

In the interest of safety, especially when the invention is employed in railway applications where fail-safe operation is an authoritative requirement, it is desirable that the main or controlled winding 29 of the magnetic amplifier MT should be constructed in such a manner that breakdown virtually cannot occur. Obviously, a full or partial short-circuiting of this winding may invalidate the security of the apparatus by permitting an increase of alternating current from the secondary winding 30 and possible cause the signal relay ASR to be picked up during an unsaturated or demagnetized condition of the magnetic amplifier MA. Since there is no part of a magnetic amplifier which cannot be designed as to be practically everlasting and, therefore, free from deterioration, the required safety from this point of view is simply and satisfactorily achieved by utilization of suitable insulated wires. Further, the windings are so arranged and wound relative to each other so as to be mutually decoupled in order to prevent the circulation of disturbing alternating currents in the control winding 28.

While we have shown and described only one form of our invention, it is obvious that certain modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore, only such limitations thereof, should be imposed as are indicated in the appended claims.

Having thus described our invention, what we claim is:

1. A code detecting arrangement for a coded track section in a railway signaling system comprising, in combination, a phase sensitive means at times receiving coded energy from said coded track section, a decoding transformer including a core having a substantially rectangular hysteresis characteristic, and primary and secondary circuit means, said primary circuit means of said decoding transformer being electrically coupled to said phase sensitive means, a magnetic amplifier having at least a first and a second winding, said secondary circuit means of said decoding transformer being electrically coupled to said first winding of said magnetic amplifier, a signal relay, and means including a source of alternating current for electrically coupling said relay to said second winding of said magnetic amplifier for energizing said signal relay and retaining said relay energized when and only when said phase sensitive means is receiving coded energy having a preselected relative phase from the track section.

2. A code detecting arrangement as defined in claim 1, wherein said primary circuit means of said decoding transformer includes a pair of primary windings and said secondary circuit means of said decoding transformer includes a single secondary winding.

3. A code detecting arrangement as defined in claim 1,

wherein said first winding of said magnetic amplifier comprises a control winding and said second winding of said magnetic amplifier comprises a controlled winding.

4. A code detecting arrangement as defined in claim 2, wherein said phase sensitive means includes a track transformer, an auxiliary transformer, and a pair of full-wave rectifiers for alternately energizing the pair of primary winding of said decoding transformer with pulses of energy of opposite relative polarity.

5. A code detecting arrangement as defined in claim 3, wherein said means for electrically coupling said relay to said second winding of said magnetic amplifier includes a matching transformer having at least one primary and one secondary winding.

6. A code detecting arrangement as defined in claim 4, wherein said auxiliary transformer includes a single primary winding and a pair of secondary windings.

7. A code detecting arrangement as defined in claim 5, wherein said means for electrically coupling said signal relay to said second winding of said magnetic amplifier also includes a full-wave rectifier connected to said secondary winding of said matching transformer.

8. A code detecting arrangement as defined in claim 5, wherein said phase sensitive means includes a track transformer having a single primary and a pair of secondary windings, an auxiliary transformer having a single primary and a pair of secondary windings, and a pair of full-wave rectifiers one of which has its alternating current terminals serially interconnected with one of said pair of secondary windings of said track transformer, the other of which has its alternating current terminals serially interconnected with the other of said pair of secondary windings of said track transformer and one of said pair of secondary windings of said auxiliary transformer.

9. A code detecting arrangement as defined in claim 8, wherein one of said pair of primary windings of said decoding transformer is adapted to be electrically coupled to the direct current terminals of one of said pair of full-wave rectifiers, and the other of said pair of primary windings of said decoding transformer is adapted to be electrically coupled to the direct current terminals of said other of said pair of full-wave rectifiers.

10. A code detecting arrangement as defined in claim 9, wherein the other of said pair of secondary windings of said auxiliary transformer, said controlled winding of said magnetic amplifier, and said primary winding of said matching transformer are adapted to be serially interconnected with each other.

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