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UNDERSPEED MOTOR PROTECTIVE SYSTEM

Albert C. Frazee, Wilmerding, Pa., assignor to The Westinghouse Air Brake Company, Wilmerding, Pa., a corporation of Pennsylvania

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This invention relates to control apparatus and has particular relation to apparatus responsive to the speed of movement of a rotary or linearly movable member for a desired indicating or control purpose.

My present invention is devised particularly as a solution for the problem of undesired stoppage of conveyor belts in industrial plants, such as foundries, where the location of the conveyor belt, or extraneous noise, prevents workmen from detecting an abnormal or unwanted operating condition of the conveyor belt.

For example, in foundries, the sand shaken out of the molds at the time the castings are removed from their molds drops through a horizontal vibrating "shake-out" screen onto an endless belt conveyor which transports the sand, either directly or through the medium of additional endless belt conveyors, to other portions of the foundry where the sand is reclaimed and reconditioned for further use. Ordinarily, the endless conveyor belts are located in sub-floor compartments or rooms and are not visible to the workman in the main foundry room. It sometimes happens that the sand load on the endless belt conveyor conducting the sand away from the shake-out screen becomes excessive and the endless belt of the conveyor slips on the driving drum, which may be driven by an electric motor. In such case, therefore, the endless belt conveyor stops or slows down to an abnormally low speed and the sand from the shake-out screen piles up on the belt and eventually stops it. By the time the workmen in the main foundry room at the shake-out screen become aware of the piling up of the sand on the endless belt conveyor beneath the shake-out screen, the amount of the sand accumulated is such as to require a complete shut-down of operations in the foundry until such time as the sand can be dug away from around the endless belt conveyor to permit the normal operation thereof. This results in inefficient operation and lost time.

In order, therefore, to detect the undesired stoppage of the endless belt conveyor in the situation above described I have devised a simple electrical apparatus for detecting the abnormal slowing down or stoppage of the endless belt conveyor and for effecting a suitable control operation or signal indication of such a nature as to immediately apprise the workmen in the main operating room of the foundry of the abnormal operating condition of the endless belt conveyor.

Essentially, my above-mentioned electrical ap-

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paratus comprises a single-pole double-throw switch operated by a rotary cam that is, in turn, driven according to the movement of the endless belt as by connection to an idler drum associated with the endless belt, for the purpose of alternately charging and discharging a pair of electrical condensers in such sequence that one condenser is being charged while the other is being discharged, the charging current of the condensers being effective to operatively energize the winding of a relay so long as the condenser charging current exceeds a certain value. If the speed of movement of the endless conveyor, as reflected in the rotary speed of the cam for operating the single-pole double-throw switch, reduces to an abnormally low value, or if the conveyor and the cam stop completely, the charging current for one condenser will have an opportunity to reduce sufficiently before the charging current for the other condenser starts to flow through the winding of the relay that the relay will be at least momentarily dropped out, that is restored to its deenergized position.

The relay may be employed for any desired purpose such as the operation of a signal, either audible or visible, or the control of one or more motors of a conveyor system, such as the motor operating the shake-out screen and the motor driving the endless belt conveyor immediately effected in the foundry system previously described.

The electrical apparatus which I have devised for detecting the abnormal slowing down or stoppage of a belt conveyor is particularly advantageous in that it requires only the installation of a small cam-operated switch in immediate association with the conveyor. Due to pollution of the air by fumes and gases and due also to the usual lack of space around the conveyors in a foundry, which render installation of apparatus difficult, the electrical apparatus which I have devised is particularly advantageous in that it may be installed in a relatively short time and in a simple manner, and occupies a negligible amount of space. Thus parts of the electrical apparatus, other than the cam-operated switch, may be disposed at a remote point where working conditions and space are more ideal and less limited, and connected to the switch through electrical wires.

It is an object of my invention, therefore, to provide a novel apparatus of the electrical type for indicating the abnormal slowing down or stoppage of a moving element, such as an endless

belt conveyor.

It is a further object of my invention to provide apparatus of the type indicated in the foregoing object, and characterized by simplicity and low cost together with ease of installation and minimum space requirements.

The above objects, and other objects of my invention which will be made apparent hereinafter, are attained by means of apparatus subsequently to be described in detail and shown in the accompanying single figure of the drawing which depicts in simplified form a motor-driven endless belt conveyor and my novel electrical apparatus associated therewith.

Referring to the single figure of the drawings, the endless belt conveyor 11 is shown in simplified form as comprising a driving drum 12, an idler drum 13, an endless belt 14 carried on the drums 12 and 13, and an electrical motor 15 for driving the drum 12 as through an endless belt drive in the manner shown. For simplicity, the journals for mounting the drums 12 and 13 as well as the guiding frame work and support for the endless belt 14 have been omitted from the drawing but it will be understood that the conveyor 11 is of standard construction.

The electrical apparatus provided according to my present invention comprises a single-pole double-throw switch 16, of the telephone type, operated by a cam 17 fixed on a shaft 18 attached to and rotating with the idler drum 13, a pair of electrical condensers 19 and 20, a resistor 21, an electric relay 22 and a source of direct-current voltage indicated as a potentiometer resistor 23 having suitable taps for providing a supply voltage of relatively low value, such as 15 volts, from a higher line voltage, such as 230 volts; and a control switch such as a double-pole single-throw knife switch 24.

The switch 16 may comprise a pair of flexible contact fingers 16a and 16b secured in insulated relation in a supporting base or block 16c with a movable or flexible contact arm 16d interposed therebetween in such a manner as to engage the two contact fingers 16a and 16b alternately upon oscillatory movement of the contact arm 16d in the plane of the contact fingers.

The cam 17 is associated with the contact arm 16d in such a manner as to cause the contact arm 16d to engage the contact finger 16a and the contact finger 16b twice for each revolution of the cam 17. Obviously cam 17 may have any other design for causing any other frequency of oscillation of the contact arm 16d of the switch 16 if the characteristics of the electrical condensers, the resistor 21 and the winding of the relay 22 are designed in accordance therewith.

The switch 16 is so connected in circuit relation with the condensers 19 and 20 and the winding of the relay 22 to the voltage source as to cause a flow of charging current to condenser 20 through the resistor 21 and the winding of the relay 22 when the contact arm 16d of the switch engages the contact finger 16a, the condenser 19 being at the same time discharged through the resistor 21 connected directly thereacross. The circuit connections of the switch 16 are also such that when the contact arm 16d engages the contact finger 16b, current flows to charge condenser 19 through the resistor 21 and the winding of the relay 22, while at the same time the condenser 20 discharges locally through the resistor 21 connected directly thereacross.

By employing suitable constants for the condensers 19 and 20, the resistor 21 and the winding of the relay 22, the drop-out of the relay 22

may be effected in response to the reduction in the rotational speed of the cam 17 below any desired speed. For example, when I have employed condensers 19 and 20 of 500 microfarad capacity, a resistor 21 having 15 ohms resistance, and a relay 22 having a winding of 700 ohms resistance, the relay 22 is maintained picked-up by the charging current to the condensers 19 and 20 so long as the cam 17 rotates at a speed of 15 R. P. M. or higher. If the rotational speed of the cam 17 reduces substantially below a speed of 15 R. P. M., the charging current to either of the condensers 19 and 20 will be reduced or attenuated sufficiently in the interval of time elapsing from the instant the contact arm 16d of the switch 16 first engages the contact finger 16a (or 16b) to the instant it first engages the contact finger 16b (or 16a) so that the relay contact will be restored to its dropped-out position.

It will be seen, therefore, that if the rotational speed of the idler drum 13 of the endless belt conveyor 11 is normally substantially in excess of 15 R. P. M. and for any reason such as previously pointed out, as for example the excessive loading of sand on the endless belt 14, the rotational speed of the idler drum 13 and consequently of the cam 17 reduces below 15 R. P. M., then the contact of the relay 22 will be alternately dropped-out and picked-up. If the idler drum 13 and cam 17 stop altogether, the relay 22 will be deenergized and the contact thereof restored to its dropped-out position and remain therein.

The relay 22 may of course be employed in any suitable manner for control or indicating purposes. For purposes of illustration, I have shown in simplified form a suitable circuit arrangement whereby the drop-out of the relay 22 will automatically cause stoppage of the motor 15 and operation of a signal device such as a signal lamp 26. In actual practice I have employed the drop-out of the relay 22 to stop not only the driving motor 15 but also other motors in a conveyor system of which the endless conveyor 11 is only one, as well as the motor (not shown) which operates the vibrating shake-out screen above the endless belt 14. For purposes of my present invention, however, it is immaterial what function the relay 22 performs because relay 22 may be utilized in well known manner for any desired control or indicating purpose.

As shown in the drawing, the motor 15 is supplied with power from a main three-phase 440 volt alternating-current source by three wires 27 under the control of a main control switch 28, the terminals of the motor 15 being connected to the wires 27 by corresponding branch wires 29 under the control of a contactor or relay 30 which is, in turn, under the control of the relay 22 as will be hereinafter explained.

As will be apparent in the drawing, the relay 30 may comprise a suitable winding 30a and five contacts or switches designated 30b, 30c, 30d, 30e and 30f, respectively. The contacts 30b, 30c, 30d, and 30e are front-contacts, that is, they are normally in open position and are actuated to closed position in response to energization of the winding 30a of the relay 30. The contact 30f is a back-contact, that is, it is normally in a closed position when the winding of the relay 30 is deenergized and is actuated to open position in response to energization of the winding of the relay.

The three contacts 30c, 30d and 30e are interposed respectively in the three branch wires 29

leading to the motor 15 to suitably control the supply of current to the motor.

The contact 30 controls the connection of the signal device 26 to a source of low voltage, indicated as an auto-transformer 31 that is connected across one phase of the three-phase alternating current supply wires 27 and has suitable low voltage taps. Accordingly, with the relay 30 in its dropped-out position, the circuit for energizing the signal device 26 is established and the signal device is energized or operated. While the signal device 26 is shown as an indicating lamp it may obviously be an audible type of signal device.

In order to insure a continued drop-out of the relay 30 in response to a momentary drop-out of the relay 22, notwithstanding that the relay 22 may be alternately picked-up and dropped-out as it will be when the cam 17 continues to rotate at an abnormally low speed, a suitable control arrangement is provided including a starting switch 32 of the manually operated type. In order to describe this characteristic operation it will be necessary to first describe the circuit arrangement including the relay 22, the relay 30, and the switch 32.

For the purpose of energizing the winding 30a of the relay 30, a source of voltage, such as a single-phase alternating-current voltage obtained as by connection of a pair of branch wires 33 across one phase of the three-phase 440-volt main supply wires 27 under the control of a switch, indicated as a single-throw double pole knife switch 34.

The starting switch 32 may be of any standard type having two insulated contacts or switch members 32a and 32b that are yieldingly biased normally, as by a spring 35, to their open positions. Upon application of manually applied pressure to a button or head 36, the switch members 32a and 32b are simultaneously actuated to their respective closed positions. Upon release of the pressure manually applied to the button 36, spring 35 automatically restores the switch members to their respective open positions.

When the switch member 32a of switch 32 is actuated to its closed position, it establishes a shunt circuit in parallel with the contact of relay 22. At the same time, the switch member 32b in its closed position cooperates with the closed switch member 32a to establish a circuit for energizing the winding 30a of the relay 30. This circuit may be traced from one of the single-phase supply lines 33 by way of a wire 37, switch member 32a, a wire 38, the winding 30a of the relay 30, a wire 39, switch member 32b, and a wire 40 to the remaining single-phase supply line 33.

The winding of the relay 30 is accordingly energized by alternating current supplied from the single-phase supply lines 33 and the contacts of the relay 30 are thus actuated to their respective picked-up positions.

Assuming that the main control switch 28 has first been closed, the actuation of the contacts 30c, 30d, and 30e of the relay 30 to their closed positions establishes the three-phase circuit supplying current to operate the motor 15, and the motor accordingly begins to drive the endless belt 14 of the conveyor 41.

Pick-up of the contact 30f of relay 30 interrupts the circuit for energizing the signal device 26 and operation thereof is accordingly terminated.

Contact 30b of the relay 30 in its picked-up or closed position, is effective to establish a shunt circuit in parallel with the switch member 32b

so as to thereby establish a self-holding circuit for the winding 30a of the relay 30 independently of the subsequent restoration of switch member 32b to its open position in response to release of manually applied pressure on the button 36 of the switch 32.

Once the motor 15 begins to drive the endless belt 14, the idler drum 13 of course rotates at a corresponding speed, as does the cam 17. Assuming that the conveyor belt 14 operates at its normal or accustomed speed above a speed corresponding to 15 R. P. M. of the idler drum 13, the winding of the relay 22 will be continuously energized by a sufficient degree of charging current supplied either to the condenser 19 or the condenser 20, to cause the single front contact of the relay 22 to remain in its picked-up or closed position.

Since the contact of the relay 22 is in shunt relation to the switch member 32a, it will be seen that once the contact of the relay 22 is picked-up in response to rotation of the cam 17 and so long as it remains picked-up, the switch member 32a may be restored to its open position without causing drop-out or deenergization of the winding of the relay 30.

On the assumption, therefore, that the conveyor belt 14 travels at a normal speed, it will be seen that the circuit for energizing the winding 30a of the relay 30 is maintained by the joint cooperation of the contact of the relay 22 and the self-holding contact 30b of the relay 30, notwithstanding restoration of both of the switch members 32a and 32b to their respective open positions.

If now it is assumed that, for reasons hereinbefore pointed out, the contact of the relay 22 drops out, that is, is restored to its open position, it will be apparent that the circuit for energizing the winding 30a of the relay 30 is interrupted and that the contacts of the relay 30 are correspondingly restored immediately to their respective dropped-out positions.

Once the self-holding contact 30b of the relay 30 is restored to its dropped-out or open position, subsequent pick-up of the contact of the relay 22 which might occur where the cam 17 continues to rotate at a slow speed is ineffective to complete the circuit for reenergizing the winding 30a of the relay 30. Consequently, the switch contacts of the relay 30 remain in their dropped-out positions wherein the supply of current to the motor 15 is interrupted and the signal device 26 is operated.

It sometimes happens that it is desired to operate the conveyor belt 14 while the relay 22 is inoperative, as when repairing or servicing the equipment. I, therefore, provide a switch 41 of any suitable type which, when closed, shunts the contact of the relay 22. In such case, the motor 15 may be started by momentary operation of the starting switch 32 as previously described, the self-holding contact 30b of the relay 30 functioning in the same manner as previously described to maintain the self-holding circuit for the winding of the relay 30 notwithstanding opening of the switch member 32b.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. Protective apparatus for use in connection with a motor-driven conveyor belt, said apparatus comprising a source of direct-current voltage, two electrical condensers, an electrical relay having a winding and a contact adapted to be actu-

ated from a dropped-out or open position to a picked-up or closed position and maintained therein only so long as the current energizing the winding exceeds a certain value, said condensers being connected in series relation with each other across said source of voltage with the winding of said relay interposed in series relation between the outer terminal of one of said condensers and one terminal of the source of voltage, a single-pole double-throw switch having two spaced stationary contacts and a movable contact shiftable alternately into engagement with the stationary contacts, a resistor having one end connected to the movable contact of said switch and the other end connected to the common terminal of connection between said two series-connected condensers, one of the stationary contacts of said switch being connected to the terminal of one condenser opposite said common terminal and the other of said stationary contacts of said switch being connected to the terminal of the other of said condensers opposite said common terminal, the arrangement being such that when the movable contact of said switch engages said one of the stationary contacts it establishes a circuit through which current flows from said source to charge the other of said condensers and also simultaneously establishes a local circuit including said resistor through which said one condenser is discharged, the movable contact of said switch being effective when it engages the said other of the stationary contacts to establish a circuit through which current flows to charge said one condenser and also simultaneously establishes a local circuit including said resistor through which said other condenser is discharged, rotary cam means associated with the movable contact of said switch and operative in accordance with the linear speed of travel of the conveyer belt to effect the operative engagement of the movable contact of said switch alternately with the two stationary contacts at a frequency corresponding to the linear speed of travel of the conveyer belt, thereby producing a pulsating uni-directional current that energizes the winding of said relay, the electrical characteristics of said condensers and said resistor being such that the condenser charging current energizing the winding of said relay is maintained above said certain value only so long as the conveyer belt travels at a speed exceeding a certain speed, with the result that the contact of said relay is restored to its dropped-out or open position when the condenser charging current energizing the winding of the relay reduces below said certain value consequent upon reduction of the conveyer belt to a speed of travel less than said certain speed, and electro-responsive control means controlled by the contact of said relay in such a manner as to interrupt the power supplied to the driving motor when said contact is restored to its dropped-out or open position.

2. Protective apparatus for use in connection with a motor-driven conveyer belt, said apparatus comprising a source of direct-current voltage, two electrical condensers, an electrical relay having a winding and a contact adapted to be actuated from a dropped-out or open position to a picked-up or closed position and maintained therein only so long as the current energizing the winding exceeds a certain value, said condensers being connected in series relation with each other across said source of voltage with the winding of said relay interposed in series relation between the outer terminal of one of said condensers and one terminal of the source of voltage, a single-

pole double-throw switch having two spaced stationary contacts and a movable contact shiftable alternately into engagement with the stationary contacts, a resistor having one end connected to the movable contact of said switch and the other end connected to the common terminal of connection between said two series-connected condensers, one of the stationary contacts of said switch being connected to the terminal of one condenser opposite said common terminal and the other of said stationary contacts of said switch being connected to the terminal of the other of said condensers opposite said common terminal, the arrangement being such that when the movable contact of said switch engages said one of the stationary contacts it establishes a circuit through which current flows from said source to charge the other of said condensers and also simultaneously establishes a local circuit including said resistor through which said one condenser is discharged, the movable contact of said switch being effective when it engages the said other of the stationary contacts to establish a circuit through which current flows to charge said one condenser and also simultaneously establishes a local circuit including said resistor through which said other condenser is discharged, rotary cam means associated with the movable contact of said switch and operative in accordance with the linear speed of travel of the conveyer belt to effect the operative engagement of the movable contact of said switch alternately with the two stationary contacts at a frequency corresponding to the linear speed of travel of the conveyer belt, thereby producing a pulsating uni-directional current that energizes the winding of said relay, the electrical characteristics of said condenser and said resistor being such that the condensers charging current energizing the winding of said relay is maintained above said certain value only so long as the conveyer belt travels at a speed exceeding a certain speed, with the result that the contact of said relay is restored to its dropped-out or open position when the condenser charging current energizing the winding of the relay reduces below said certain value consequent upon reduction of the conveyer belt to a speed of travel less than said certain speed, an electro-responsive control device having a winding and contacts effective to establish a power supply circuit for the motor when the winding is energized and to interrupt the power supply circuit for the motor when the winding is deenergized, said control device also having an additional contact that is actuated from an open position to a closed position responsively to the energization of the winding of said control device, a manually operated starting switch having two normally open contacts, one of which is connected in parallel to the contact of said relay and the other of which is connected in parallel to said additional contact of said control device, the contacts of said manually operated starting switch being effective when actuated to their closed position to initially establish the energizing circuit for the winding of said control device, and the contact of said relay and the additional contact of said control device cooperating to maintain the energizing circuit for said control device following restoration of said contacts of said manually operated switch to their open positions, the arrangement being such as to preclude establishment of the power supply circuit to the motor following deenergization of the winding of the control device responsively to drop out of the

contact of said relay unless the contacts of the manual starting switch are first operated to their closed positions.

ALBERT C. FRAZEE.

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