Jan. 12, 1960 L. J. SRNKA 2,920,776

TWO MOTOR HOIST CONTROL

Filed Sept. 18, 1958 3 Sheets-Sheet 1

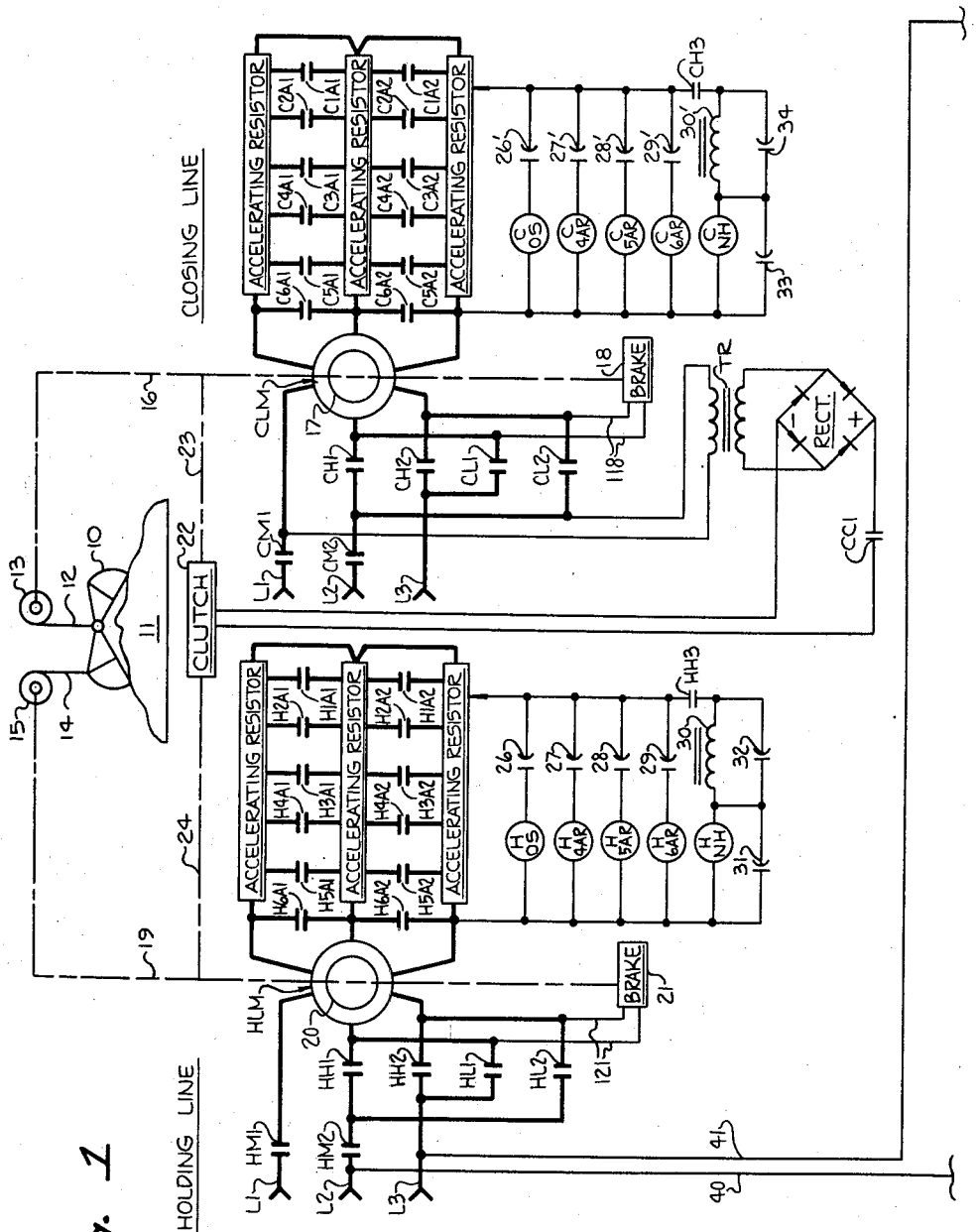


Fig. 1

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TWO MOTOR HOIST CONTROL

Filed Sept. 18, 1958 3 Sheets-Sheet 2

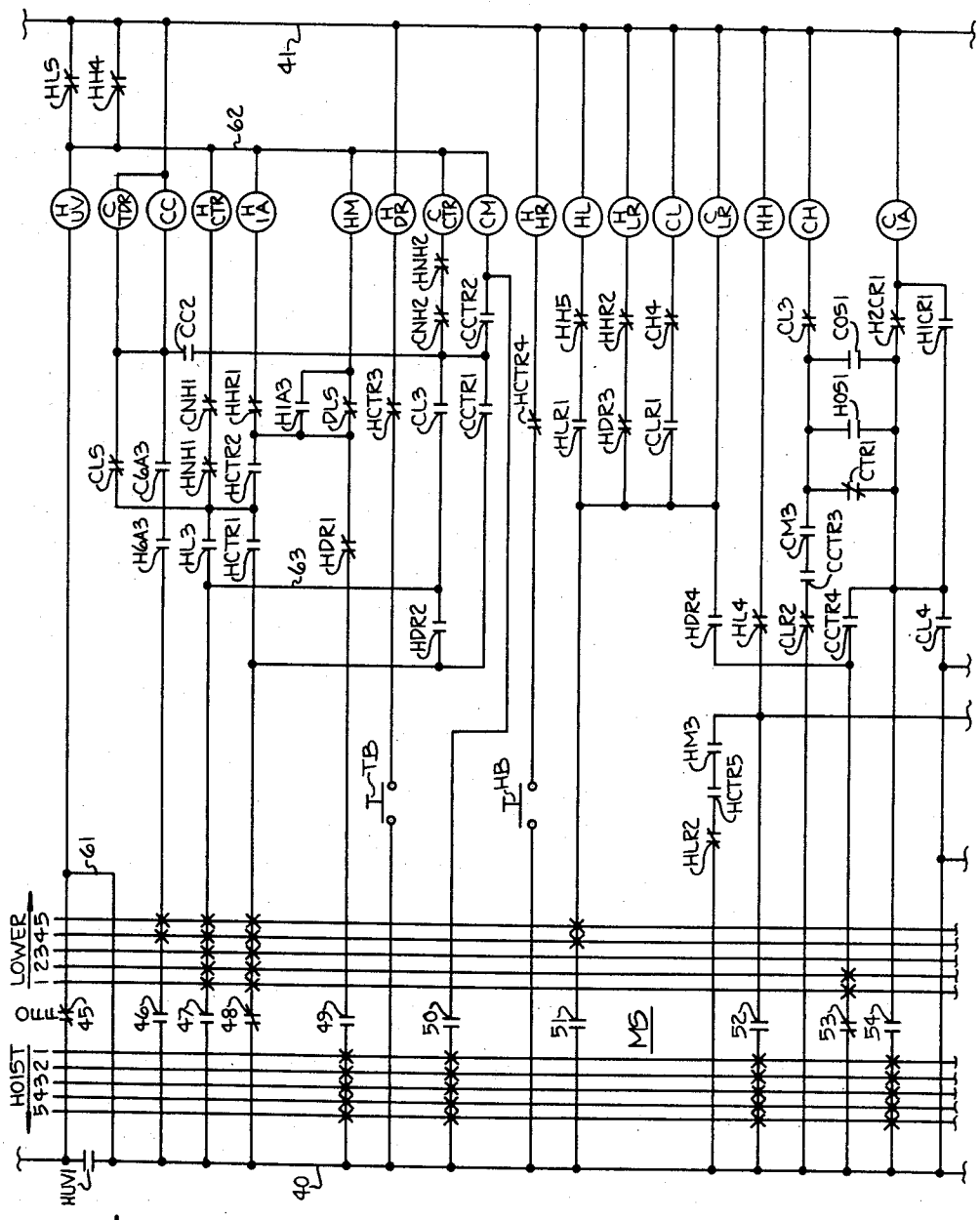


Fig. 2

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TWO MOTOR HOIST CONTROL

Filed Sept. 18, 1958 3 Sheets-Sheet 3

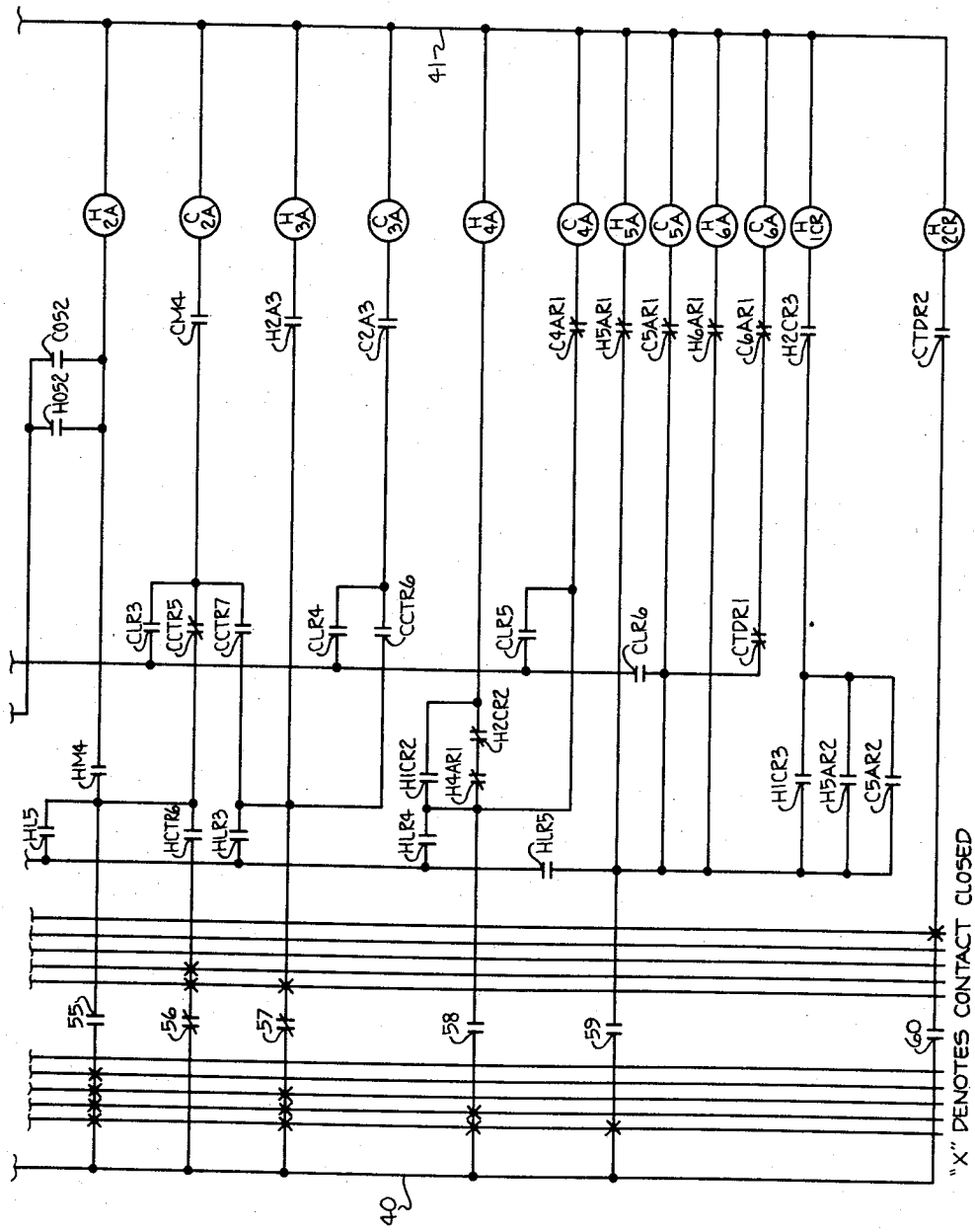


Fig. 3

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2,920,776

TWO MOTOR HOIST CONTROL

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Application September 18, 1958, Serial No. 761,762

15 Claims. (Cl. 214—656)

The present invention relates to a control system for controlling a plurality of motors in such manner that the rotors may be rotated independently of each other and may be rotated in synchronism with each other, and more in particular to a control system wherein the hoist line and closing line motors of a two bucket hoist may be simultaneously and cooperatively or independently controlled from a single master switch to hoist the bucket and to lower the bucket while maintaining it in a single attitude, for example, open.

The present invention is adaptable for use in hoisting applications wherein it is desired to use at least two lines, each having its own motor, for hoisting and lowering loads and particularly for lowering a load at high rates of speed while maintaining it in a single attitude. For the purpose of better understanding, the invention will hereafter be described in the application of a two line bucket type hoist.

In bucket hoists commonly used in the industry, a clam shell type bucket is usually suspended from a hoist support or trolley by a closing line and a holding line. The closing line is attached to the hinge of the bucket and the holding line usually is attached to one of the shells of the bucket at a distance from the hinge. By proper manipulation of these lines relative to each other, it is convenient for the hoist operator to open and close the bucket and to hoist and lower it. Generally each line is wound on its own drum, which is driven by its respective motor. Since these motors must be operated in a coordinated relationship which includes a simultaneous operation of both motors as well as the independent operation of one motor relative to the other, in the past it was found necessary to provide each motor with its own independent motor control circuits. This meant that each motor control system had to have its own master switch. It has long been recognized that if the master switches in each of the motor control systems could be combined into a single master switch the hoist would be much easier for the operator to control.

Another problem encountered with the prior hoist was controlling the closing line and holding line motors so that they would operate cooperatively and in synchronism during lowering of the bucket into a pile of dirt or other material in such manner that the bucket would maintain a single attitude throughout the lowering operation. In other words, the operators would like to open the bucket when they empty it and then maintain the bucket open while it is lowered onto the pile for refilling. Generally the operators like to lower the bucket at a very high speed, including speeds above the normal operating speeds of the motors or at speeds which would be termed hypersynchronous speeds when wound rotor motors are used to drive the holding line and closing line drums. It is well recognized that to maintain the bucket in the open attitude during its lowering at hypersynchronous speeds, as well as at other speeds, the controls of the motors must be so arranged that the motors are operated at speeds which will keep

the bucket open. In the prior devices wherein each motor had its own independent control and its own master switch, this meant that the operator had to carefully manipulate both master switches to keep the bucket in the open attitude. If one motor tended to run faster than the other motor there was the additional problem of trying to regulate the speeds of the motors to obtain the desired results. This problem was often unsurmountable if the load on one of the lines was an overhauling load which would run one motor at a hypersynchronous speed. In such cases it was almost impossible to make the motors cooperate with each other and run at the same speed since there was no means to directly tie the drums or the rotors together to cause them to operate at the same speed in the lowering direction to hold the bucket in the desired single attitude (generally open) throughout the lowering of the bucket into the pile of material. It is thus apparent that one of the objects of the present invention is to provide a control system which overcomes the aforementioned problems and deficiencies in the prior control systems.

Another object of the present invention is to provide an electromagnetic clutch interconnecting the holding line and closing line motors and a control device for controlling the clutch in such manner that the rotors of the two motors rotate together during lowering of the bucket onto a pile of material to maintain the bucket in a single desired attitude during such lowering thereof.

Another object of the present invention is to provide apparatus to tie the rotors of two motors together when they have accelerated to a predetermined speed so that they will rotate simultaneously at speeds above the predetermined speed to lower the load while maintaining the load in a single attitude.

A further object of the invention is to provide a new, useful, and novel control having a single master switch for a two line bucket hoist wherein the two motors are operable independently and/or cooperatively to (1) close a bucket, (2) hoist the closed bucket, (3) empty the bucket and (4) lower the open bucket onto a pile of material while maintaining the bucket open.

A still further object of the invention is to provide a manually operable control means for completely controlling the hoisting, lowering, and attitude of a load, the control means including a multi-position controller and a switch interconnected with the controller for energizing two electric motors and an electromagnetic clutch cooperatively joining the motors.

A still further object of the invention is to provide a control for a two line hoist which is positive in operation, quick in response, and easy to operate.

Further objects and a fuller understanding of the invention will become apparent from the following description of a specific example incorporating the invention and the attached claims directed to the invention, taken in conjunction with the accompanying drawings in which Figures 1, 2, and 3 compositely illustrate a control system for the holding line and closing line motors of a two line bucket hoist, the system including an electromagnetic clutch and a single master switch controlling the clutch and motors.

In the following description, the Figures 1, 2 and 3 will be treated as a single drawing since they compositely illustrate the circuit diagram of a control system which may be used to control a two line bucket hoist incorporating the features of the present invention. It is understood that the present illustration is for the purpose of exemplification and is not intended in any way to limit the scope of the invention either to the specific application illustrated or to the functions obtained thereby. Insofar as possible the relays are illustrated with the relay coils represented by a circle and the contacts operated

thereby are represented by parallel lines. The individual sets of contacts and their operating coils are identified in the drawings either by letters or a combination of letters and numbers with the reference to a respective coil or contacts being identified by the reference of the other plus a suffix. It is further noted that where convenient the letters used as reference characters or identification for a relay coil or relay contacts are to some extent an abbreviation of the function performed by the respective relay in the control system.

In the specific example illustrated in the drawings a two line bucket 10 is adapted to be lowered towards and raised from a pile of material 11. As symbolically illustrated, the bucket 10 is of the clam shell type supported by a closing line 12 attached to the hinge portion of the bucket 10 and wound on a holding line drum 13, and a holding line 14 attached to one of the shells of the bucket at a distance from the hinge and wound on a holding line drum 15. The closing line drum 13 is mechanically interconnected, as indicated by the dash-dot lines 16, to a rotor 17 of a closing line motor CLM and a brake 18. Similarly, the drum 15 is mechanically interconnected as indicated by the dash-dot lines 19 to a rotor 20 of a holding line motor HLM and a brake 21. Interconnecting the rotors 17 and 20 or drums 13 and 15 is an electromagnetic clutch 22, the mechanical connections for which are illustrated in dash-dot lines 23 and 24 which interconnect the clutch 22 with the mechanical linkages 16 and 19, respectively. In the illustrative example, the motors are polyphase induction type motors with respective acceleration controls and with wound rotors constituting secondaries, and with stators constituting primaries connectable to a source through the well known forward and reversing switches.

The holding line motor HLM has its primary side energized from the lines L1, L2 and L3 of a three-phase power supply, the line L1 and L2 including main contacts HM1 and HM2, respectively, of a main contactor and the lines L2 and L3 containing hoist contacts HH1 and HH2, respectively, of a hoist contactor. Electrically interconnected with the hoist contacts HH1 and HH2 are reversing or lowering contacts HL1 and HL2 to provide reversing of the direction of rotation of the rotor 20 by opening the contacts HH1 and HH2 and closing the contacts HL1 and HL2 or vice versa.

The brake 21 is of a standard type spring applied, electrically released brake normally used in hoist applications wherein the brake sets and prevents rotation of the rotor so long as the brake is de-energized and wherein the brake releases the rotor 20 for rotation so long as the brake 21 is energized. The brake 21 is therefore connected across the line L2 and L3 by suitable wires 121 so that the brake will be energized whenever the primary or stator of the holding line motor HLM is energized.

The wound rotor 20 of motor HLM is provided with accelerating resistors, one for each phase, connected in such manner that one end of each resistor is connected to its respective end of the rotors phase windings and the opposite ends of the resistors are electrically connected together. The effective resistance value of the accelerating resistors is changed in the well known and customary manner by providing a plurality of holding line motor acceleration contacts H1A1, H1A2, H2A1, H2A2, H3A1, H3A2, H4A1, H4A2, H5A1, H5A2, H6A1 and H6A2 which interconnect the accelerating resistors at various points along the resistors, and in such manner that part of the resistors are shunted by the contacts when they are closed. Connected in shunt with at least a major portion of one of the accelerating resistors is a series circuit including relay coil HOS of an overspeed relay and a capacitor 26. In shunt with the major portion of the accelerating resistor is a series circuit including an accelerating relay coil H5AR and a condenser 28. The accelerating resistor is at least partially shunted by a series circuit including a relay coil H6AR and a condenser 29. Finally, at least a major portion of the accelerating resistor is shunted by a series circuit including a non-hoist relay coil HNH, an inductor 30 and a set of normally open contacts HH3 of the hoist contactor, and which are closed upon energization of hoist contactor coil HH. Shunting the HNH coil is a condenser 31 and shunting the inductor 30 is a condenser 32.

The closing line motor CLM has its primary side energized from the lines L1, L2 and L3 of a three-phase power supply, the lines L1 and L2 including main contacts CM1 and CM2, respectively, of a main contactor and the lines L2 and L3 containing hoist contacts CH1 and CH2, respectively, of a hoist contactor. Electrically interconnected with the hoist contacts CH1 and CH2 are reversing or lowering contacts CL1 and CL2 to provide reversing of the direction of rotation of the rotor 17 by opening the contacts CH1 and CH2 and closing the contacts CL1 and CL2, or vice versa.

The brake 18 is the same as or similar to brake 21 and is connected across the lines L2 and L3 by suitable wires 118 so that the brake will be energized whenever the primary or stator of the closing line motor is energized.

The wound rotor 17 of motor CLM is provided with accelerating resistors, one for each phase, connected in such manner that one end of each resistor is connected to its respective end of the rotors phase windings and the opposite ends of the resistors are electrically connected together. The effective resistance value of the accelerating resistors is changed in well known and customary manner by providing a plurality of closing line motor acceleration contacts C1A1, C1A2, C2A1, C2A2, C3A1, C3A2, C4A1, C4A2, C6A1 and C6A2, which interconnect the accelerating resistors at various points along the resistors and in such a manner that part of the resistors are shunted by the contacts when they are closed. Connected in shunt with at least a major portion of one of the accelerating resistors is a series circuit including a relay coil COX of an overspeed relay and a condenser 26'. In shunt with the major portion of the same accelerating resistor is a series circuit including an accelerating relay coil C4AR and condenser 27'. In shunt with the major portion of the accelerating resistor is a series circuit including an accelerating relay coil C5AR and a condenser 28'. The accelerating resistor is at least partially shunted by a series circuit including an accelerating relay coil C6AR and a condenser 29'. Finally, at least a major portion of the accelerating resistor is shunted by a series circuit including a non-hoist relay coil CNH, an inductor 30', and a set of normally open contacts CH3 of the hoist conductor and which are closed upon energization of hoist contactor CH. Shunting the CNH coil is a condenser 33, and shunting the inductor 30 is a condenser 34.

The electromagnetic clutch 22 is electrically energized through a set of contacts CC1 of a clutch control relay having a relay coil CC, a full wave rectifier RECT, and a transformer TR, the primary of which is connected across one phase of the incoming power, particularly lines L1 and L2. When the contacts CC1 are closed, the clutch is energized to effectively tie the rotor 17 with rotor 20, and thus drum 13 with drum 15 so that the drums rotate at a speed in the same or in a desired direction relative to each other whereby lines 12 and 14 are paid out at a speed in which the load or bucket will maintain a single attitude during the lowering thereof.

The remainder of the control system for carrying out the present invention comprises a master switch MS and a plurality of relays, each having relay contacts and an operating coil. The master switch MS and the relays which complete the control circuit are interconnected between control energization lines 40 and 41, the line 40 being electrically connected to the power line L2, and the line 41 being electrically interconnected to the power line L3. The multi-position reversing master switch MS

has contacts 45 to 60 inclusive with one side of each set of contacts connected to the line 40. The contacts 45, 48, 53, 56, and 57 are normally closed and the remaining contacts are normally open in the off position. In this instance a master switch having an off position and five hoist and five lowering positions is illustrated. In the first position hoist contacts 49, 50, 52 and 54 are closed. In the second position, hoist contacts 49, 50, 52, 54, and 55 are closed. In the third position, hoist contacts 49, 50, 52, 54, 55, and 57 are closed. In the fourth position, hoist contacts 49, 50, 52, 54, 55, 57, and 58 are closed, and in the fifth position contacts 49, 50, 52, 54, 55, 57, 58, and 59 are closed. When the master switch is moved to the first position lower, only the contacts 47, 48, 53, 56, and 57 are closed. In the second position lower, contacts 47, 48, 53, and 56 are closed. In the third position lower, contacts 47 and 48 are closed, while in the fourth position lower, the contacts 46, 47, 48, and 51 are closed, and finally, in the fifth position lower, the contacts 46, 47, 48, 51, and contact 60 are closed. When the master controller is in one of the hoist or lower positions, closure of a contact is indicated in the drawings by a cross aligned with the respective contact and the respective position. The master switch MS is preferably of the standard and well known drum or cam type controller and necessarily has an operating handle (not shown). The structure of the handle and the master switch has not been detailed since such type master switches are commonly used in the industry.

To insure operation and energization of the motors HLM and CLM and the control system only when there is sufficient voltage in the power lines L1, L2, and L3, there is provided an undervoltage relay including undervoltage relay coil HUV and the respective normally open contacts HUV1. The contacts HUV1 are inserted in series in the line 40 between the connection of the master controller contacts 45 to the line 40 and the connection of the master controller contacts 46 to the line 40. The operating coil HUV is inserted in series with the contacts 45 and a normally closed hoist limit switch HLS and across the lines 40 and 41. Since contacts 45 are open when the master switch is in any of the hoist and lowering positions, a wire 61 interlocks the contacts 45 and the contacts HUV1 so that power is continued to the relay coil HUV after the contacts HUV1 have been closed and the master switch is moved from the off position to any of the hoist or lower positions. Shunting the hoist limit switch HLS are normally closed holding line motor hoist contacts HH4, which are operated with the hoist contactors HH1 and HH2.

Connected in series with the master switch contacts 46 and between the lines 40 and 41 are relay contacts H6A3, relay contacts C6A3, and the clutch control coil CC. Shunting the clutch control relay coil CC is a time delay relay coil CTDR. Connected in series with the master switch contacts 47 and between the lines 40 and 41 are holding line motor normally open lowering contacts HL3, normally closed non-hoist contacts HNH1, closing line motor normally closed non-hoist contacts CNH1, a contra-torque relay operating coil HCTR and the aforementioned normally closed holding line motor hoist contactor contacts HH4. A normally closed clutch limit switch CLS is electrically interconnected from a point between the contacts HL3 and the contacts HNH1 to a point between the contacts C6A3 and the coil CC. For purposes of description, the point or portion of the circuit between the contra-torque relay coil HCTR and the hoist contactor contacts HH4 will be given reference character 62.

Interconnected in series with the normally closed master switch contacts 48 and between the line 40 and the electrical connection 62 are contra-torque open contacts HCTR1 and HCTR2, and normally closed hoist holding line motor acceleration relay coil H1A. It is noted that electrically the point of connection between the contacts HL3 and HNH1 and the point of connection between the contacts HCTR1 and HCTR2 is a single electrical point. Shunting the normally closed contacts HHR1 and the H1A relay operating coil are contacts H1A3 in series with holding line motor main contactor operating coil HM. Shunting the normally open contacts H1A3 are normally closed digging limit switch contacts DLS. Continuing the design of the circuit, it is noted that the off position open master switch contacts 49 are connected in series with normally closed digging relay contacts HDR1, the limit switch DLS and the operating coil HM and between the line 40 and the point 62.

Shunting the relay contacts HCTR1, HCTR2, HHR1, and relay coil H1A are normally open digging relay contacts HDR2, normally open closing line motor lowering contactor contacts CL3, normally closed non-hoist relay contacts CNH2, normally closed non-hoist relay contacts HNH2, and time delay relay coil CCTR. Shunting the contacts HDR2 and CL3 are normally open time delay relay contacts CCTR1 and shunting the contacts CNH2, contacts HNH2, and the coil CCTR are time delay relay contacts CCTR2 and closing line motor main contactor coil CM. A wire 63 also connects the electrical point between the switch contacts 47 and the contacts HL3 with a point between the contacts HDR2 and the contacts CL3. Also normally open clutch control relay contacts CC2 are interconnected from a point between the contacts C6A3 and the coil CC to a point between the contacts CL3 and CNH2. The master switch contacts 50 are interconnected between the line 40 and a point between the contacts CCTR2 and the coil CM.

There is provided a pushbutton TB, which is normally open and which may be closed when desired to cause an opening of the bucket 10. The pushbutton TB is connected in series with contra-torque relay contacts HCTR3 and digging relay coil HDR between the lines 40 and 41. There is also provided a button type switch HB which is normally positioned in the control handle of the master switch MS and which may be closed for causing the bucket to open to empty itself. This button switch HB is connected in series with normally closed contacts HCTR4 and a hoist holding relay operating coil HHR and between the lines 40 and 41. The master switch contacts 51 are connected in series with normally open lowering relay contacts HLR1, normally closed hoist contactor contacts HH5 and lowering contactor operating coil HL between the lines 40 and 41. Shunting the contacts HLR1, contacts HH5 and coil HL are normally closed digging relay contacts HDR3, normally closed hoist holding relay contacts HHR2, and lowering relay coil HLR, all of which are connected in series. Similarly, lowering contactor normally open contacts CLR1, hoist contactor contacts CH4, and lowering contactor coil CL, all of which are connected in series, shunt the series including contacts HLR1, HH5, and coil HL. A lowering relay operating coil CLR is further connected in shunt with the contacts HLR1, contacts HH5 and the coil HL.

The master switch contacts 52 are connected in series with normally closed holding line motor lowering contactor contacts HL4 and hoist contactor coil HH between the lines 40 and 41. Shunting the master switch contacts 52 are normally closed lowering relay contacts HLR2 and normally open contra-torque contacts HCTR5 and normally open main contactor contacts HM3. There is further interconnected in series and between the lines 40 and 41 normally closed lowering relay contacts CLR2, normally open contra-torque relay contacts CCTR3, normally open main contactor contacts CM3, normally closed lowering contactor contacts CL3, and the hoist contactor coil CH. Connected in series with the master switch contacts 53 are normally open contra-torque relay contacts H2CR1 and the acceleration contactor coil C1A. The master switch contacts 54 shunt the series connection

of the master switch contacts 53 and the contacts CCTR4. It is also noted that a set of contacts HDR4 interconnect a point between the switch contacts 53 and the relay contacts CCTR4, and a point between the switch contacts 51 and the lowering relay coil CLR. The drawing further illustrates normally open timing relay contacts CTR1, overspeed relay contacts HOS1 and COS1 which are connected in parallel with each other and from a point between the switch contacts 54 and the relay contacts H2CR1 to a point between the contacts CM3 and CL3. Normally open lowering contactor contacts CL4 shunt the master switch contacts 54 and normally open control relay contacts H1CR1 shunt the contacts H2CR1.

The master switch contacts 55 are connected in series with normally open main contactor contacts HM4 and an accelerating contactor coil H2A and between the lines 40 and 41. Shunting the master switch contacts 55 are normally open lowering contacts HL5. Also shunting the series connection of the contacts 55 and HM4 are the contacts 52 and relay contacts HOS2, the contacts HOS2 in turn being shunted by relay contacts COS2.

The normally closed master switch contacts 56 are connected in series with normally open contra-torque relay contacts HCTR6, normally closed contra-torque relay contacts CCTR5, normally open main contactor contacts CM4, and acceleration contactor coil C2A, all of which are interconnected between the lines 40 and 41. In addition, the master switch contacts 55 shunt the master switch contacts 56 and the normally closed contacts HCTR6.

The master switch contacts 57 are connected in series with the acceleration contactor contact H2A3 and the acceleration contactor coil H3A and between the lines 40 and 41. Shunting the contacts H2A3 and the coil H3A is a series circuit including normally closed contra-torque relay contacts CCTR6, normally open acceleration contactor contacts C2A3, and the acceleration contactor coil C3A. Lowering relay contacts HLR3 shunt the master switch contacts 57.

The master switch contacts 58 are connected in series with normally closed accelerating relay contacts H4AR1, normally closed control relay contacts H2CR2, and the acceleration contactor coil H4A. Shunting the master switch contacts 58 are normally open lowering relay contacts HLR4, and shunting the contacts H4AR1 and H2CR2 are the normally open control relay contacts H1CR2. Also shunting the relay contacts H4AR1, H2CR2 and the coil H4A are normally closed acceleration relay contacts C4AR1 and acceleration contactor coil C4A.

The master switch contacts 59 are connected in series with normally closed acceleration relay contacts H5AR1 and acceleration contactor coil H5A, and between the lines 40 and 41. Shunting the relay contacts H5AR1 and the coil H5A are a plurality of shunt circuits, one of which comprises acceleration relay contacts C5AR1 and the acceleration contactor coil C5A, another of which comprises the acceleration relay contacts H6AR1 and an acceleration contactor coil H6A, and a third of which comprises normally open control relay contacts H1CR3, normally open control relay contacts H2CR3, and control relay coil H1CR. Shunting the contacts C5AR1 and the coil C5A are normally closed time delay relay contacts CTDR1, normally closed accelerating relay contacts C6AR1, and the acceleration contactor coil C6A. In addition, acceleration relay contacts H5AR2 shunt the contacts H1CR3, and normally open accelerating relay contacts C5AR2 also shunt the contacts H1CR3. It is noted that a set of normally open lowering relay contacts HLR5 shunt the master switch contacts 59.

This part of the control circuit is completed by including in cooperative arrangement with the aforementioned coils and contacts, lowering relay contacts CLR3, CLR4, CLR5, CLR6, and contra-torque relay contacts CCTR7. The contacts CLR3 are connected between the line 40 and a point between the contacts CCTR5, and the contacts CM4 which are connected in series with the master switch contacts 56. The normally open contra-torque contacts CCTR7 are connected to a point between the master switch contacts 57 and the switch contacts H2A3 and the aforementioned point between the contacts CCTR5 and the contacts CM4, which were in series with the master switch contacts 56. The contacts CLR4 are connected in shunt with the contacts 57 of the master switch MS and the relay contacts CCTR6. Similarly the contacts CLR5 are connected in shunt with the master switch contacts 58 and the contacts CLR6 are connected in shunt with the master switch 59.

The system is completed by connecting the normally open master switch contact 60 in series with time delay relay contacts CTDR2 and control relay coil H2CR and between the lines 40 and 41.

Having thus described the physical construction of the circuit and the relays and contactors and master switch used herein, as well as the electromagnetic clutch and motors, the operation of the circuit will now be described.

Operation

The operation of the system is best understood by starting with the bucket 10 open and resting on the material pile 11 and with the master switch MS in the Off point. The digging limit switch DLS is closed when the bucket 10 is at the pile of material 11, or what is called the digging zone. The undervoltage relay coil HUV is energized by closed master switch contacts 45 to close its contacts HUV1, which establish a circuit through wire 61 and around contacts 45. Moving the master switch MS to the first point hoist and closing the push-button HB in the hoist handle energizes the contactor coils CM, CH, and C1A to close their respective contacts CM1, CM2, CM3, CM4, CH1, CH2, CH3, C1A1 and C1A2 to give a relatively large (normally 50%) torque on the closing line motor CLM which will then start closing the bucket 10 by its rotor 17 turning drum 13 to reel in line 12. The closing line motor CLM is accelerated by the successive closing of contacts C2A1, C2A2, C3A1, C3A2, C4A1, C4A2, C5A1, C5A2, C6A1 and C6A2 in accordance with normal well known procedures for accelerating wound rotor type motors.

At this same time, contactor coils HM, HH, and relay HHR (controlled by push button HB) are also energized, causing coil HM to close contacts HM1, HM2, HM3, and HM4, causing coil HH to close contacts HH1, HH2, HH3, and open contacts HH4 and HH5, and causing coil HHR to open contacts HHR1 and HHR2. Opening of contacts HHR1 prevents energization of acceleration contactor coil H1A, thereby holding acceleration contacts H1A1, H1A2, and H1A3 open. In remaining open, the acceleration contacts H1A2 prevent the energization of acceleration contactor coils H2A, H3A, H4A, H5A, and H6A and thus prevents acceleration of the motor HLM. This gives a very small (usually 10%) torque to the holding line motor HLM to allow the bucket 10 to settle while digging and without allowing cable or line 14 to become slack.

If the bucket 10 starts to tip over during digging, the holding line motor HLM can be stopped to stop rotation of rotor 20 and drum 15 by closing the pushbutton TB, which is usually placed in one of the handles of the trolley operating controls (not shown). Closing push-button TB causes energization of coil HDR, thereby opening contacts HDR1 and effecting de-energization of contactor coil HM to open contacts HM1 and HM2. With lack of current in lines L1, L2, and L3, the holding line brake sets while pushbutton TB is closed. As soon as the bucket 10 is again leveled, the button TB is released and opened thus restoring the normal bucket closing operation and circuits under the control of master switch MS and button HB.

When the bucket 10 is closed, i.e. reaches its closed attitude, the pushbutton HB is released and opened, de-energizing hoist holding relay coil HHR and thereby closing hoist holding relay contacts HHR1, thereby energizing acceleration contactor coil H1A which closes contacts H1A1 and H1A2. This permits the remaining accelerating contactors for the holding line motor HLM to be operated in the well known manner, the same as the closing line motor CLM. The bucket 10 will then be hoisted with both motors HLM and CLM sharing the load of the filled bucket, until either the hoist limit switch HLS is tripped, or the master switch MS is moved to the Off point.

To open the bucket, the master switch MS is moved to the fourth point lower and the pushbutton HB in the hoist master switch handle is closed. The master switch contacts S1 are closed in the fourth point lower to effect energization of lowering relay coil CLR, the closing of its contacts CLR1 to energize lowering coil CL, whereupon normally open contacts CL1, CL2 and CL3 close. Upon closure of contacts CL3, contra-torque relay coil CCTR is energized through normally closed contacts CNH2 and HNH2 and master switch contacts 47. Energizing coil CCTR closes contra-torque relay contacts CCTR1 and CCTR2, thereby energizing main contactor coil CM to close contacts CM1 and CM2 in lines L1 and L2. At this same time, the lowering relay coil CLR is energized through master switch contacts 51 to close contacts CLR1 and energize lowering contactor coil C1, which, in turn, closes contacts CL1 and CL2. Closure of contacts CM1, CM2, CL1 and CL2 connects motor CLM to lines L1, L2, and L3 releases brake 18 and cause rotation of rotor 17 in the lowering direction. Also closure of contacts CL4 and CLR3 permit energization of acceleration contactor coils C1A and C2A and acceleration of the rotor in a normal manner so that it will rotate drum 13 in a direction to pay out line 12 and open bucket 10. During this time, the holding line motor HLM is held still by brake 21 and hoist holding relay contacts HHR2 (coil HHR being maintained energized by the pushbutton HB in the hoist master switch handle) being open, thereby keeping lowering relay coil HLR de-energized. So long as coil HLR is de-energized, its contacts HLR1 prevent closing of contacts HL1 and HL2 by preventing energization of lowering contactor coil HL and this prevents energization of motor HLM.

After the bucket reaches its open attitude, the operator releases and thus opens the pushbutton HB, effectively de-energizing the hoist holding relay coil HHR which, in turn, allows the contacts HHR1 and HHR2 to close. When contacts HHR2 close, a circuit is established through master switch contacts 51 and normally closed contacts HDR3 to energize lowering relay coil HLR which, in turn, closes contacts HLR1 to energize lowering contactor coil HL and thereby close contacts HL1, HL2, and HL3 and open contacts HL4. With contacts HL3 now closed, a circuit is established through master switch contacts 47 to energize contra-torque relay coil HCTR which, in turn, closes contra-torque contacts HCTR1 and HCTR2. This establishes a circuit through the master switch contacts 48, contacts HCTR1, HCTR2, normally closed contacts HHR1, and acceleration contactor coil H1A, to energize the coil H1A. Energization of coil H1A effects a closure of contacts H1A1, H1A2, and H1A3 with the contact H1A3 establishing energization of the main contactor coil HM. Upon energization of the main contactor coil HM, the main contacts HM1 and HM2 are closed, whereupon the brake 21 is released and the holding line motor HLM energized so that its rotor 20 rotates drum 15 in the lowering direction to pay out line 14. Since the contacts HL5, HLR3, HLR4, and HLR5 are also now closed, the holding line motor HLM accelerates to full speed in the lowering direction upon sequential energization of the accelerating contactors H2A, H3A, H4A, H5A, and H6A.

When the accelerator contacts close, a circuit is established through master switch contacts 46 to energize the clutch control relay coil CC, which closes contacts CC1 to energize clutch 22 and tie the two motors HLM and CLM together. Timing relay coil CTDR is also energized when coil CC is energized and after a brief (usually ½ second) time delay, the normally closed contacts CTDR1 open and de-energize acceleration contactor coil C6A. The time delay permits the magnetic clutch 22 to build up to its maximum torque. The de-energizing of acceleration contactor coil C6A reduces the regenerative torque of the closing line motor CLM. This limits the torque transmitted through the magnetic clutch to a maximum value (usually within the 50% of full load torque of one motor). The bucket will then be lowering with the two motors synchronized at a speed which, due to the weight of the bucket 10, is slightly higher than synchronous speed, and with clutch 22 maintaining the bucket in a single attitude (in this instance open).

Moving the master switch MS to fifth point lower causes contacts 60 to energize control relay coil H2CR and effect the closing of the contacts H2CR3 and opening of contacts H2CR1 and H2CR2. Opening contacts H2CR2 de-energizes contactor coil H4A, and opening contacts H2CR1 de-energizes contactor coil C1A. With contactor coils H4A and C1A de-energized, coils H5A, H6A, C2A, C3A, C4A, C5A, and C6A will become de-energized and the respective acceleration contacts will open to effectively increase the accelerating resistors to their larger resistance value. This will cause the motors HLM and CLM to rotate at hyper-synchronous speed in the lowering direction, usually at about 150% speed of the motors, thereby rapidly lowering the bucket 10 towards pile 11 with clutch 22 maintaining the bucket in a single attitude. It is also noted that the closure of relay contacts H2CR3 also establishes a circuit for energizing the control relay coil H1CR. If overspeeding occurs, the frequency responsive accelerating relays H5AR and C5AR are energized to close their contacts H5AR2 and C5AR2 to energize the relay coil H1CR. The energization of control relay coil H1CR closes contacts H1CR1, H1CR2, and H1CR3 to return the motors HLM and CLM to synchronous speed in event the bucket 10 overspeeds during lowering. Contacts H1CR1 and H1CR2 then close and energize the accelerating contactors C1A and H4A and close contacts C1A1, C1A2, H4A1, and H4A2, respectively, to slow the bucket 10 down and return the motors to synchronous speed. De-celeration of the motors is controlled through the frequency responsive acceleration relays H4AR, H5AR, H6AR, C4AR, C5AR, and C6AR. The relay coil H1CR is then maintained energized through its own contacts H1CR3, and the motors remain near synchronous speed for the rest of the lowering cycle. This is desirable since an overload condition is indicated, and the control is prevented from oscillating between slowing down and overspeeding.

When the bucket approaches the material pile, and assuming that the master switch is in the fifth point lower without an overspeed condition existing, slowing down is achieved by moving the master switch back to fourth point lower, which de-energizes relay coil H2CR by the opening of the master switch contacts 60. De-energizing coil H2CR opens contacts H2CR1, H2CR2, and closes contacts H2CR3 to energize coil H1CR and return the motors to synchronous speed in the same manner as explained for an overspeed condition. Moving the master switch back to third point lower applies counter torque to supply stronger braking of both motors. This is accomplished by the de-energization of the lowering relay and contactor coils HLR, CLR, HL and CL through the opening of master switch contact 51. Contacts HLR1, HLR3, HLR4, HLR5, CLR1, CLR3, CLR4, CLR5, CLR6, HL1, HL2, HL3, HL5, CL1, CL2, and CL4 are thus returned to open position, and contacts HLR2, CLR2, HL4, CL3 are returned to closed position. Also

frequency responsive relay coils H4AR, H5AR, H6AR, C4AR, C5AR, and C6AR respond to allow their contacts H4AR1, H5AR1, H6AR1, C4AR1, C5AR1 and C6AR1 to open, thereby de-energizing acceleration contactor coils H4A, H5A, H6A, C4A, C5A and C6A. Upon closing of contacts HL4 and CLR2, CCTR3 and CM3, the contactor coils HH and CH are energized to close contacts HH1, HH2, CH1, and CH2, respectively, to energize motors HLM and CLM in a hoisting direction. At this time, relay coils HCTR and CCTR remain energized through their own contacts HCTR2 and CCTR2. Contactor coils HM and CM remain energized by current flow through contacts HCTR2 and CCTR2. Hoisting power is now applied to both motors HLM and CLM with contactor coil H1A energized and acceleration contacts H1A1 and H1A2 on the holding line motor HLM closed, and with all accelerator contacts on the closing line motor CLM open. This will slow the bucket to a slow speed, usually approximately 20% of its synchronous speed.

Moving the master switch MS to second point lower will effect energization of contactor coils H1A and C1A, thereby closing acceleration contacts H1A1, H1A2, C1A1, and C1A2 to increase the braking torques for a faster slowdown. The torque on this point should be sufficient to stop the movement of the bucket towards the pile, however faster torque braking may be obtained by moving the master switch to first point lower, effectively energizing contactor coils H3A and C2A and thereby closing contacts H3A1, H3A2, C2A1, and C2A2 to provide the strongest counter torque for fast stops. If the operator sees that he is going to stop short of the pile, he can move the master switch back to third point lower, which will allow the bucket to slowly lower onto the pile.

In event the master switch is pulled to the Off point quickly from one of the lower points, the motors will have counter torque applied and will bring themselves to a stop before setting of the magnetic brakes 18 and 21. This is accomplished by the non-hoist relay coils HNH and CNH remaining inoperative so long as the rotors are turning. The normally closed contacts HNH1, HNH2, CNH1 and CNH2, in circuit with coils HCTR and CCTR, remain closed until the rotors 17 and 20 are at a virtual standstill, at which time coils HNH and CNH become energized and contacts HNH1, HNH2, CNH1, and CNH2 open. It is also noted that the clutch control relay coil CC is also energized so long as the non-hoist relay contacts HNH1 and CNH1 are closed to insure the bucket remaining in the open attitude as the motors HLM and CLM stop.

For the operator's convenience, the bucket can also be opened by use of the pushbutton TB, which is usually placed in the master switch of the controls for a trolley used to transport the bucket horizontally away from the pile. As the bucket runs over a hopper or other place of depositing the contents thereof, depressing and closing the pushbutton TB opens the bucket 10, providing master switch MS is in the off, first or second point lower positions. In these positions, the hoist master switch MS has no effect since the control is inoperative.

When the pushbutton TB is closed, the relay coil HDR is energized and contacts HDR2 and HDR4 are closed, energizing the relay coil CLR which effects the energization of the closing line motor CLM and thus the opening of the bucket in a manner as previously described. Also, closing contact HDR2 energizes the relay coil CCTR and the contactor coil CM, thereby permitting the lowering sequence to be completed. At this same time, the relay contacts HDR3 are open to keep the relay coil HLR from being energized to prevent the holding line from running.

While in the embodiment of the present invention disclosed for the purposes of illustration, alternating current polyphase induction motors are used, obviously other types of motors can be substituted therefor without departing from the invention as set forth in the objects and defined in the claims.

I claim:

1. A device for lowering a load suspended by spaced first and second lines from an elevated position towards a mass by paying out said lines and for maintaining said load at a predetermined attitude relative to the mass during the lowering thereof towards the mass, said device comprising, a first motor provided with a rotor for paying out the first line, a second motor provided with a rotor for paying out the second line, energizing means for selectively energizing said motors independently of each other, first means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said first motor in a lowering direction to pay out the first line, second means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said second motor in a lowering direction to pay out the second line, a first acceleration control in circuit with said first motor to accelerate the rotor of the first motor to a predetermined speed and independently of said second motor, a second acceleration control in circuit with said second motor to accelerate the rotor of the second motor to a predetermined speed and independently of said first motor, an electromagnetic clutch inter-associating the rotors of said first and second motors and energizable to clutch the rotors together for rotation together and deenergizable to unclutch the rotors so that one rotor may rotate independently of the other rotor, and circuit means responsive to said first and second acceleration controls to energize said clutch upon the rotors reaching said predetermined speed of rotation in the lowering direction to cause the rotors to rotate together in said lowering direction whereby the first and second lines are simultaneously paid out to lower the load while maintaining the load in a single attitude throughout the lowering thereof.

2. The structure as defined in claim 1 wherein said rotors are wound rotors and said acceleration controls are in circuit with their respective ones of said rotors.

3. The structure of claim 2 wherein each of said acceleration controls include acceleration resistors and said circuit means includes a frequency responsive relay for each rotor, each said relay having a frequency responsive coil in circuit with its respective resistor and relay contacts in said circuit means.

4. A material handling device comprising spaced first and second lines, a first motor provided with a wound rotor for paying out the first line, and a second motor provided with a wound rotor for paying out the second line, a bucket suspended by said lines and responsive to movement of one of said lines relative to the other of said lines to attain various attitudes including an open attitude in which the bucket will dig into a pile of material and a closed attitude in which the bucket will carry material from said pile of material, said bucket having a bucket weight sufficient to overhaul said motors and cause the rotors to rotate at speeds above predetermined speeds of the motors during lowering of the bucket onto a pile of material, energizing means for selectively energizing said motors independently of each other, first means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said first motor in a lowering direction to pay out the first line, second means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said second motor in a lowering direction to pay out the second line, a first acceleration control in circuit with the wound rotor of said first motor to accelerate the first motor to a predetermined speed and independently of said second motor, a second acceleration control in circuit with the wound rotor of said second motor to accelerate the second motor to a predetermined speed and independently of said first motor, an electro-

magnetic clutch inter-associating the rotors and energizable to clutch the rotors together for rotation together and de-energizable to unclutch the rotors so that one rotor may rotate independently of the other rotor, and circuit means responsive to said first and second acecleration controls to energize said clutch upon the rotors of said motors reaching said predetermined speed of rotation in the lowering direction to cause the rotors to rotate together in said lowering direction at speeds above said predetermined speed whereby the first and second lines are simultaneously payed out to lower the bucket while maintaining the bucket in a single attitude throughout the lowering thereof onto the pile of material.

5. The structure as defined in claim 4 wherein the motors are alternating current motors and each of said acceleration controls include acceleration resistors and said circuit means includes a frequency responsive relay for each rotor, each said relay having a frequency responsive coil in circuit with its respective resistor and relay contacts in said circuit means.

6. A material handling device comprising spaced first and second lines, a first induction motor provided with a wound rotor for winding in and paying out the first line, a second induction motor provided with a wound rotor for winding in and paying out the second line, a bucket suspended by said lines and responsive to movement of one of said lines relative to the other of said lines to attain various attitudes including an open attitude in which the bucket will dig into a pile of material and a closed attitude in which the bucket will carry material from said pile of material, said bucket having a bucket weight sufficient to overhaul said motors and cause the rotors to rotate at speeds above the rated synchronous speeds of the motors during lowering of the bucket onto a pile of material, energizing means for selectively energizing said motors independently of each other and with alternating current, first means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said first motor in a hoisting direction to wind in the first line and to rotate the rotor of said first motor in a lowering direction to pay out the first line, second means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said second motor in a hoisting direction to wind in the second line and to rotate the rotor of said second motor in a lowering direction to pay out the second line, a first acceleration control in circuit with the wound rotor of said first motor to accelerate the first motor in both directions independently of said second motor, a second acceleration control in circuit with the wound rotor of said second motor to accelerate the second motor in both directions independently of said first motor, a multi-position master controller inter-associated with said first and second means and said acceleration controls, said master controller being operative in a first of said positions to cause said first means to de-energize the first motor and said second means to energize the second motor to rotate the rotor thereof to wind in the second line while said first line remains relatively stationary to effect a closed bucket attitude, said master controller being operative in a second of said positions to cause said first and second means to energize said first and second motors to rotate the rotors thereof in said hoist direction to wind in the first and second lines to hoist the bucket while maintaining the bucket in said closed attitude, said master controller being operative in a third position to cause said first means to de-energize the first motor and said second means to energize the second motor to rotate the rotor of the second motor in the lowering direction to pay out the second line while said first line remains relatively stationary to change the bucket from said closed attitude to an open bucket attitude, said master controller being operative in a fourth position to cause said first and second means to energize said first and second motors to rotate the rotors thereof in said lowering direction to pay out the first and second lines and lower the bucket, an electromagnetic clutch inter-associating the rotors and energizable to clutch the rotors together for rotation together and de-energizable to unclutch the rotors so that one rotor may rotate independently of the other rotor, and circuit means responsive to said master control while said master control is in said fourth position and said acceleration controls to energize said clutch upon the rotors of said motors reaching a predetermined speed of rotation in the lowering direction to cause the rotors to thereafter rotate together in said lowering direction at speeds above said predetermined speed whereby the first and second lines are simultaneously payed out to lower the bucket while maintaining the bucket in a single attitude throughout the lowering thereof onto a pile of material.

7. The structure as defined in claim 6 wherein each of said acceleration controls includes acceleration resistors and said circuit means includes a frequency responsive relay for each rotor, each said relay having a frequency responsive coil in circuit with its respective resistor and relay contacts in said circuit means.

8. The structure as defined in claim 6 wherein each of said acceleration controls includes acceleration resistors, shunt means progressively shunting out said resistors as the speed of the respective rotors increases, and deceleration means in circuit with at least one of said acceleration resistors and said master controller and responsive to the speed of the rotors reaching a certain speed when said master controller is in said fourth position to effect an increase in the acceleration resistance to limit the speed of payout of the lines during lowering of the bucket when the bucket is overhauling the motors.

9. The structure as defined in claim 6 including a clutch limit switch means in said circuit means and operative while the bucket is in close proximity with the pile of material to keep the clutch energized while the master control is moved from one position to another position.

10. A material handling device comprising spaced first and second lines, a first induction motor provided with a wound rotor for winding in and paying out the first line, a second induction motor provided with a wound rotor for winding in and paying out the second line, a bucket suspended by said lines and responsive to movement of one of said lines relative to the other of said lines to attain various attitudes including an open attitude in which the bucket will dig into a pile of material and a closed attitude in which the bucket will carry material from said pile of material, said bucket having a bucket weight sufficient to overhaul said motors and cause the rotors to rotate at speeds above the rated synchronous speeds of the motors during lowering of the bucket onto a pile of material, energizing means for selectively energizing said motors independently of each other and with alternating current, first means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said first motor in a hoisting direction to wind in the first line and to rotate the rotor of said first motor in a lowering direction to pay out the first line, second means in circuit with said energizing means and operable to cause said energizing means to rotate the rotor of said second motor in a hoisting direction to wind in the second line and to rotate the rotor of said second motor in a lowering direction to pay out the second line, a first acceleration control in circuit with the the wound rotor of said first motor to accelerate the first motor in both directions independently of said second motor, a second acceleration control in circuit with the wound rotor of said second motor to accelerate the second motor in both directions independently of said first motor, manually operable master control means including a switch and a multi-position master controller inter-associated with said first and second means and said acceleration controls, said switch having an operative and an inoperative position, said master control means being

operative when said controller is in a first of said positions to cause said first means to de-energize the first motor and said second means to energize the second motor to rotate the rotor thereof to wind in the second line while said first line remains relatively stationary to effect a closed bucket attitude, said master control means being operative when said controller is in a second of said positions to cause said first and second means to energize said first and second motors to rotate the rotors thereof in said hoist direction to wind the first and second lines to hoist the bucket while maintaining the bucket in closed attitude, said master control means being operative when said controller is in a third position and said switch is in operative position to cause said first means to de-energize the first motor and said second means to energize the second motor to rotate the rotor of the second motor in the lowering direction to pay out the second line while said first line remains relatively stationary to change the bucket from said closed attitude to an open bucket attitude, said master control means is operative when said controller is in one of said positions and said switch is in inoperative position to cause said first and second means to energize said first and second motors to rotate the rotors thereof in said lowering direction to pay out the first and second lines and lower the bucket, an electromagnetic clutch inter-associating the rotors and energizable to clutch the rotors together for rotation together and de-energizable to unclutch the rotors so that one rotor may rotate independently of the other rotor, and circuit means responsive to said master control means and said acceleration controls when said master controller is in said one of said positions and said switch is in said inoperative position to energize said clutch upon the rotors of said motors reaching a predetermined speed of rotation in the lowering direction to cause the rotors to thereafter rotate together in said lowering direction at speeds above said predetermined speed whereby the first and second lines are simultaneously payed out to lower the bucket while maintaining the bucket in a single attitude throughout the lowering thereof onto a pile of material.

11. The structure as defined in claim 10 wherein each of said acceleration controls includes acceleration resistors and said circuit means includes a frequency responsive relay for each rotor, each said relay having a frequency responsive coil in circuit with its respective resistor and relay contacts in said circuit means.

12. The structure as defined in claim 10 wherein each of said acceleration controls include acceleration resistors, shunt means progressively shunting out said resistors as the speed of the respective rotors increase, and deceleration means in circuit with at least one of said acceleration resistors and said master controller and responsive to the speed of the rotors reaching a certain speed when said master controller is in one of said positions and said switch is in said inoperative position to effect an increase in the acceleration resistance to limit the speed of payout of the lines during lowering of the bucket when the bucket is overhauling the motors.

13. The structure as defined in claim 1 wherein the motors are wound rotor motors.

14. The structure as defined in claim 13 wherein the wound rotor motors are induction motors.

15. The structure as defined in claim 5 wherein the motors are induction motors.

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