CLASS 6131 FRONTLINE® DC HOIST SINGLE MOTOR CONTROLLER

INTRODUCTION

Class 6131 dc dynamic lowering hoist controllers described in this service bulletin are rated for use on 230 volt dc systems. They are used with dc series wound motors on crane hoist drives without mechanical load brakes.

DESCRIPTION

The dc dynamic lowering hoist controller consists of the equipment listed below. Additional equipment may be supplied for a specific installation.

1 — Two pole unfused main line knife switch with padlock clip (LSW).
1 — Two pole fused control circuit knife switch with padlock clip (CSW).
4 — Single pole contactors with mechanical interlocks for hoisting and lowering (H, 1L, 2L, 3L).
1 — Single pole spring-closed dynamic lowering contactor (DB).
3 — Single pole acceleration contactors (1A, 2A, 3A).
2 — Static acceleration timers (1AR, 2AR).
1 — Undervoltage relay (UV).
1 — Voltage relay for acceleration lowering (VR).
1 — Limit switch relay (LSR).
2 — Magnetic overload relays — one instantaneous (1OL) and one inverse time (2OL).

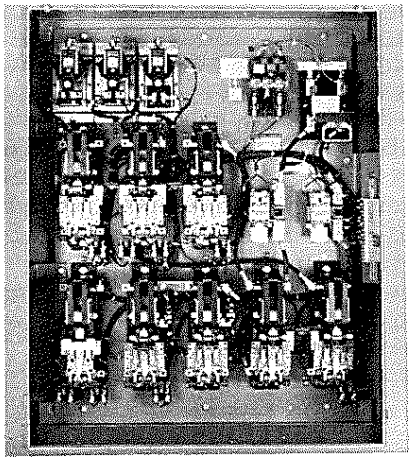
The following equipment is not supplied as part of the controller but is required for a complete set of control. They are for separate mounting:

1 — Set of Class 6715 TAB-WELD® acceleration resistors.
1 — Class 9004 master switch.
1 — Class 5010 series wound brake.
1 — Class 6170 YOUNGSTOWN® power limit switch and resistor or a control circuit limit switch.

PRECAUTIONS

The following list of recommended "PRECAUTIONS" must be studied and followed during installation, operation and servicing of the equipment.

WARNING: POWER MUST BE DISCONNECTED PRIOR TO PERFORMING ANY INSTALLATION. WHEN PERFORMING MAINTENANCE AND/OR TESTING ON THE CONTROLLER, EXTREME CAUTION MUST BE EXERCISED IN VIEW OF THE PRESENCE OF HAZARDOUS VOLTAGE. ALL METAL PARTS OF THE CONTACTORS, RELAYS AND OTHER DEVICES MAY BE AT LINE VOLTAGE. ALL POWER SHOULD BE DISCONNECTED WHEN CONNECTING METERS, MAKING INSPECTIONS OR PERFORMING OTHER PROCEDURES WHICH MAY EXPOSE PERSONNEL TO ACCIDENTAL CONTACT WITH LIVE ELECTRICAL PARTS.



NOTE: THIS SERVICE BULLETIN COVERS THE SERVICING OF BASIC CONTROLLERS. FOR CONTROLLERS HAVING VARIATIONS FROM THE BASIC CONTROLLERS, BE SURE TO REFER TO THE APPLICABLE CONTROLLER DRAWINGS TO DETERMINE HOW TO PROCEED SAFELY IN PERFORMING TROUBLESHOOTING AND MAINTENANCE.

1. Read this service bulletin prior to installing or operating the equipment.
2. If hoist controllers are to be stored prior to installation, they must be protected from the weather and be kept free of condensation and dust.
3. Be sure all contactor arc chutes are in place before operating controller.
4. Only authorized personnel should be permitted to operate or service the controllers.

INSTALLATION

1. Unpack the controller carefully; check nameplate data for correct equipment.
2. Make a thorough inspection of all controller equipment to insure that all parts are undamaged. Remove shipping tape (if used).
3. Bolt the controller to the floor or to a vertical surface.
4. Master switch, brake, acceleration resistors and power or control limit switch should also be rigidly mounted after equipment is verified correct and undamaged.

WARNING: INCOMING LINE POWER TO THE CONTROLLER MUST BE DE-ENERGIZED BEFORE PROCEEDING.

5. Check that both the main line knife switch (LSW) and control circuit knife switch (CSW) in the controller are open. Wire all external circuits to the controller in accordance with the wiring diagram making sure to observe polarity shown.

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CAUTION: TWO COLLECTOR SHOES ARE RECOMMENDED FOR THE Y1 MOTOR CIRCUIT CONNECTION TO INSURE CONTINUITY OF THE MOTOR ARMATURE CIRCUIT. LOSS OF CONTINUITY OF THE MOTOR ARMATURE CIRCUIT DURING LOWERING WILL RESULT IN LOSS OF RETARDING MOTOR TORQUE AND THE BRAKE WILL NOT SET UNLESS THE MASTER SWITCH IS RETURNED TO THE OFF POSITION.

START-UP AND ADJUSTMENTS

1. Check that both the main line knife switch (LSW) and control circuit knife switch (CSW) are open.

WARNING: WHEN OPENING THE KNIFE SWITCHES, ALWAYS OPEN THE CONTROL CIRCUIT KNIFE SWITCH (CSW) BEFORE OPENING THE MAIN LINE KNIFE SWITCH (LSW).
NEVER OPEN LSW IF CSW IS CLOSED.
WHEN CLOSING THE KNIFE SWITCHES, FIRST CLOSE THE MAIN LINE KNIFE SWITCH (LSW) AND THEN CLOSE THE CONTROL CIRCUIT KNIFE SWITCH (CSW).
NEVER CLOSE LSW IF CSW IS CLOSED.

2. Refer to the wiring diagram and check that all external circuits and devices (master switch, resistor, etc.) have been properly wired to the controller.
3. Check that all parts of the controller are firmly attached and undamaged. Then check that no wires or leads are broken, loose or short-circuited as a result of shipment. Check all terminals for loose connections.
4. Check that the inverse time overload relay has oil in the dashpot.
5. Manually operate the contactors and relays. Check each device for free movement without binding.
6. Operate the master switch and check for easy movement without binding. Return the master switch to the off position.
7. Check that the brake has been properly installed and adjusted in accordance with the manufacturer's instructions.
8. Manually operate the power or control limit switch. Check for free movement without binding.
9. Energize incoming line power to the controller.

CAUTION: BE SURE INCOMING LINE VOLTAGE AND POLARITY ARE CORRECT BEFORE ENERGIZING CONTROLLER.

10. With the main line knife switch (LSW) open, close the control circuit knife switch (CSW) and check that the undervoltage relay (UV) is energized. Each controller is checked at the factory prior to shipment. However, the check at the time of installation will call attention to any faulty external connections or any damage that may have been sustained during shipment.
11. Open the control circuit knife switch (CSW).
12. Move the master switch from the off position to the last speed point hoist.
13. With the main line knife switch (LSW) open, close the control circuit knife switch (CSW) and check that the coil of the undervoltage relay (UV) is not energized.
14. Move the master switch from the last speed point hoist to the off position and check that the undervoltage relay (UV) does not energize until the master switch is returned to the off position.
15. Move the master switch from the off position to the first speed point hoist. Check that the closed contactor power tips match that of the contactor sequence table on the controller wiring diagram. Then check that the closed contactor power tips match that of the contactor sequence table in the other hoist and lower speed points except for the last point lower which should match the contact sequence of the next to last point lower. An X in the contactor sequence table on the wiring diagram denotes a closed contactor power tip.
16. If the controller sequences properly, open the control circuit knife switch (CSW).
17. Block the armature of the voltage relay (VR) in the energized position.
18. With the main line knife switch (LSW) open, close the control circuit knife switch (CSW).
19. Check that the closed contactor power tips match that of the contactor sequence diagram when the master switch is in the last point lower.
20. If the controller sequences properly, open the control circuit knife switch (CSW).
21. Unblock the armature of the voltage relay (VR). Then block the armature of the limit switch relay (LSR) in the energized position.
22. With the main line knife switch (LSW) open, close the control circuit knife switch (CSW).
23. With the master switch in the off point, check that the coil of the undervoltage relay (UV) is not energized. Also check that no relays or contactors operate when the master switch is moved from the off point to any speed point hoist or lower.
24. If the controller sequences properly, open the control circuit knife switch (CSW).
25. Unblock the armature of the limit switch relay (LSR).
26. Close the main line knife switch (LSW). Then close the control circuit knife switch (CSW).

WARNING: WHEN CLOSING THE KNIFE SWITCHES, FIRST CLOSE THE MAIN LINE KNIFE SWITCH (LSW) AND THEN CLOSE THE CONTROL CIRCUIT KNIFE SWITCH (CSW).
NEVER CLOSE LSW IF CSW IS CLOSED.
WHEN OPENING THE KNIFE SWITCHES, ALWAYS OPEN THE CONTROL CIRCUIT KNIFE SWITCH (CSW) BEFORE OPENING THE MAIN LINE KNIFE SWITCH (LSW).
NEVER OPEN LSW IF CSW IS CLOSED.

27. With no load on the hook, check for proper rotation of the motor by jogging the master switch. If the motor rotates in the wrong direction, first open the control circuit knife switch (CSW) and then open the main line knife switch (LSW). Proper motor rotation is obtained by interchanging armature connections A1 and A2 at the motor. Improper motor operation will result if connections are interchanged at the controller.
28. With no load on the hook, check the operation of the hoist drive with the master switch in each speed point hoist. Also move the master switch rapidly from the off point to the last speed point hoist and check that the acceleration is rapid without being jerky.
29. Refer to the limit switch service bulletin and check the operation of the limit switch. Any motion into the limit switch should be made at a slow speed. Also check the operation of the limit switch relay (LSR) when lowering out of the tripped limit switch by referring to the OPERATION — YOUNGSTOWN Power Limit Switch section of this service bulletin.
30. With no load on the hook, check the operation of the hoist drive with the master switch in each speed point lower.
31. Open the control circuit knife switch (CSW). Then open the main line knife switch (LSW).

OPERATION

The class 6131 dc dynamic lowering hoist controller connects the dc series motor as a series motor in the hoisting direction and as a shunt motor in the lowering direction. It is supplied with four speed points on controllers rated up to 55 horsepower at 230 volts dc for use on crane hoist drives without mechanical load brakes.

STATIC ACCELERATION TIMERS

The controller is supplied as standard with Class 7001 Type ST-1 static acceleration timers for control of acceleration. The static acceleration timers are wired in series with the acceleration contactor coils and appear as normally open timed close contacts. Voltage applied across terminals 1 (+) - 3 (−) initiates a 0.6 second time delay whereas voltage applied across terminals 2 (+) - 3 (−) initiates a 1.2 second time delay. Upon completion of the timing cycle the module appears as a contact closure and allows energization of the contactor coil.

VOLTAGE RELAY

Voltage relay (VR) is connected across the motor armature and prevents excessive current through the armature when the master switch is moved to the last point lower. This relay does not energize until the motor has accelerated sufficiently for the counter-emf voltage to be about 110 volts on a 230 volt controller which corresponds to about 70% of full load speed. If the motor has not accelerated to this speed when the master switch is moved to the last point lower, the voltage relay prevents the closing of 3L and the opening of 2L until the motor reaches 70% of full load speed.

YOUNGSTOWN® POWER LIMIT SWITCH

Tripping of the power limit switch (LS) removes power from the motor, causes the brake to set, and connects the motor in a dynamic braking circuit with the limit switch resistor (LS RES). The hoist will be brought to a stop through the combined effect of the series brake and the limit switch dynamic braking loop. Should the operator move the master switch to any lowering speed point at the instant of tripping the limit switch, the motor will be plugged to lower as a series motor and the series brake will not set. If the hoist block travels into the limit switch at a significant speed, the plugging torque may not be sufficient to prevent the hook block from coasting into the hoist drum. To minimize the possibility of overhoisting, a limit switch relay (LSR) is included as a standard feature on the Class 6131 dc dynamic lowering hoist controller.

The limit switch relay is a voltage relay which is connected across the limit switch resistor. If the voltage drop across the limit switch resistor is 55 volts or greater (for a 230 vdc system), the limit switch relay will operate to de-energize the undervoltage relay (UV) removing power from the motor and allowing the series brake to set. If the hoist does not enter the limit switch at sufficient speed to energize the limit switch relay, the over-hoisting possibility should be minimal. At reduced speed the plugging torque should be sufficient to stop the hoist within a safe distance.

After the limit switch trips, the load cannot be moved further in the hoisting direction.

To lower out of the limit switch, the motor is connected as a series motor and driven down by applying lowering torque with no retarding torque available until the limit switch resets. Should the series motor tend to overspeed before the limit switch can reset or should the limit switch fail to reset, the limit switch relay will operate to de-energize the control and set the brake. Before further lowering can be accomplished, the control circuit must be reset by returning the master switch to the off position. The limit switch relay will continue to prevent overspeeding until the limit switch resets and the dynamic lowering circuit is again established. Normally the limit switch will reset after a short movement of the load in the lowering direction, and the motor will automatically be reconnected as a shunt motor.

SEQUENCE OF OPERATION

The standard elementary diagram and the contactor sequence table for a standard four speed point hoist controller is shown in this service bulletin. The sequence of contactor operation in the hoisting and lowering direction is shown below. For completeness, the entire sequence for acceleration is included. The description of operation is based on the master switch being moved slowly through the indicated speed points.

HOIST ACCELERATION

HOIST SPEED POINT	OPERATION OF CONTACTORS	PURPOSE
1	H closes DB opens	Motor connected as a series motor in series with resistor section R1-R4. Slack cable and light loads hoisted.
2	1A closes	Reduces the amount of resistance in series with the motor. Motor voltage and torque is increased.
3 4	After 1AR closes, 2A closes After 2AR closes, 3A closes	Reduces amount of resistance in series with the motor. Motor voltage, torque and speed increased.

If the master switch is moved rapidly from the off point to the fourth speed point hoist, H closes instantly followed by 1A without time delay. The DB contactor opens, contactors 2A and 3A close in timed sequence under control of the static acceleration timers 1AR and 2AR respectively.

HOIST DECELERATION

SPEED POINT	OPERATION OF CONTACTORS	PURPOSE
4th to 3rd 3rd to 2nd 2nd to 1st	3A opens 2A opens 1A opens	To reduce voltage applied to motor.
1st to off	H opens DB closes	To disconnect motor from line and set service brake.

If the master switch is moved rapidly from the fourth speed point hoist to the off point, all of the above happens simultaneously.

LOWER ACCELERATION

SPEED POINT	OPERATION OF CONTACTORS	PURPOSE
1	1L and 3A close DB remains closed	Provides all of the line current for brake release. Motor connected as shunt motor with limited driving down torque. Dynamic braking provided in case load is overhauling.
2	After 1AR closes, 2L closes before DB opens and 2A closes	Reduces but maintains dynamic braking. Increases voltage to armature. Lowering speed for all loads is increased.
3	2A & 3A open	Weakens field and reduces dynamic braking. Lowering speed is increased for all loads.
4	If motor CEMF (counter electromotive force) is 50% or more of applied voltage, voltage relay (VR) is energized and then 3L closes. 2L opens after 3L closes	Voltage relay (VR) prevents excessive current thru armature. Field is further weakened and dynamic braking reduced. Voltage to armature is increased. Speed is maximum for all loads.

If the master switch is moved rapidly from the off point to the fourth speed point lower, 1L and 3A close instantly. After static timer 1AR closes, 2L closes. This provides a time delay for releasing the series brake. DB opens, followed by the opening of 3A. When the motor attains sufficient speed, VR is energized to permit closure of 3L. 2L opens after 3L closes.

LOWER DECELERATION

SPEED POINT	OPERATION OF CONTACTORS	PURPOSE
4th to 3rd	Voltage relay (VR) de-energizes 2L closes followed by 3L opening DB remains open	To maintain and strengthen dynamic braking.
3rd to 2nd	2A and 3A close	Strengthens the field and increases dynamic braking.
2nd to 1st	2L opens DB closes 2A opens	Maintains and increases dynamic braking.
1st to off	1L and 3A open DB remains closed	Dynamic braking maintained and brake sets.

If the master switch is moved rapidly from the fourth speed point lower to the off point, VR de-energizes, 3L opens, 3A may close and reopen, DB closes and 1L opens in rapid sequence.

RESISTORS

Hoist performance is affected by changing the ohmic values of the resistance steps. Consideration should be given to the overall effects on both the hoist and lower operations that are caused by changing ohmic values. In no instance should the ohmic values of any given step or steps be changed by more than 10% of the original design values. If resistance changes greater than these are required, consult your local Square D Field Office.

The tables below show how the hoist performance characteristics are affected by changing the resistor values.

HOISTING

NO. OF SPEED POINTS	STEP	INCREASING OHMIC VALUE	DECREASING OHMIC VALUE
4	R1 - R4	Reduces first point current, torque and speed. Reduces size of load that can be hoisted on first point. If increased too much, brake releases too slowly.	Increases first point current, torque and speed. Increases size of load that can be hoisted on first point.
4	R2 - R4	Reduces second point current, torque and speed. Reduces size of load that can be hoisted on second point. Increasing the value of any section reduces the current, torque and speed for any point having that section in the circuit.	Increases second point current, torque and speed. Increases size of load that can be hoisted on second point. Decreasing the value of any section increases the current, torque and speed for any point having that section in the circuit.
4	L.S. Res.	Reduces dynamic braking torque and current upon tripping of limit switch	Increases dynamic braking torque and current upon tripping of limit switch.

LOWERING

NO. OF SPEED POINTS	STEP	INCREASING OHMIC VALUE	DECREASING OHMIC VALUE
4	R1 - R2	Reduces first point speed and inrush current.	Increases first point speed and inrush current.
4	R1 - R9	Reduces speed of all points but last. Increases speed of last point.	Increases speed of all points but last. Decreases speed of last point.
4	R9 - R4	Increasing any of these sections increases the speed for all points having the increased section effective in the field branch.	Decreasing any of these sections decreases the speed for all points having the decreased section effective in the field branch.

LOWERING (CONT'D)

LOWERING (CONT'D)

NO. OF SPEED POINTS	STEP	INCREASING OHMIC VALUE	DECREASING OHMIC VALUE
4	R5 - R6	Decreases speed and line current of non-overhauling loads on last point. Increases speed of overhauling loads on last point.	Increases speed and line current of non-overhauling loads on last point. Decreases speed of overhauling loads on last point.
4	R5 - R7	Decreases speeds of non-overhauling loads and increases speeds of overhauling loads on the intermediate points. If done by moving R7 toward R8, current interrupted by DB contactor upon transfer from first to second point is increased.	Increases speeds of non-overhauling loads and decreases speeds of overhauling loads on the intermediate points. If done by moving R7 toward R6, current interrupted by DB contactor upon transfer from first to second point is decreased.
4	R5 - R8	Reduces torque and speed of non-overhauling loads and increases speed of overhauling loads on first point. Reduces dynamic braking torque and current when master switch moved from lower to off position.	Increases torque and speed of non-overhauling loads and decreases speed of overhauling loads on first point. Increases dynamic braking torque and current when master switch moved from lower to off position.
4	Moving R9	TOWARD R1 Increases speeds and starting torques of intermediate points. Increases current interrupted by DB contactor upon transfer from first to second point.	TOWARD R2 Reduces speed and starting torques of intermediate points. Decreases current interrupted by DB contactor upon transfer from first to second point.

TROUBLESHOOTING

WARNING: WHEN PERFORMING MAINTENANCE AND/OR TESTING ON THE CONTROLLER, EXTREME CAUTION MUST BE EXERCISED IN VIEW OF THE PRESENCE OF HAZARDOUS VOLTAGE. ALL METAL PARTS OF THE CONTACTORS, RELAYS AND OTHER DEVICES MAY BE AT LINE VOLTAGE. ALL POWER SHOULD BE DISCONNECTED WHEN CONNECTING METERS, MAKING INSPECTIONS OR PERFORMING OTHER PROCEDURES WHICH MAY EXPOSE PERSONNEL TO ACCIDENTAL CONTACT WITH LIVE ELECTRICAL PARTS.

Trouble in a controller can be located most efficiently if it is done in a systematic manner. Experience has shown that reported symptoms may not be accurate. Therefore, first check with the operator. Then, if the drive can be operated, personally observe the trouble.

Locate the operational problem in the table and follow the troubleshooting instructions in sequence from left to right; performing all steps described in each instruction.

OPERATIONAL PROBLEMS

WARNING: WHEN OPENING THE KNIFE SWITCHES, ALWAYS OPEN THE CONTROL CIRCUIT KNIFE SWITCH (CSW) BEFORE OPENING THE MAIN LINE KNIFE SWITCH (LSW).
NEVER OPEN LSW IF CSW IS CLOSED.
WHEN CLOSING THE KNIFE SWITCHES, FIRST CLOSE THE MAIN LINE KNIFE SWITCH (LSW) AND THEN CLOSE THE CONTROL CIRCUIT KNIFE SWITCH (CSW).
NEVER CLOSE LSW IF CSW IS CLOSED.

When an operational problem cannot be defined in the table below, check equipment as outlined in the START-UP AND ADJUSTMENT section (steps 1 through 25) of this service bulletin.

OPERATION PROBLEM	TROUBLESHOOTING INSTRUCTIONS				
1 Drive will not move up or down	A	B	G		
2 Drive travels in wrong direction	A	B	E	G	
3 Jumpy operation	A	B	C	D	G
4 Sluggish operation	A	B	C	D	G
5 Overloads tripping	A	B	C	D	G
6 Brake setting during operation	B	F	G		

A. 1. Check equipment as outlined in the START-UP AND ADJUSTMENT section (steps 10 through 16) of this service bulletin.

2. If the problem can be isolated to a contactor not operating in a specific speed point or speed points, connect a voltmeter across the contactor coil and then close the control circuit knife switch (CSW). Check the voltage across the coil of the contactor in that particular speed point or points.

a. If the voltage across the coil is the same as the line voltage, open the control circuit knife switch (CSW) and refer to the TROUBLESHOOTING section in the contactor service bulletin.

b. If the voltage across the coil is less than the line voltage, open the control circuit knife switch (CSW).

1) Visually check all electrical interlocks and any static acceleration timer in series with the coil for burned or broken parts, connectors and wires.

2) Visually inspect any master switch contact in series with the coil and check for proper operation in that speed point or speed points.

3) If the visual check does not isolate the problem, place a jumper wire across the terminals of any static acceleration timer in series with the contactor coil. Close the control circuit knife switch (CSW) and check the contactor operation in the various speed points.

a) If the contactor operates properly, replace the static acceleration timer.

b) If the contactor fails to operate and the voltage across the coil is the same as the line voltage, refer to the TROUBLESHOOTING section in the contactor service bulletin.

c) If the contactor fails to operate and the voltage across the coil is less than the line voltage, check for discontinuity in the circuit by checking the voltage from the coil through each device in the circuit in sequence. Replace any defective wiring, connections or devices.

4) Open the control circuit knife switch (CSW) and remove the acceleration timer jumper wire.

B. 1. With the main line knife switch (LSW) and control circuit knife switch (CSW) open, visually inspect the acceleration resistors. Replace any burned or broken connectors, wires or resistor sections.

2. Check resistor units for continuity and proper ohmic value using an ohmmeter.

3. The values of resistance in the circuit can be adjusted by moving the taps on the resistor units. Refer to the OPERATION section of this service bulletin.

C. 1. With the control circuit knife switch (CSW) open, disconnect the wire from terminal 3 on each static acceleration timer. Connect meter negative input to timer terminal 3 and meter positive input to timer terminal 1 or 2. Check that the resistance across each of the timers is at least 20K ohms. If the resistance is less, the static acceleration timer should be replaced.

2. The timing period of the static acceleration timer can be changed by changing the connection. Refer to the OPERATION section of this service bulletin.

D. 1. Open the control circuit knife switch (CSW). Check the equipment as outlined in the START-UP AND ADJUSTMENT section (steps 17 through 19) of this service bulletin.

a. If the controller does sequence properly, open the control circuit knife switch (CSW) and unblock the armature of the voltage relay (VR).

b. If the controller does not sequence properly, open the control circuit knife switch (CSW) and unblock the armature of the voltage relay (VR). Refer to the TROUBLESHOOTING section (paragraph A2) of this service bulletin.

2. Close the main line knife switch (LSW) and then close the control circuit knife switch (CSW).

3. With the master switch in the last point lower, check that the voltage relay (VR) does not energize until the hook has accelerated to about 70% of full load hoisting speed. This can be checked by placing a voltmeter across the coil of the voltage relay and checking that the relay pick-up voltage is approximately 110 vdc.

4. Open the control circuit knife switch (CSW) and then open the main line knife switch (LSW).

E. 1. Check the equipment as outlined in the START-UP AND ADJUSTMENT section (steps 26 through 27) of this service bulletin.

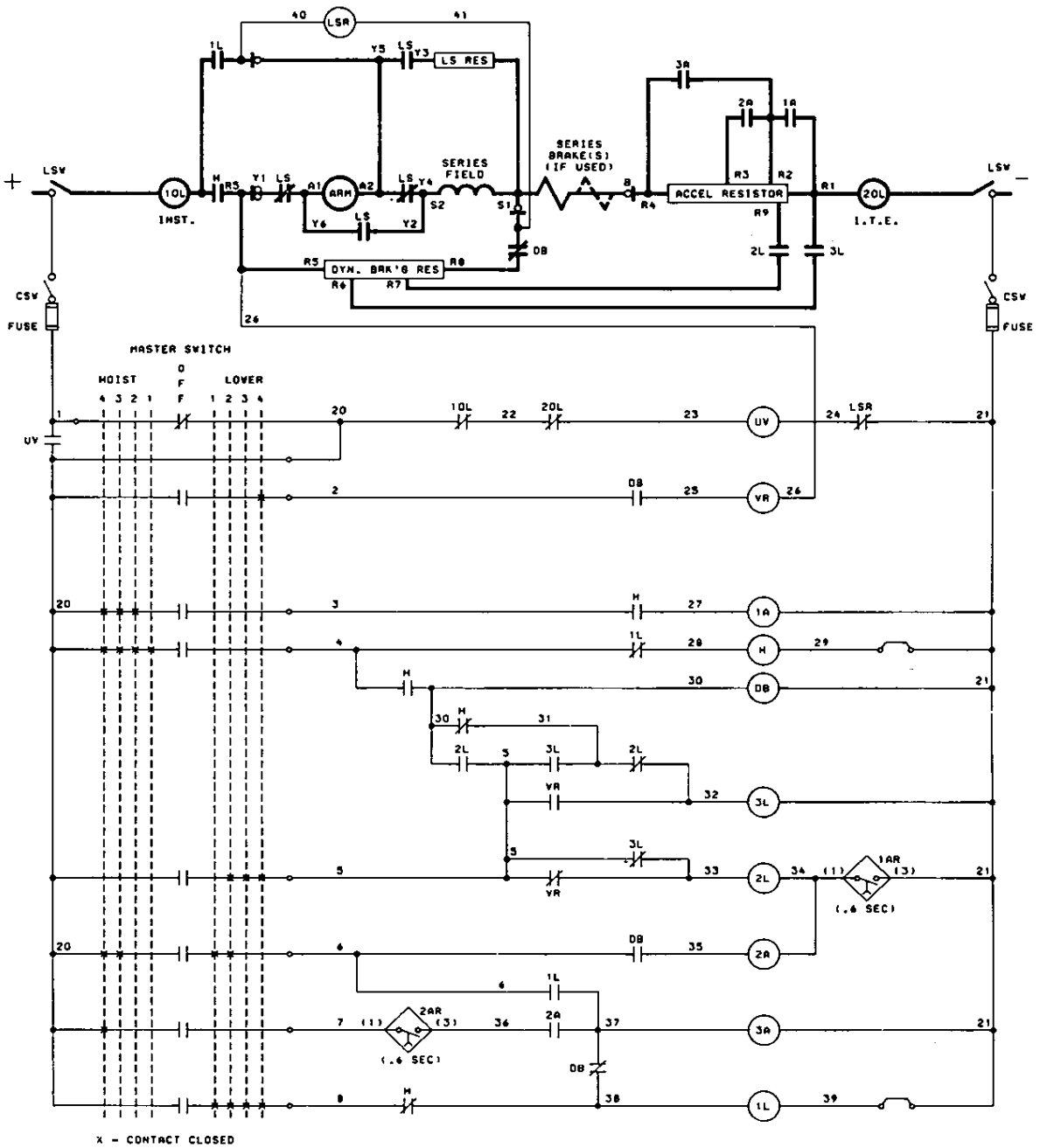
2. Open the control circuit knife switch (CSW) and then open the main line knife switch (LSW).

F. Motor must be loaded to at least 10% of its full load current value.

G. If the problem cannot be isolated by any of the preceding procedures, the problem is not in the control. Check the integrity of all external circuits, connectors, wiring and devices.

CLASS 6131 DC HOIST CONTROLLER

ELEMENTARY DIAGRAM FOR FOUR SPEED POINT DC DYNAMIC LOWERING CONTROLLER



CONTACTOR SEQUENCE X = POWER TIPS CLOSED											
DEVICE	HOIST				OFF	LOWER					
	4	3	2	1	F	1	2	3	4		
H	X	X	X	X							
DB					X	X					
1L						X	X	X	X		
2L							X	X			
3L									X		
1A	X	X	X								
2A	X	X					X				
3A	X					X	X				

CONTACTORS 1A & 1L, 3L & H, H & 2L, ARE MECHANICALLY INTERLOCKED