# Instructions for Type SJO 720 Ampere, 7200 Volt Vacuum Contactor

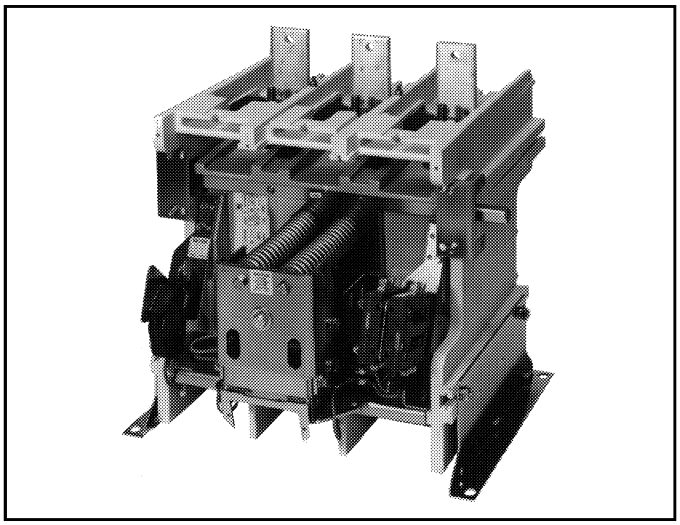

*Fig. 1 Front View*

## THE CONTACTOR

The Type SJO vacuum contactor is a NEMA Size H6 contactor designed for starting and controlling three-phase, 50 or 60 Hz AC motors on nominal 2400, 4160, 4800 and 6900 volt systems. Horsepower ratings are shown in Table I. Motor full load current should not exceed the contactor current rating. Two-pole contactors have the same current ratings as 3 pole devices but are not suitable for controlling three-phase motors.

The contactor is referred to as the Type SJO, for simplicity. The exact catalog number is more complex. Any communication with Cutler-Hammer should include the complete style or part, and catalog numbers, exactly as they appear on the nameplate.

## SHORT-CIRCUIT PROTECTION

The short-circuit capacity of the power system may exceed the interrupting capacity of the contactor. The contactor should have short-circuit protection with current-limiting motor-starting fuses as specified for the application. Substitute fuses should not be used without proper authorization by a qualified person.

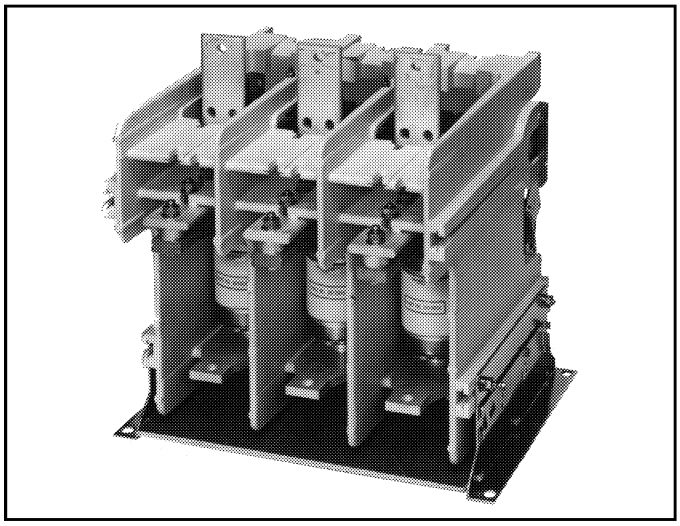

*Fig. 2 Rear View*

## INSTALLATION

This industrial type control is designed to be installed, operated, and maintained by adequately trained personnel, with adequate supervision. These instructions do not cover all details, variations, or combinations of the equipment, its storage, delivery, installation, checkout, safe

**TABLE I — CONTROLLER RATINGS**

| Enclosed Current Rating Continuous | System Voltage | Horsepower Ratings | | | Interrupting Capacity In A Coordinated Starter 3-Phase, Symmetrical MVA* | |
|---|---|---|---|---|---|---|
| | | Synchronous Motor | | Induction Motor | | |
| | | 1.0 P.F. | 0.8 P.F. | | Unfused NEMA Class E1 | Fused NEMA Class E2 |
| 720 | 2200-2500 | 3500 | 3000 | 3000 | 50 | 200 |
| 720 | 4000-5000 | 6000 | 5000 | 5000 | 75 | 350 |
| 720 | 6200-7200 | 10,000 | 8000 | 8000 | 100 | 570 |

** The asymmetrical interrupting rating is 1.6 times the symmetrical values shown.*

operation, or maintenance. Care must be exercised to comply with local, state, and national regulations, as well as safety practices, for this class of equipment.

## WARNING

**ALL WORK ON THIS CONTACTOR SHOULD BE DONE WITH THE MAIN DISCONNECT DEVICE OPEN. AS WITH ANY CONTACTOR OF THIS VOLTAGE, THERE IS DANGER OF ELECTROCUTION AND/OR SEVERE BURNS. MAKE CERTAIN THAT POWER IS OFF.**

The Type SJO contactor is intended to be mounted in a medium voltage starter with overload relays and power fuses. In a factory assembled starter, the contactor is ready for service except for routine check-out as described later.

If the Type SJO contactor is a replacement for an air-break Type LF contactor in an assembled starter, make the exchange as follows:

1. Jumper the rectifier on the control panel, to apply AC directly to the SJO coil.
2. Check the wiring of the control plug to make certain that the control functions correctly.
3. Continue with routine check-out.

### CONTACTOR OPERATION

The Type SJO contactor has its main contacts sealed inside ceramic tubes from which all air has been evacuated, i.e., the contacts are in vacuum. No arcboxes are required, because any arc formed between opening contacts in a vacuum has no ionized air to sustain it. The arc simply stops when the current goes through zero as it alternates at line frequency. The arc usually does not survive beyond the first half cycle after the contacts begin to separate. The ceramic tube with the moving and stationary contacts enclosed is called a **vacuum interrupter** or a **bottle,** and there is one such bottle for each pole of the contactor. A two pole contactor has two vacuum bottles, and a three pole contactor has three vacuum bottles. A metal bellows (like a small, circular accordian) allows the moving contact to be closed and pulled open from the outside without letting air into the vacuum chamber of the bottle. Both the bellows and the metal-to-ceramic seals of modern bottles have been improved to the point that loss of vacuum is no longer cause for undue concern.

The moving contacts are driven by a molded plastic crossbar (See Figure 4.) rotating with a square steel shaft supported by two shielded, pre-lubricated ball bearings that are clamped in true alignment for long life and free motion. Only the end edges of the square shaft are rounded to fit the bearings, so that portions of the four shaft flats go through the bearings for positive indexing of mechanical safety interlocks.

The contacts in an unmounted bottle (vacuum interrupter) are normally-closed, because the outside air pressure pushes against the flexible bellows. For contactor duty, the contacts must be open when the operating magnet is not energized. Therefore, the contacts of the vacuum bottles must be held apart mechanically against the air pressure when used in a contactor. In the Type SJO contactor, all of the bottles are held open by two kickout springs on the front of the contactor. (See Figure 4.) The kickout springs press against the moving armature and crossbar and thereby force the bottles into the open contact position. Note that in the open position, the crossbar is pulling the moving contacts to hold them open.

Up to an altitude of 3300 feet, the contactor is designed to tolerate normal variations in barometric pressure.

The contact force at sea level when fully closed is intended to be 65 to 75 pounds. This will decrease approximately 0.75 pounds per 1000 feet above sea level.

If the contact force is below 65 pounds, it should be increased by adding one or more extra-wide flat washers to the bottle stud ON TOP OF THE SHUNT and underneath the contact spring. This will increase the contact force provided by the spring. See **Contact Force Measurement** under **MAINTENANCE**.

The kickout springs are adjustable and occupy the space above the operating magnet. The kickout springs must be removed before the magnet coil can be changed if that becomes necessary. The normal position of the kickout spring lever is vertical, but it might be set slightly differently as will be explained later. The lever can be loosened to unload the kickout springs (after loosening the setscrew that locks the adjusting screw) by unscrewing the 3/8" screw immediately below the kickout springs. Although it can be loosened, the lever is captive. As the 3/8" screw is loosened, the kickout springs will reach their relaxed, free length and can be removed easily. To re-install them, reverse the procedure. Insert each uncompressed, free spring into position; then apply load by tightening the 3/8" adjusting screw on the lever until the lever is approximately vertical. See specific instructions later. Because the spring forces exceed 100

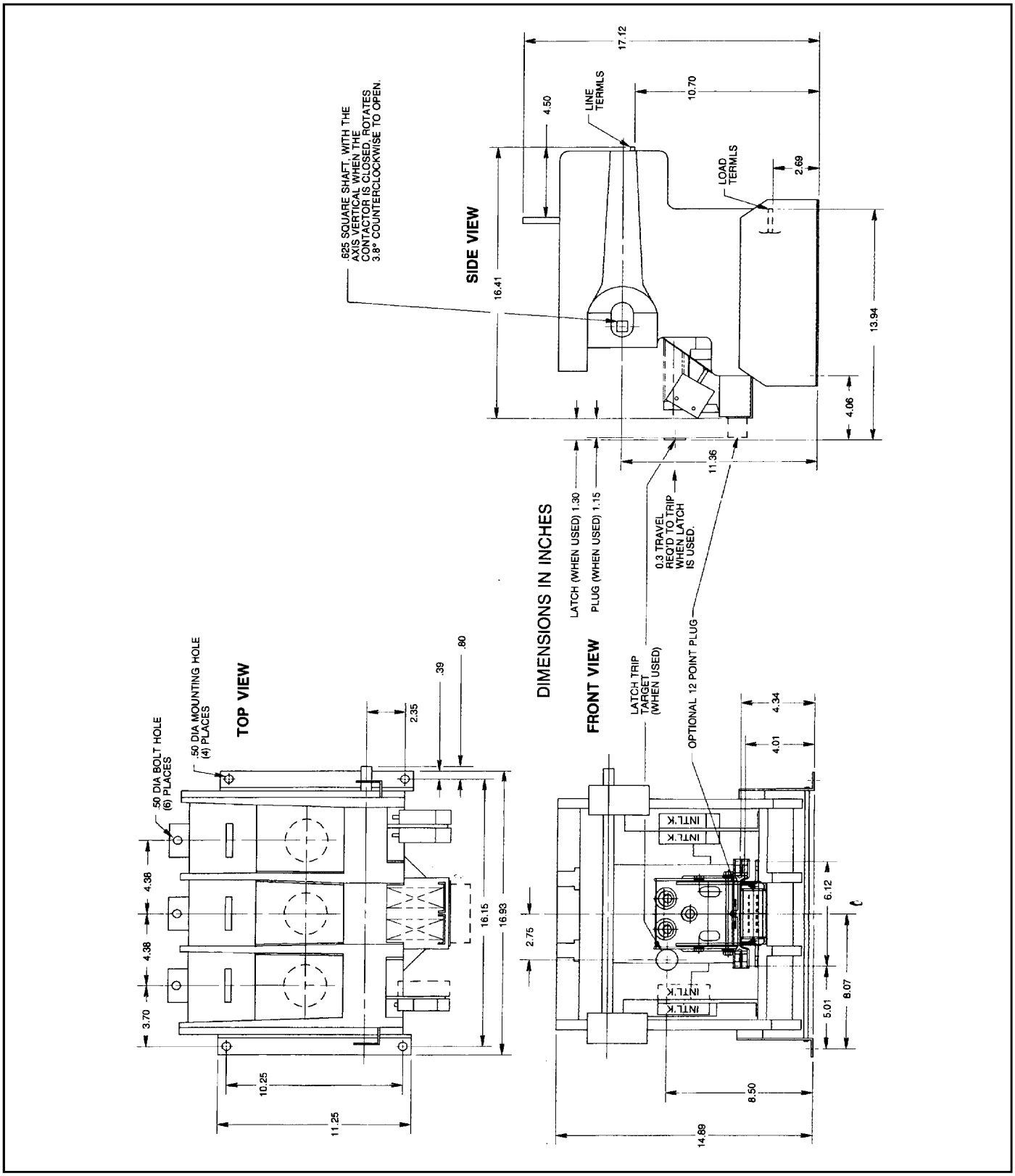


*Fig. 3 Outline and Mounting Dimensions*

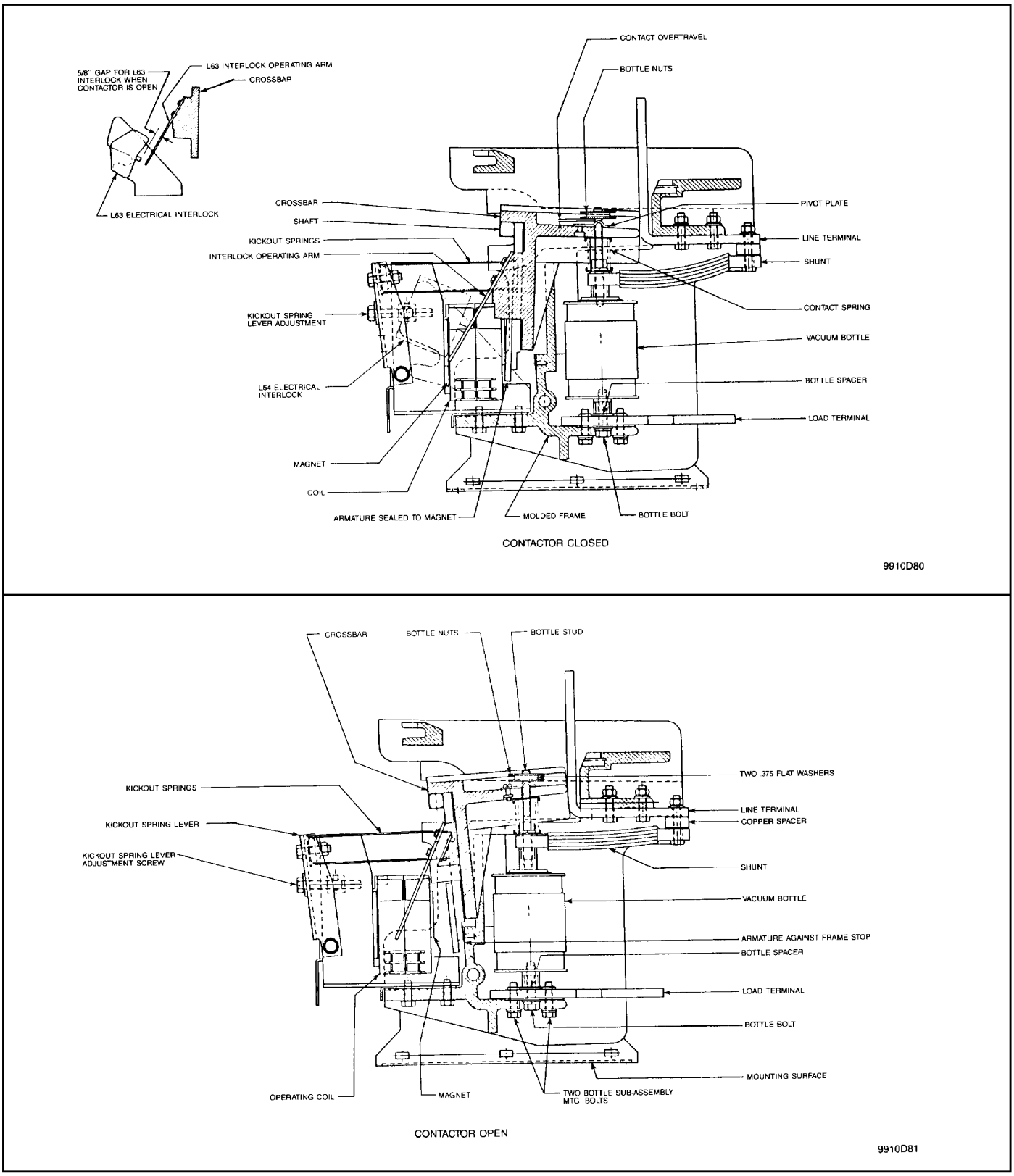


*Fig. 4 Contactor Positions*

pounds, it is recommended that the free hand be placed over the kickout springs as a precaution while turning the 3/8" adjusting screw in either direction.

The operating magnet (See Figure 4.) is on the front of the contactor. The coil has a “figure-eight” shape and is really two coils in series, with a connection to their common point. Both coils are encapsulated in one environmentally-immune coil shell, which also contains a full-wave silicon diode rectifier. An AC or DC source can be connected to terminals A and B on the coil shell. When an AC source is applied, the rectifier converts the AC to unfiltered DC to excite the magnet. When a DC source is applied, only two legs of the full-wave rectifier are active and pass DC current for magnet excitation. The magnet will not chatter as AC magnets sometimes do, but at less than rated voltage, it may hum slightly. A normally-closed auxiliary contact, set to open slightly before the armature fully closes, is connected to terminals C and D on the coil shell. When adjusted correctly, this auxiliary contact allows a relatively high current through the pick-up winding, and as the contactor closes, the auxiliary contact inserts the holding winding, which reduces the coil current to a low value, sufficient to hold the magnet closed without overheating.

In the description of the bottles, it was mentioned that no arcboxes are required. However, because of electrical clearances the **one bottom barrier must be installed before the contactor is energized.**

### HANDLING

The contactor weighs about 95 pounds. It should be handled gently to avoid damage to the vacuum bottles and factory adjustments.

### MOUNTING

The Type SJO contactor should be mounted inside an enclosure that protects the unit from adverse environments such as dust, water, etc.

The mounting surface should be flat and horizontal, with provision for securely bolting the contactor in place with four 3/8" x 16 bolts. Do not remove the insulating barrier between the mounting rails below the contactor. Arrange the four bolts on the center lines shown in Figure 3.

### CHECK-OUT, MECHANICAL

Make sure all power circuits are deenergized and/or isolated. The contactor can be checked in its cell or outside. If the starter is a new factory assembly, it is probably easiest to test the contactor as installed. Any mechanical interlocks **must** be checked as installed, to make certain that safety interlocks function properly.

If the contactor is checked in its cabinet, make certain that the contactor coil is electrically isolated, to prevent feedback into a control transformer that could be hazardous.

With an extension cord and a separate power source of correct AC voltage, connect power to the coil of the contactor. Operate the appropriate pushbuttons to close and open the contactor, and to check out the sequence. If the contactor does not close fully or does not drop out fully, refer to **MAINTENANCE** below.

While the contactor is **closed,** observe the overtravel gap between the pivot plates on the crossbar and the underside of the lower bottle nut on each pole. This overtravel gap should be no less than .115 inch when the contactor is new. If less, refer to **Contact Wear Allowance.**

While the contactor is **open**, push the armature rearward with a long screwdriver or other rod applied to the lower end of the armature above the coil terminals. The armature should not move because it should be firmly against the plastic main frame. See Figure 4. To correct a problem, see paragraph 11 under **CHANGING OPERATING COIL.**

Disconnect extension cord and proceed with installation.

### CHECK-OUT, VACUUM INTERRUPTERS

The dielectric strength of the interrupters should be checked before the contactor is energized for the first time and regularly thereafter to detect at the earliest possible date any deterioration in the dielectric strength of the contact gap since this may result in an interruption failure. Although an AC dielectric test is recommended, a DC test may be performed if only a DC test unit is available. A good interrupter will withstand a 16kV-60 Hz test or a 23kV-DC test across a .320 inch contact gap for one minute. When performing DC tests, the voltage should be raised to test value in discrete steps and held for a period of one minute.

### ⚠ CAUTION

**SOME DC HIGH POTENTIAL UNITS, OPERATING AS UNFILTERED HALFWAVE RECTIFIERS, ARE NOT SUITABLE FOR TESTING VACUUM INTERRUPTERS, BECAUSE THE PEAK VOLTAGE APPEARING ACROSS THE INTERRUPTERS CAN BESUBSTANTIALLY GREATER THAN THE VALUE INDICATED.**

When a vacuum bottle is tested with voltages over 5000 volts across its open gap, there is some possibility of generating X-rays. Test time should be minimized, and personnel should not be closer than 10 feet and preferably located behind some barrier. This is a precaution until such time as the possible hazard is better understood and standards are published.

Periodic dielectric tests across open contacts should not be omitted on the basis of satisfactory contactor performance since under certain operating conditions, the contactor may perform satisfactorily even though one vacuum interrupter becomes defective.

The interval between periodic tests depends on the number of operations per day, environmental factors, and experience. It is a matter of operator judgement.

## CHECK-OUT, INSULATION LEVEL

After installation, and before energizing the contactor for the first time, the insulation resistance between poles and from each pole to ground should be measured and recorded. It is not practical to specify an absolute value for this reading since it is dependent on other connected apparatus, and conditions of service. However, any unusually low reading or abrupt reduction in this reading would indicate a possible source of trouble, and the cause should be established and corrected.

## MAINTENANCE

This industrial type control is designed to be installed, operated, and maintained by adequately trained personnel, with adequate supervision. These instructions do not cover all details, variations, or combinations of the equipment, its storage, delivery, installation, checkout, safe operation, or maintenance. Care must be exercised to comply with local, state, and national regulations, as well as safety practices, for this class of equipment.

A maintenance program should be established as soon as the contactor is installed and put into operation. After the contactor has been inspected a number of times at monthly intervals, and the condition noted, the frequency of inspection can be increased or decreased to suit the conditions found, since this will depend upon the severity of the contactor duty. It is a matter of operator judgement.

All work on this contactor should be done with the main circuit disconnect device open, and using a separate source of control power to operate the magnet. Before applying external control circuit power, make certain that the contactor coil circuit is electrically isolated, to prevent feedback into a control transformer that could be hazardous. Disconnect power from any other external circuits. Also, discharge any hazardous capacitors.

### Insulation Level

Refer to the insulation resistance measurements between poles and from each pole to ground that were recorded at start-up and subsequent intervals. Measure the same points in the same manner and record. Investigate any abrupt reduction in resistance or any unusually low reading.

Dust and moisture are detrimental to electrical equipment, can cause trouble, and should be wiped or blown off at appropriate intervals. If the contactor is wet for any reason, it must be dried until insulation resistance between poles and from each pole to ground has returned to normal.

The contacts inside the interrupters are immune to dust and moisture and require no attention of this type.

### Vacuum Interrupters

Gross loss of vacuum is highly unlikely, but it can be checked easily. With the contactor open, pull upward on the bottle nuts, one pole at a time, using an effort of about 65 pounds. If the bottle nuts move easily away from their pivot, the vacuum has probably failed and the bottle must be replaced.

It is also unlikely, but possible, to have a very slight leak that does not change the bottle force appreciably, but which might seriously damage the ability of the bottle to interrupt. In this regard, it must be remembered that in a three-phase circuit, it is possible for any two good interrupters to successfully interrupt the circuit even if the third interrupter is weak. But this condition should not be allowed to continue. It can be detected only by a dielectric test.

The dielectric strength of the interrupters should be checked before the contactor is energized for the first time and regularly thereafter to detect, at the earliest possible date, any deterioration in the dielectric strength of the contact gap since this may result in an interruption failure. The vacuum interrupters should be tested as specified by the section **CHECK-OUT, VACUUM INTERRUPTERS**.

### Contact Force Measurement

Contact force can be measured with the contactor on a bench or on the floor. Energize the contactor via the control power plug and an extension cord. Place a loop of wire or string between the bottle nuts of each vacuum

interrupter in turn and pull on a spring scale as shown in Figure 5. Connect a continuity checker between the line and load side of each pole and determine the force required to pull the contacts open.

### Contact Wear Allowance

Contact material vaporizes from the contact faces during every interruption and condenses elsewhere inside the bottle. This is normal, and is provided for by **overtravel,** or wear allowance. When the contactor is fully closed, there is a gap between the lower bottle nut and the pivot plate. See Figures 4 and 5. As the contacts wear, this gap decreases. When the gap goes **below .020 in.** on any pole, all the bottle subassemblies should be replaced. Use the .020 inch thick fork-shaped overtravel gauge supplied for this measurement, part no. 5259C11. DO NOT RE-ADJUST THE BOTTLE NUTS TO RESET OVERTRAVEL AS THE CONTACTS WEAR. Once placed into service, overtravel should be checked but not adjusted.

### Inspection After Short Circuit or Overload

The Type SJO contactor is intended to be protected by power fuses and/or a circuit breaker in accordance with the NEC. However, the magnitude of a short circuit may exceed the damage threshold of the vacuum bottles. After the interruption of a short circuit at the maximum MVA rating of the contactor, the unit should be examined for any apparent physical damage, or deformation of conductor bars and cables. If there is any evidence of severe stress, it is recommended that the bottle subassemblies be replaced. If the overtravel has changed significantly (from the last inspection) on one or more bottles, all bottle subassemblies should be replaced.

A dielectric test would not by itself confirm that the bottles should be returned to service after a fault. However, if there is no physical evidence of stress, and if the overtravel exceeds the .020 in. minimum, the bottles can then be dielectrically tested as outlined previously. If physical stress, overtravel, and dielectric are within acceptable limits, it is reasonable to return the bottles to service after a fault.

If the SJO contactor opens locked rotor current as a result of a relay tripping, the mechanical damage typical of a short circuit will not occur. However, the bottles should be dielectrically tested as specified in the section **CHECK-OUT, VACUUM INTERRUPTERS** before returning to service.

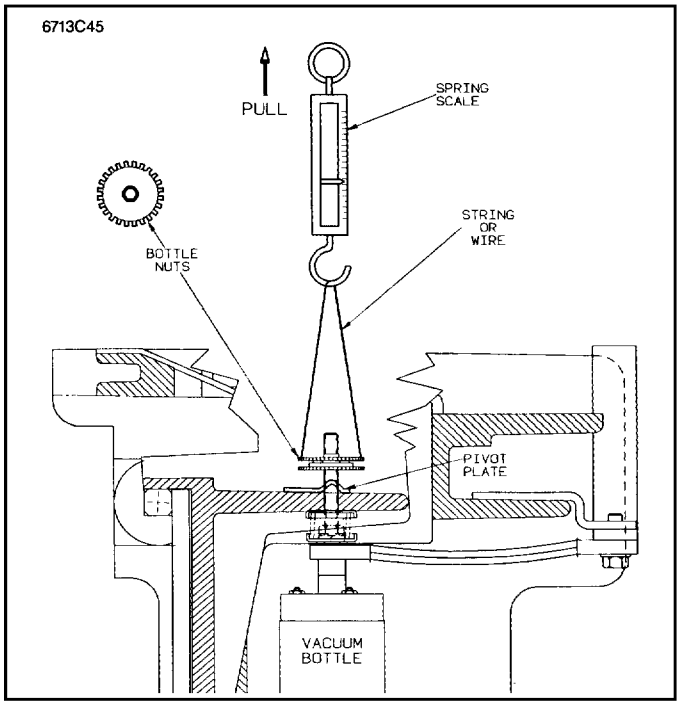


*Fig. 5 Measuring Contact Force*

### MAGNET OPERATING RANGE

When properly adjusted as described in previous sections, the contactor should operate within the ranges shown in Table IV.

If the magnet chatters, look for mechanical interference that prevents the magnet from sealing. If there is no interference, then the magnet itself may be misaligned. The magnet gap can be seen from the left and right sides with the help of a flashlight. The stationary magnet can be aligned with a 1/2" diameter steel rod inserted into the two holes in the core of the magnet and used as a lever to put a corrective set into the magnet frame. It should not be necessary to do this unless the contactor has been damaged and it can be seen that the armature does not fit against the magnet. A poor magnet-to-armature fit usually produces a high dropout voltage and/or chatter.

Mechanical interference can be produced by various incorrect adjustments. Two specific points to check are:

A. Armature travel incorrect, causing the contact springs to be compressed into a solid, non-resilient “tube” that stops the crossbar rigidly. Call Cutler-Hammer Service for assistance.

B. The auxiliary contact operating arms are misadjusted, so that an interlock plunger bottoms solidly before the magnet seals. When the contactor is fully

sealed closed, there should still be a small amount of travel remaining for these plungers. Adjust as described below.

## AUXILIARY CONTACTS (ELECTRICAL INTERLOCKS)

Two Type L64 electrical interlocks are mounted on the front (right side) to provide four auxiliary, isolated 600V, 10A, double-break contacts for use in control circuits. Any combination of normally open or normally closed circuits is available by selection of the appropriate style of interlock assembly from Table II.

The normally closed Type L63 auxiliary mounted on the front (left side) has only one circuit, and is connected to coil terminals C and D. This auxiliary contact (578D461G03) is equipped with permanent magnet blowouts on the contacts.

## AUXILIARY CONTACT ADJUSTMENT

The 5/8" gap shown for the L63 interlock (normally closed) in the insert picture in the upper portion of Figure 4 is important and must be held between .615 and .625 inch. If the gap is too big, the hold winding of the operating coil will not be inserted as the contactor closes, and the pick-up winding will burn out, because the pick-up winding is only intermittently rated. If the .625 inch gap is too small, the hold winding will be inserted too soon, reducing the pull force before the contactor is closed, and producing an oscillation like an old doorbell.

The L64 interlocks are not as critical. In the open position, their plungers should rest lightly against the interlock operating arm.

However, neither L63 nor L64 interlocks should bottom solidly in the closed contactor position as discussed under **MAGNET OPERATING RANGE**.

If required, the interlock operating arms can be adjusted by bending, using the forked end of the bottle wrench. See Figure 6.

**TABLE II — L64 AUXILIARY CONTACTS**

| Part Number | Circuit Combination Provided By One Interlock Assembly |
|---|---|
| 843D943G04 | One Normally Open, One Normally Closed |
| 843D943G05 | Two Normally Open |
| 843D943G06 | Two Normally Closed |

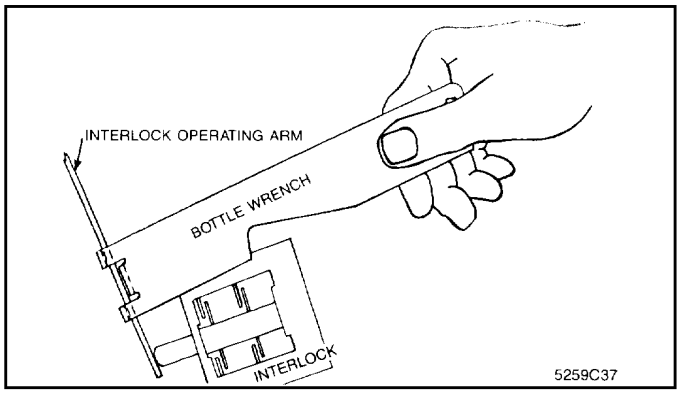


*Fig. 6 Use of Bottle Wrench*

## CHANGING OPERATING COILS

The operating coils have pick-up windings which are intermittently rated. They may burn out in only minutes if continuously energized at rated voltage and the L-63 interlock does not open correctly.

The coils contain their own rectifier to convert applied AC into unfiltered full-wave rectified DC. When parts are in alignment and the coil is at rated voltage, the magnet will be silent. At reduced voltage, some slight hum may be heard. However, the magnet must not chatter.

If for some reason a coil must be changed, proceed as follows:

1. De-energize **all** circuits.
2. Loosen the setscrew holding the kickout spring lever adjusting screw. See Figure 4.
3. Loosen the kickout spring lever adjusting screw until the kickout springs can be removed easily.
4. Remove leads to coil terminals, noting their position for later reconnection.
5. Remove the four 5/16" magnet mounting bolts. Remove bolts completely and set aside until later.
6. Remove entire coil assembly from contactor.
7. Remove the two 8-32 screws holding the coils and remove the two coils from the assembly.
8. Transfer the crossover wires to the new coils exactly as removed (wires from coil to coil are A to B, C to C, and D to D).
9. Install new coils on the magnet assembly and replace the two 8-32 screws previously removed.
10. Place the coil assembly into the contactor and replace the four 5/16" mounting bolts previously removed.

| TABLE III — OPERATING COILS | | | |
|---|---|---|---|
| Coil Part Number (Two Required) | Rated Voltage A-B | Total Volt-ampere Burden for Two Coils | |
| | | Inrush | Sealed |
| 7860A34G02 | 110-120 50-60 Hz | 2600 | 50 |
| | 125 VDC | 3000 | 56 |
| 7860A34G04 | 220-240 50-60 Hz | 2800 | 52 |
| | 250 VDC | 3200 | 58 |

11. Re-connect the coil circuits.
12. After checking for safety, energize the coil and close the contactor.
13. Re-install the kickout springs, making sure to put the two ends of the spring wire downward, so that the springs will take a natural bow. Note: Whenever adjusting the kickout spring lever, put your free hand over the kickout springs as a precaution. Tighten the adjusting screw until the kickout spring lever is approximately vertical, and the armature is solidly against its stop on the molded frame. See Figure 4. When a screwdriver is pushed against the bottom end of the armature in the open position, the armature must not move. If it does, the kickout springs should be tightened further to push the armature to a solid position. Tighten setscrew to lock the kickout spring lever adjusting screw.

| TABLE IV — COIL PERFORMANCE | | | | |
|---|---|---|---|---|
| Rated Coil Voltage | Pick-Up-To-Seal Voltage | | Drop-Out-To-Full-Open Voltage | |
| | Above | Below | Below | Above |
| 110-120 VAC<br>125 VDC | 50<br>55 | 96<br>100 | 75<br>82 | 10<br>11 |
| 220-240 VAC<br>250 VDC | 100<br>110 | 192<br>200 | 150<br>164 | 20<br>22 |

## OPERATING COILS

The standard operating coils are shown in Table III. Two of the proper voltage rating, connected in parallel are required. They should be supplied directly from an AC or DC source with sufficient volt-ampere capacity to maintain coil voltage during inrush while closing. No external resistors are required.

| TABLE V — RENEWAL PARTS | |
|---|---|
| ITEM | REPLACEMENT KIT NO. |
| VACUUM BOTTLE (3) SUBASSEMBLIES | 2147A87G13 |
| 12-POINT PLUG WITH WIRES | 2147A15G12 |
| 12-POINT RECEPTACLE WITH WIRES | 2147A15G11 |
| FEELER GAUGE AND BOTTLE WRENCH | 2147A47G15 |

## VACUUM BOTTLE SUBASSEMBLY REPLACEMENT

If it becomes necessary to replace vacuum bottles, obtain Vacuum Bottle Subassembly Replacement Kit part number 2147A87G13, and follow the enclosed instructions (I.L. 16-200-34). This kit includes three bottle subassemblies, as **all bottle subassemblies must be replaced at the same time.**

## CONNECTION DIAGRAM

Figure 7 shows the routing of the conductors and connection points to the internal portion of the SJD control circuit. The conductor cable pattern shown in Figure 7 is used for both two-pole and three-pole contactors.

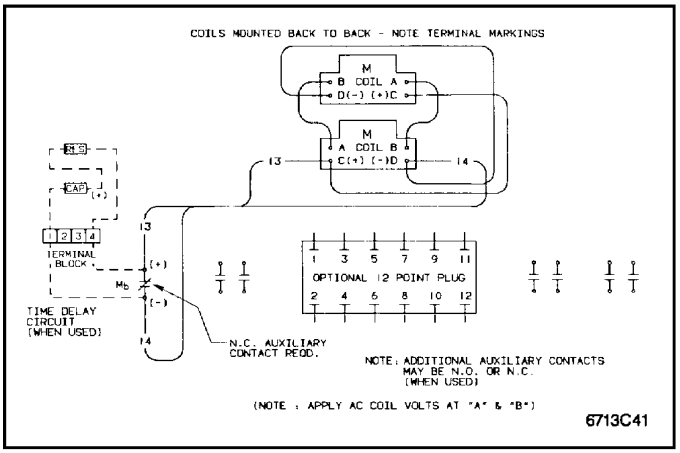


*Fig. 7 Cable and Connection Diagram*

**Cutler-Hammer**

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