

INSTALLATION/MAINTENANCE INSTRUCTIONS

***Medium Voltage  
Vacuum Power Circuit Breakers***

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**VHK Model 20/21**

**VHKR Model 80**



Model 21

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These instructions do not purport to cover all details or variations nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose the matter should be referred to the nearest District Office or send E-mail to: [dsinfo@ustra.mail.abb.com](mailto:dsinfo@ustra.mail.abb.com).

## **INTRODUCTION**

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This manual contains instructions for inspection, application, installation, operation, testing, adjustment and maintenance of all VHK Model 20/21 and VHKR Model 80 vacuum power circuit breakers. Use of these instructions will facilitate proper application and maintenance of the circuit breaker and prolong its life and usefulness.

The specific ratings for each breaker are located on each Breaker Nameplate.

Throughout this manual, there are three terms that must be heeded.

### **CAUTION**

***Not adhering to these instructions can result in damage to the breaker.***

### **WARNING**

***Not adhering to these instructions can result in personal injury or DEATH, and damage to the breaker.***

### **DANGER**

***Not adhering to these instructions will result in personal injury or DEATH, and permanent damage to the breaker and other equipment.***

## **RECEIVING AND STORAGE**

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Immediately upon receipt of the circuit breaker, examine it to determine if any damage or loss was sustained during transit. If abuse or incorrect handling is evident, file a damage claim at once with the carrier and promptly notify the nearest District Office. The company is not responsible for damage of goods after delivery to the carrier. We will, however, lend assistance if notified of claims.

Unpack the circuit breaker as soon as possible after receipt. If unpacking is delayed, difficulty may be experienced in making a claim for damages not evident upon receipt. Use care during unpacking in order to avoid damaging any of the circuit breaker parts. Check the contents of each device against the packing list before

discarding any packing material. If any shortage of material is discovered, promptly notify the nearest District Office. Information specifying the purchase order number, device serial numbers and part numbers of the damaged or missing parts should accompany the claim.

The circuit breaker should be installed in its permanent location as soon as possible. If the breaker is not to be placed into service for some time, it is advisable to provide some means of protection. This may be done by keeping the breaker in its original shipping crate and storing it in a warm, dry, uncontaminated atmosphere. If the breaker cannot be stored properly due to circumstances beyond your control, it must be thoroughly checked before being put into service. This is to insure it has not absorbed any moisture, or has become rusted or generally contaminated in any way.

## **INSTALLATION**

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### **General**

Prior to installation of the circuit breaker into the compartment, certain preliminary inspections should be made to insure proper operation. This section lists the recommended inspection procedures.

ABB VHK vacuum circuit breakers are shipped with the contacts closed, Closing Springs discharged and Opening Springs charged. This is to protect against the possibility of the contacts striking the inside of the vacuum interrupter enclosure and damaging themselves during shipping.

### **WARNING**

***Prior to any disassembly or inspection of the circuit breaker, the closing springs must be discharged, and the breaker should be open. Failing to do so could result in personal injury.***

If the circuit breaker is equipped with an Undervoltage Trip Device (a.k.a., *UVTD*), the Retaining Strap applied to the *UVTD* at the factory must be removed. The Retaining Strap was applied to hold the Armature of the *UVTD* in the energized position so the breaker could be closed.

If the Retaining Strap is not removed, the *UVTD* will not be able to trip the breaker.

If it is necessary to raise or move the breaker, attach a lifting yoke to the truck or a fifth wheel to transport the breaker as required. See Figure A1 in the Appendix.

## General Inspection

Inspect the condition of the circuit breaker vacuum interrupters and electrical connections prior to installing the circuit breaker into the compartment. Even though each circuit breaker is completely adjusted and tested at the factory, shipping and handling conditions, and/or incorrect storage could cause defects.

The front cover and barrier assembly (Figure A3 or A4) must be removed for access to and inspection of the vacuum interrupters and their associated adjustments.

## Vacuum Interrupter Examination

### WARNING

*If the circuit breaker has been energized, or it is unsure if the circuit breaker has ever been energized, the mid-band ring (on vacuum interrupters so equipped) must first be discharged before any work is performed on or near the interrupters. A grounding stick must be used to discharge the ring by fastening the ground cable of the stick to a known ground and touching the grounding tip of the stick to each mid-band ring.*

The insulated vacuum container should be examined carefully for cracks in the area of the metal-to-insulation interface seals on both ends and around the Mid-Band Ring. Since a certain amount of transmitted light is usually required to detect cracks, the inspection should be done in a well lighted area. If the mid-band ring, when so equipped, has been bent by accidental impact, that area should be specially scrutinized for seal damage. Small external chips will not impair the useful life of the interrupter.

## Barrier and Insulation Inspection

All barriers and insulated parts should be checked for damage. Any dust or dirt should be removed

by compressed air or with a clean lint-free cloth. If these parts have become contaminated with any heavy dirt or grease, a clean, lintless cloth saturated with alcohol should be used.

The lead support moldings are polyester glass and occasionally have some resin rich cracks or crazing that develops. These do not indicate defective material and should not cause concern.

## Installing Front Barrier

Install the assembly and fasten with four lower front barrier screws and one screw on each side, inside the front barrier.

**Note:** It is recommended that a dielectric withstand test be performed prior to initially putting this or any type vacuum circuit breaker into service. Refer to "Dielectric Tests" in the "Adjustments, Tests and Periodic Maintenance" section for the correct test procedure.

## Manual Operation For Inspection

The electrically operated circuit breakers can be charged manually with a removable Manual Charge Handle for bench tests or emergency operation. The removable Manual Charge Handle is an accessory and is supplied only when ordered.

Position the handle onto the Manual Charging Lever hooked section in the long slot on the Pawl Carrier (See Figure A5 in the Appendix). The small tabs on the Manual Charging Handle will fit in the small holes of the Pawl Carrier. Push down on the Manual Charging Handle until it will not travel any further. This partially charges the Closing Springs. Repeat this operation until the charging mechanism is heard to snap over center (approximately 10 operations), and the Spring Indicator clearly shows the message SPRINGS CHARGED. The circuit breaker can now be closed by pulling out on the Manual Close Lever. The Circuit Breaker can then be closed by pressing the Manual Trip Button. See Figures A3 and A4 in the Appendix.

## Padlock Hasp Provision

Refer to Figure A6 located in the Appendix. The Racking Mechanism Padlock Hasp provision permits the breaker to be padlocked in the DISCONNECT and TEST positions. This provision is accomplished by the Padlock Hasp blocking the Blocking Lever attached to the Racking Release Assembly, preventing the Rack Screw from being rotated clockwise to the *release* position. If not functioning properly, the Adjustable Link must be adjusted as follows.

1. Remove the lower Front Panel of the breaker.
2. Remove the Retaining Ring from one of the pins securing the Adjustable Link.
3. Rotate the free end of the Adjustable Link to vary its length, so that when reconnected to the pin, the padlock functions as noted above.
4. Replace the Retainer.
5. This adjustment might effect feature "D" of the "Interlocks (*Racking Mechanism*)", below, and it should be checked also.

**NOTE:** As a special option, the breaker may be ordered with Three-Position Padlocking, which also permits the breaker to be padlocked in the CONNECT position.

## Interlocks (*Racking Mechanism*)

The four mechanical interlocks that work in conjunction with the Racking Mechanism to protect both user and breaker should function as specified below. If malfunction is identified and the recommended adjustments do not correct the problems consult the factory before placing the breaker in service.

Refer to the next sections "Installing Circuit Breaker Into Compartment" and "Removing Circuit Breaker" for a complete description of the Racking Mechanism components and operation.

- A. When in the WITHDRAW position, the Closing Springs will discharge automatically. If the Closing Springs have been previously charged, they will discharge when the racking mechanism reaches this position. This is accomplished by a linkage, activated by an Adjusting Screw on a welded tab at the center of the Rack Shaft. This pulls the Discharge Link Assembly which releases the Close Latch to its unlatched position. If the interlock does not function as specified, adjust as follows:
  1. Make sure Racking Mechanism is in the DISCONNECT position.
  2. Following the instructions in "Removal from DISCONNECT Position," rotate the Rack Screw counterclockwise. The Manual Close Lever should begin moving after one-half (1/2) turn from the DISCONNECT position.
  3. If the Manual Close Lever requires more than one-half (1/2) turn to begin moving, then adjustment of the Adjusting Screw on the Racking Shaft will have to be made. The gap between the Adjusting Screw and the Discharge Link Assembly is between 0.010" – 0.031". See Figure A7 in the Appendix.
- B. The Rack Screw cannot be turned to move the breaker starting from the DISCONNECT, TEST and CONNECT positions, unless the Release Lever is first operated. A finger in the Index Lever engages one of three holes in the Rack Screw corresponding to each of the previously mentioned positions, preventing it from rotating. Turning the Release Lever to the left disengages the finger from the hole, allowing the Rack Screw to be rotated.
  1. If the Rack Screw can be rotated without turning the Release Lever, check if the Release Lever is jammed in the left (*release*) position. If so, see if it can be freed.
  2. Visually inspect that the finger of the Index Lever is engaging in the corresponding hole in the Rack Screw.

**NOTE:** If the Release Lever cannot be turned to the left, make sure breaker is first in the Open position.

C. The Release Lever cannot be operated when the breaker is in the closed position. This prevents connecting or disconnecting the breaker from the Primary Stabs in the compartment with the breaker closed. A Racking Lock Bracket, operated by the breaker's Jackshaft, blocks the Index Lever when the Jackshaft is in the closed position. If the interlock is not functioning as noted, perform the following inspections. Refer to Figure A6 in the Appendix.

1. Check that the Racking Lock Bracket is connected to the Jackshaft via a Link. If not connected then reconnect.

**NOTE:** The Operations Counter and the Open/Closed Indicator are also driven by the same Racking Lock Bracket.

2. Check that nothing in the Racking Mechanism is bent.

D. When the circuit breaker is between the WITHDRAW, DISCONNECT, TEST and CONNECT positions, any attempt to close the breaker will discharge the Closing Springs, and the contacts will not close. This is referred to as "Trip Free" operation. The finger of the Index Lever rides on the circumference of the Rack Screw, holding the Release Lever in its released position. A linkage between the Release Lever and Trip Latch then holds the Trip Latch in its unlatched position. If this interlock is not functioning as noted, perform the following:

1. Confirm that the Trip Latches are properly adjusted and functioning. Position the Rack Screw so the Rack Mechanism is in the DISCONNECT, TEST or CONNECT position. Charge and Close the breaker, and then press the Manual Trip Button.

**NOTE:** If the breaker does not trip the Trip Latch and/or linkage is at fault. Contact the Customer Service Center for assistance.

**NOTE:** When the Racking Mechanism is between the WITHDRAW, DISCONNECT, TEST, or CONNECT positions the Manual Trip Button should have a slight amount of play so as not to "Bottom Out". The Adjustable Link and the Link to Trip Lever (See Figure A6 in the Appendix) both can be adjusted to accomplish this. Adjustment is as follows:

1. If adjustment is necessary, the "Link to Trip Lever" should be adjusted first to get the slight play in the Trip Linkage.
2. If necessary, the Adjustable Link can be adjusted after first removing one of the securing Retainer Rings.
3. The interlock should now be properly adjusted. Confirm by retesting the interlock.
4. If the interlock is now functioning properly, replace the retainer removed in step 2.
5. If the Adjustable Link setting is changed, the Padlock Hasp Provision in the previous section will have to be rechecked for proper operation.

## Installing Circuit Breaker Into Compartment (See Figure A8 in the Appendix)

**NOTE:** Model 80 breakers do not have Racking Mechanisms. They are bolted-in units.

**NOTE:** CLOCKWISE rotation of racking crank for inserting breaker. COUNTERCLOCKWISE rotation of racking crank for removal of breaker.

1. Turn Motor Disconnect Switch (if so equipped) to the OFF position. Refer to Figures A3 and A4 in the Appendix.

**NOTE:** Step 2 is possible only if Racking Mechanism is in CONNECT, TEST or DISCONNECT positions, and the breaker is Open)

2. Make sure the Racking Mechanism is in the WITHDRAW position. This can be done by first turning the Release Lever to the left. While holding the Release Lever to the left, engage the Racking Crank (accessory) into



the Rack Screw and rotate crank counterclockwise until a definite resistance is felt (Do Not Force).

**NOTE:** If the Index Lever is observed (and/or heard, by a "click" sound) to instead engage in one of the holes of the Rack Screw, causing the Release Lever to turn back to the right, the Racking Mechanism is still not in the WITHDRAW position. Step 2 must be repeated.

**NOTE:** If the Closing Springs were previously charged, they will automatically discharge when the Racking Mechanism reaches the WITHDRAW position.

3. Engage the Fifth Wheel accessory into the Hole Guide in the breaker's truck. See Figure A1 in the Appendix. Push the circuit breaker into the switchgear compartment until a definite stop is felt. This stop is the rollers of the breaker's Racking Arms hitting the back edge of the Racking Ports of the compartment.
4. Turn the Release Lever to the left, engage Racking Crank into the Rack Screw, and rotate Crank clockwise until racking mechanism automatically stops at the DISCONNECT position. The breaker is now held captive in the compartment by the rollers of the Racking Arms and the Racking Ports of the compartment.
5. To rack the circuit breaker to TEST position, turn the Release Lever to the left, turn Crank clockwise one-quarter ( $\frac{1}{4}$ ) turn, and then release the Release Lever. It will remain in the *released* position. Continue cranking clockwise until the racking mechanism automatically stops at the TEST position.
6. With the circuit breaker now in the TEST position, turn the Motor Disconnect Switch to the ON position to electrically charge the Closing Springs. If a Motor Disconnect Switch was not provided, the Closing Springs will automatically charge when the breaker approaches the TEST position.

Check for proper operation by closing and opening (tripping) the circuit breaker both electrically and mechanically. This includes control switches, relays, etc.

## WARNING

*For safety, when racking the circuit breaker "to" or "from" the CONNECT position, the compartment door must be closed, and the racking crank inserted through the opening provided in the compartment door.*

7. To rack circuit breaker to the CONNECT position, close the compartment door, and reinsert the crank into the Racking Screw via the Access Door in the compartment door. See Figure A8.
8. Turn the Release Lever to the left, rotate Crank clockwise one-quarter ( $\frac{1}{4}$ ) turn, and then release the Release Lever. It will remain in the *released* position. Continue cranking clockwise until the Racking Mechanism automatically stops at the CONNECT position.

## CAUTION

*Do not attempt to rack circuit breaker any further, damage to the racking mechanism may result.*

## CIRCUIT BREAKER REMOVAL (MODEL 21)

### Removal From CONNECT Position

## WARNING

*For safety, when racking the circuit breaker "to" or "from" the CONNECT position, the compartment door must be closed, and the racking crank inserted through the opening provided in the compartment door.*

1. Open Access Door in the front compartment door, and engage Racking Crank into the Rack Screw. See Figure A8.
2. Turn the Release Lever to the left, rotate the Crank counterclockwise one-quarter ( $\frac{1}{4}$ ) turn, and then release the Release Lever. It will remain in the *released* position. Continue rotating the crank counterclockwise until the Racking Mechanism automatically stops at the TEST position.



## Removal From TEST Position

1. Turn the Release Lever to the left, rotate the Crank one-quarter ( $\frac{1}{4}$ ) turn counterclockwise, and then release the Release Lever. It will again remain in the *released* position. Continue Cranking counterclockwise until Racking Mechanism automatically stops at the DISCONNECT position.

## Removal From DISCONNECT Position

1. Turn the Rack Release Lever to the left, and turn Crank counterclockwise one-quarter ( $\frac{1}{4}$ )-turn. Release the Rack Release Lever. It will again remain in the released position. Continue cranking counterclockwise until a resistance is felt (approximately 2-3 turns) (Do Not Force.) The breaker is now in the WITHDRAW position.

If the Closing Springs were previously charged, they will automatically discharge as the Racking Mechanism reaches the WITHDRAW position.

2. The circuit breaker can now be removed from the compartment by pulling on the handle located on the Front Barrier.

## Safe Operations Recommendations

It is recommended that any circuit breaker be withdrawn and stored in the withdrawn position whenever it is to be maintained in the OPEN position with no planned switching.

It is recommended that a Ground & Test Device (a.k.a. G&T Device) be connected to the proper compartment when any work is to be done on any bus or feeder circuit. See section "Ground and Test Devices" for a description.

## ADJUSTMENTS, TESTS AND PERIODIC MAINTENANCE

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The circuit breakers are designed and tested to insure minimum maintenance. The few adjustments that are noted are required only when

an operational check indicates a problem. Of course, during the maintenance checks, all accessible bolts, units and screws should be routinely checked to insure that they are tight.

It is recommended that the circuit breaker be inspected after the first 1000 mechanical operations and on a yearly basis unless environmental considerations and operating experience indicate that more or less frequent inspections are appropriate.

Vacuum interrupters, as used on the VHK vacuum circuit breakers, have an inherently long contact life and will provide trouble-free service under varied application conditions as long as the circuit breaker is applied within its rating. The interrupters have been tested up to 2000% KSI minimum. It is unlikely that a circuit breaker will be subjected to this much duty in its life, and it is not expected that the interrupters will have to be replaced due to excessive contact erosion.

The wear condition of the individual vacuum interrupters will vary, however, depending on circuit conditions and such variables as single phase versus three-phase interruption, X/R ratio (asymmetry) and relay delay times. Therefore, the interrupters in all three phases may not erode equally. Additionally, interrupting high short-circuit current will cause contact erosion to occur faster than load current interruptions.

There is, however, a check for Contact Wipe (Contact Spring overtravel), which is a measure of contact erosion. This check is covered under the subsection "Contact Wear and Contact Pressure." When Contact Wipe is less than the minimum specified and there is not any mechanical problem, the interrupter should be replaced due to contact erosion.

If, after the first inspection period, there is no indication of any problems, actual operating experience with specific circuits will indicate the future amount of maintenance needed for the various circuit breakers, and the procedure can be modified as required.

Where unusual service conditions exist, as covered by ANSI Standard C37.04, it must be presumed that these conditions were considered at the time of order, the equipment supplied was

designed for special application, and an appropriate supplemental maintenance program has been developed. These maintenance instructions only cover circuit breakers used under the standard service conditions.

At the selected maintenance period, the following maintenance, tests and adjustments (if necessary) should be made:

### Insulation Cleaning

#### WARNING

*If the circuit breaker has been energized, or it is unsure if the circuit breaker has ever been energized, the mid-band ring (on vacuum interrupters so equipped) must first be discharged before any work is performed on or near the interrupters. A grounding stick must be used to discharge the ring by fastening the ground cable of the stick to a known ground, and touching the grounding tip of the stick to each mid-band ring.*

Any dirt, dust or grease should be removed from the surfaces of the entire current carrying structure and vacuum interrupter. Wiping the surface with a clean, lint-free cloth is normally sufficient. If there is heavy grease, alcohol should be used.

### DC Millivolt Drop Test / Micro-ohm Test

During maintenance periods, the condition of the breaker current circuit can easily be determined by performing a Millivolt Drop Test or a Micro-ohm test. This test should be performed regardless of whether the circuit breaker had interrupted low or high currents, or has minimum operations.

**NOTE:** The values for resistance, given in Table A3, are for new breakers. It is normal and acceptable for a used breaker to have resistance values as much as 100% greater than these values.

Refer to Table A3 in the Appendix for the Millivolt drop and Resistance values for the circuit breakers covered, from lead to lead. If the Primary Disconnects (a.k.a., Tulips) are to be included in the test path, a 2.000"  $\pm$  0.005" diameter smooth (62rms) copper conductor must be inserted into the open end of each Primary Disconnect to achieve the proper contact pressure.

### Contact Wear and Contact Pressure (Contact Wipe)

The amount of contact wear can be determined by measuring what is referred to as Contact Wipe (or overtravel). This can be accomplished by closing the breaker and carefully measuring the gap between the Nut and the Trunion Block of the Contact Spring Assembly. See Figure A9 in the Appendix.

#### WARNING

*Keep hands clear of all moving parts. Serious injuries can result if a person comes in contact with breaker parts when the breaker is being opened or closed, or closing springs are being charged or discharged. Use extension tools for manipulating breaker parts.*

This adjustment is initially set at the factory to a range of 0.093 - 0.101 (2.4mm – 2.6mm). As the breaker sees service and the contacts start to erode, this value will decrease. Asymmetrical and single phase interruption will cause contact erosion and wipe deterioration to occur differently for all three poles. Once the Wipe has decreased to 0.031" and it is determined that the breaker is operating properly, the interrupter assembly will need replacement. The measurement is made as follows:

1. Close the breaker and measure between the Nut and Spring Base. See Figure A9.
2. The gap should be in the range shown in Table A3.
3. When the Contact Wipe is less than 0.031", and it has been determined that the breaker closes fully, and there is not a mechanical problem than the Interrupter should be replaced due to contact erosion.

### Contact Gap

Upon opening the breaker, the resulting gap between the vacuum interrupter contacts is referred to as Contact Gap. This gap is also the distance the contacts travel upon closing. This can range from a minimum of 0.310 " (7.9mm) on a new breaker, to a maximum of 0.540" (13.5mm)

on a used breaker with an interrupter nearing replacement. As the breaker sees service, and the contacts start to erode, this value will increase.

The following procedure describes how to determine the Contact Gap. The necessary tools are: an ink pad and a thin flat straight edge with approximate dimensions should in Figure A9 in the Appendix. Proceed with the circuit breaker withdrawn from the compartment.

## WARNING

*If the circuit breaker has been energized, or it is unsure if the circuit breaker has ever been energized, the mid-band ring (on vacuum interrupters so equipped) must first be discharged before any work is performed on or near the interrupters. A grounding stick must be used to discharge the ring by fastening the ground cable of the stick to known ground, and touching the grounding tip of the stick to each mid-band ring.*

## Contact Gap Check (See Figure A9).

1. Open the breaker and discharge the closing springs.
2. The Racking Mechanism must be in either the DISCONNECT, TEST or CONNECT position.
3. Apply ink from the Ink Pad to the end of the Straight Edge.
4. Slide the Straight Edge along the bottom of the Molded Chair Assembly until the Straight Edge contacts the Pushrod. This will be the first of two markings needed. See Figure A9.
5. Close the breaker and repeat Steps 3 and 4.
6. The Gap is the distance measured between the two lines. The acceptable limits are listed in Table A3, located in the Appendix.

## Contact Sequencing (Synchronization)

Before checking contact sequence, verify that the Contact Wipe and Gap for each pole is correct. Refer to the subsections "Contact Wipe" and

"Contact Gap". It is not expected that the contact sequence should exceed the 4 millisecond limit, therefore, before attempting to readjust, verify that the test equipment and procedure are correct. Also consider, especially when testing with electronic equipment, that multiple 2 millisecond vacuum interrupter contact bounces are permissible during normal closing, and these bounces can influence the contact time measurements. If there are any questions, consult the factory.

If it is determined that the contact sequence is not within 4 milliseconds, adjustment is required. Usually, readjustment of one pole should be sufficient so that all three poles touch within 4 milliseconds. The gap of the pole to be changed should be decreased if the contacts of that pole are touching after the other two poles, or increased if the contacts are touching before the other two poles. The gap is decreased by turning the Pushrod clockwise, and increased by turning the Pushrod counterclockwise, as viewed from the top of the breaker.

## WARNING

*Keep hands clear of all moving parts. Serious injuries can result if a person comes in contact with breaker parts when the breaker is being opened or closed, or closing springs are being charged or discharged. Use extension tools for manipulating breaker parts.*

Before the Pushrod can be turned, the breaker must be in the Open position, Closing Springs discharged and the Pushrod Pin removed. See Figure A9 in the Appendix. With the breaker Open, the vacuum in the interrupter maintains a constant upward force of approximately 25 pounds on the moving contact and Pushrod. Therefore, before removing pin, the contact must be held down in the open position by temporary spacers. After removing the Retaining Ring and Pushrod Pin, rotate Pushrod as required.

One quarter (1/4) turn of the Pushrod will change the gap by approximately 0.019" (0.5mm). After rotating the pushrod, carefully reposition it vertically to align the holes and the stud. Replace the pin and retainer and remove the temporary spacer. During the readjustment procedure, note that the Contact Wipe and Contact Gap dimensions must be maintained. The Contact

Gap and Contact Wipe are inversely related; increasing one decreases the other, and visa-versa. Also, note that no more than one-half (1/2) turn should be required when readjusting for contact sequence.

After completing the contact sequence procedure, recheck the Contact Wipe and gap for each pole. If the specified Contact Gap, Contact Wipe and contact sequencing cannot all be obtained, and it is determined that the breaker is operating properly, the interrupter is in need of replacement.

The front cover and interphase barrier assembly can now be reinstalled. Return the rack screw to its original position by turning it counterclockwise approximately two to three turns until it stops.

### Closing and Opening Times

After the operation intervals, it is recommended that the Closing and Opening Times be checked. This can be done by use of a cycle counter, travel recorder or oscillograph to monitor the time from coil energizing to contact kiss (closing) or part (opening).

**Note:** Normally, the Closing Time is not critical. The breaker performance is satisfactory if the Closing Speed, Opening Speed and Opening Time are within specification. See Table A3 in the Appendix for the nominal values for these parameters.

The circuit breaker closing and opening times should be within the time ranges for normal operation.

Note the following:

- Times are from signal initiation to primary contact kiss (make) or break.
- Times for DC controls supplied by a rectified unconditioned power source, and all AC controls, may wander by as much as  $\pm 4\text{ms}$  due to the "current-zeroes" associated with such currents.
- Below  $0^{\circ}\text{C}$ , the closing times will increase (but with no reduction in closing force), and opening times will usually be within the limits.

- Adjustments to correct times, if found to be outside limits, are critical and the nearest District Office should be contacted for recommendations.

### Closing and Opening Speeds

The Closing and Opening speeds of the Primary Contacts can be determined by use of a travel recorder, which records their linear travel versus time. The output can be fed into a travel recorder or oscilloscope.

Before the Closing and Opening speeds are checked, the Contact Wipe should first be inspected. This is because, in addition to the energy provided by The Opening Springs, the Contact Springs provide additional acceleration energy through the wipe distance upon contact part. As the Primary Contacts erode, the Contact Wipe decreases, and the opening speed will decrease. Speed should still be within acceptable limits if the wipe is still within limits. Refer to Table A3 in the Appendix.

#### WARNING

***Do not attempt to increase the opening speed by readjusting the push rod to gain more contact wipe.***

If either of the speeds is too slow, and the Contact Wipe is within the limits specified, examine the breaker for any moving parts that appear to be binding. If none can be found, consult the factory for assistance.

### Operating Mechanism

#### Trip Latch Engagement (Bite) (See Figure A10).

The Latch Engagement Adjusting Screw (3) is located at the right of the right-hand mechanism housing (1). It can be reached easily from the top of the breaker, after removal of the top cover plate.

To adjust the Latch (2) Engagement, proceed as follows:

1. Back off Adjusting Screw (3) to assure excessive latch engagement.
2. Close the circuit breaker.
3. Turn Adjusting Screw (3) down slowly until the Latch just releases, tripping the circuit breaker.
4. Back off the Adjusting Screw (3) 2 turns.

## WARNING

***Keep hands clear of all moving parts. Serious injuries can result if a person comes in contact with breaker parts when the breaker is being opened or closed, or closing springs are being charged or discharged. Use extension tools for manipulating breaker parts.***

## Control Device (See Figure A11)

The Control Device is adjusted before leaving the factory. It is recommended that no attempt be made to adjust the internal relays and contacts of this device in the field. If replacement of the Control Device is required, the Close Latch Release Rod (5) *overtravel* may be adjusted as described below.

## Close Latch Rod Release Overtravel

1. Back off on Close Latch Release Rod (5) and check that the circuit breaker will not close electronically or manually by pushing up on the Close Latch Release Rod to the full extent of its travel.
2. Charge the Closing Springs. Push up the Close Latch Release Rod to the full extent of its travel and hold.
3. While holding the Close Latch Release Rod in this position, turn up on the Close Latch Release Rod until the circuit breaker closes. Turn the Close Latch Release Rod up an additional 1-1/2 turns.

## Lubrication

All mechanism parts, bearings, pins etc. of the VHK vacuum circuit breakers have been lubricated with Anderol 757 during factory

assembly. While any adjustments, tests and/or periodic maintenance is being performed, it is recommended that the grease for those parts be examined.

If the grease should become contaminated or unduly oxidized (hardened and darkened), or if parts are replaced, any relubrication should be done with the same lubricant, available from ABB as part number 712994-C00 (1 LB can).

Note the following:

- The mechanism should be periodically inspected for lubrication contamination. The frequency of inspection is dependent upon experience with the operating environment.
- Anderol is a Lithium soap-based synthetic lubricant. Anderol is not compatible with many other lubricants. Mixing with other incompatible lubricants will cause caking and discoloration and will require complete purging and relubrication of breaker parts.
- Do not apply grease to latch or roller surfaces.
- Do not use light oil to lubricate any mechanism parts. In emergency situations, Anderol 732 may be used as a temporary lubricant, if adequate time (several hours) is allowed for the solvents to evaporate prior to any mechanical operations. It is mandatory that the breaker undergo thorough lubrication with Anderol 757 as soon as possible. Note that bearing surfaces must be repacked, requiring disassembly of the mechanism. Do not operate the circuit breaker without completing this procedure.
- Use of solvents to free contaminated lubricant is strictly forbidden without immediate relubrication using Anderol 757.
- The charging motor has sealed bearings. No lubrication is required.

## Dielectric Tests

It is recommended that dielectric withstand tests be made prior to use and at routine maintenance periods to verify the integrity of vacuum circuit breakers. If, during the dielectric withstand test,



the required test voltage cannot be sustained across the open contacts of the vacuum interrupter, the interrupter may be faulty and must be replaced. Always insure that the contact air gap is correct before conducting primary circuit dielectric tests.

**WARNING**

*Do not run any primary circuit dielectric withstand tests on isolated interrupters with open contacts above rated voltage, unless test personnel are adequately shielded or are no less than six feet from the test unit.*

**WARNING**

*If the circuit breaker has been energized, or it is unsure if the circuit breaker has ever been energized, the mid-band ring (on vacuum interrupters so equipped) must first be discharged before any work is performed on or near the interrupters. A grounding stick must be used to discharge the ring by fastening the ground cable of the stick to known ground, and touching the grounding tip of the stick to each mid-band ring.*

Note the following:

- Dielectric test voltages higher than rated voltage, applied across open contacts, may cause a vacuum interrupter to emit some X-radiation, which could be a health hazard on prolonged exposure at close range. Accordingly, even though the emission is low, it is considered appropriate to exercise caution. Therefore, do not run any primary circuit dielectric withstand tests on isolated interrupters with open contacts above rated voltage unless test personnel are adequately shielded or they are no less than six feet from the test unit.
- It is to be noted that no hazardous X-radiation is produced with closed contacts at any test voltage, nor with open contacts at rated voltage, and there should be no cause for concern. If the breaker is tested in its compartment at the test voltages recommended below, the steel enclosure will provide sufficient shielding to protect personnel from X-radiation at the normal distances maintained for electrical safety.

**NOTE:** Only an AC hi-pot test is recognized as a valid test. DC, Meggers, etc. are not valid for hi-pot testing.

The following test values should be used for dielectric testing the new breaker, and are to be applied for a one-minute period:

- Primary Circuit, new interrupters  
36kV for 7.5kV and 15kV  
19kV for 5kV
- Secondary Circuit  
1100VAC (except motor)  
540VAC (motor)

Once in service, the different circuits should be tested at 75% of these ratings.

If it is desired to make a dielectric test on the secondary control wiring, turn the spring charging Motor Disconnect Switch to the "OFF" position. Apply test voltage (1100VAC) for one minute to each of the secondary contacts of the circuit breaker.

If it is desired to make a dielectric test on the spring charging motor, turn the Motor Disconnect Switch to the "ON" position. Apply test voltage (540VAC) for one minute to the motor circuit.



## **ELECTRICAL CHARACTERISTICS OF CONTROL DEVICES - (REFER TO FIGURES A12 AND A13 IN THE APPENDIX)**

**NOTE:** The charging time of the breaker with the new Ryobi Motors is approximately four seconds.

For operating voltage ranges and normal current draw for various nominal control voltages, refer to Tables A1 and A2 in the Appendix. The current values given are average steady state values. Momentary inrush currents for all charging motors and coils are approximately three times these values.

Please refer to the specific schematic diagrams and other operational information furnished with your order. Typical schematics for general electrical information can be found in the Appendix.

### **DC and AC Closing Operating Sequence**

With the circuit breaker open, closing springs discharged, control power source energized, and motor disconnect switch to ON position, operation occurs as follows:

1. Immediately upon the availability of control power across disconnects "5" and "02", the spring charging motor is energized, which in turn charges the closing springs. When the closing springs are charged, limit switch contact "LSb" is opened, and limit switch contact "LSa" is closed.
2. Operation of the close control switch (with its power source), connected to disconnects "03" or "7" and disconnect "6", energizes the latch release coil (X) through the circuit breaker auxiliary switch "b" contact, the normally closed lockout relay contact "Yb", limit switch contact "LSa". The latch release coil (X) releases the closing latch. The springs then discharge to close the circuit breaker.
3. When the springs discharge, limit switch contacts "LSb" closes and switch contact "LSa" opens.

4. When limit switch "LSb" in the motor circuit closes, the spring charging motor is energized, which in turn recharges the closing springs.
5. When the circuit breaker closes, all auxiliary switch "b" contacts open and all auxiliary switch "a" contacts close.
6. When the limit switch contact "LSb" closes, the lockout relay coil (Y) is energized and opens lockout relay contact "Yb", which de-energizes the latch release coil (X). Lockout relay contact "Ya" closes, which seals-in the lockout relay coil (Y) as long as the "close" contact is maintained. The purpose of the lockout relay coil (Y) is to prevent pumping of the closing mechanism when closing against a faulted circuit.
7. After the breaker has closed and the "close" switch is released by the operator, the lockout relay coil (Y) is de-energized. This allows the normally-closed lockout relay contact "Yb" to close, and the normally-open lockout relay contact "Ya" to open.
8. The circuit breaker can be tripped by operation of the trip control switch, connected to disconnects "3" or "04" and disconnect "10", which energizes the circuit breaker trip coil (TC) through the auxiliary switch "a" contact.
9. The Undervoltage Device, if furnished, provides a direct acting lock-open and undervoltage tripping feature. This device must be energized to initially close the breaker, and also to maintain the breaker in a closed position.
10. The latch check switch, if furnished, insures that the tripping mechanism must be reset prior to energizing the closing latch release coil (X).

### **AC Closing Operating Sequence (Prior to January 1996)**

With the circuit breaker open, the closing springs uncharged, the control power source energized across disconnects "5" & "02" and "01" & "6", and the motor disconnect switch to ON position, operation occurs as follows:

1. Immediately upon the availability of control power at terminals "05" and "02", the spring charging motor is energized, which in turn charges the closing springs. When the closing springs are charged, limit switch contact "LSa" is closed. Also, upon availability of control power at disconnects "01" and "6" through auxiliary switch "b" contact, and after the closing springs have been charged, the lockout relay coil (Y) will be energized through the circuit breaker auxiliary switch "b" contact and the parallel resistors R1 and R2. The lockout relay will pick up and close contact "Ya".
2. Connecting wires "03" or "7" to control power via operation of the close control switch energizes the latch release coil (X) through the circuit breaker auxiliary switch "b" contact, the normally open lockout relay contact "Ya", and the limit switch contact "LSa". The latch release coil (X) releases the closing latch. The springs then discharge to close the circuit breaker.
3. When the springs discharge, limit switch contact "LSb" closes and limit switch contact "LSa" opens.
4. When limit switch contact "LSb" in the motor circuit closes, the spring charging motor is energized, which in turn recharges the closing springs.
5. When the circuit breaker closes, all auxiliary switch "b" contacts open and all auxiliary switch "a" contacts close.
6. When the limit switch contact "LSb" closes, the lockout relay coil (Y) is de-energized and opens lockout relay contact "Ya", which de-energizes the latch release coil (X). Lockout coil (Y) is locked out as long as the *Close* signal is maintained. This is because the maintained control power on disconnects "03" or "7" puts resistor R1 in parallel with lockout coil (Y). The additional current flow through parallel resistors R2 & R3 and the associated increased voltage drop leaves insufficient voltage to pick up the lockout relay. The purpose of the lockout relay is to prevent pumping of the circuit breaker's mechanism when closing against a faulted circuit.
7. After the breaker has closed and when the closing control switch is released by the operator, the lockout relay coil (Y) remains de-energized due to the auxiliary switch "b" contact in the closing circuit being open.
8. The Circuit Breaker can be tripped by operation of the Remote Trip Switch which is connected to Disconnects "04" and "10". This energizes the breaker Trip Coil (TC) through the auxiliary switch "a" contact.
9. The Undervoltage Device, if furnished, provides a direct acting lock-open and Undervoltage tripping feature. This device must be energized to initially close the breaker, and to maintain the breaker in a closed position.
10. The Latch Check Switch (LCS), if furnished, insures that the operating mechanism must be reset prior to energizing the closing latch release coil (X).
11. The remote mounted capacitor trip feature (recommended for AC trip), if furnished, provides an electrical energy storage network. Should a loss of control power occur at the instant of a tripping signal, sufficient energy will be furnished to insure an electrical tripping operation.
12. The stopping device switch, if applicable, prevents electrical reclosing of the Circuit Breaker after a manual trip until the stopping device switch has been manually reset.

## ***GROUND AND TEST DEVICES***

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These devices are supplied when ordered with certain component variations such as Test Ports and Interlocks. The three basic types are:

- Simple, three or six-terminal.
- Simple, three or six-terminal electrically (remote) operated.
- Complex, six-terminal, electrically (remote) operated with manual selector switch.

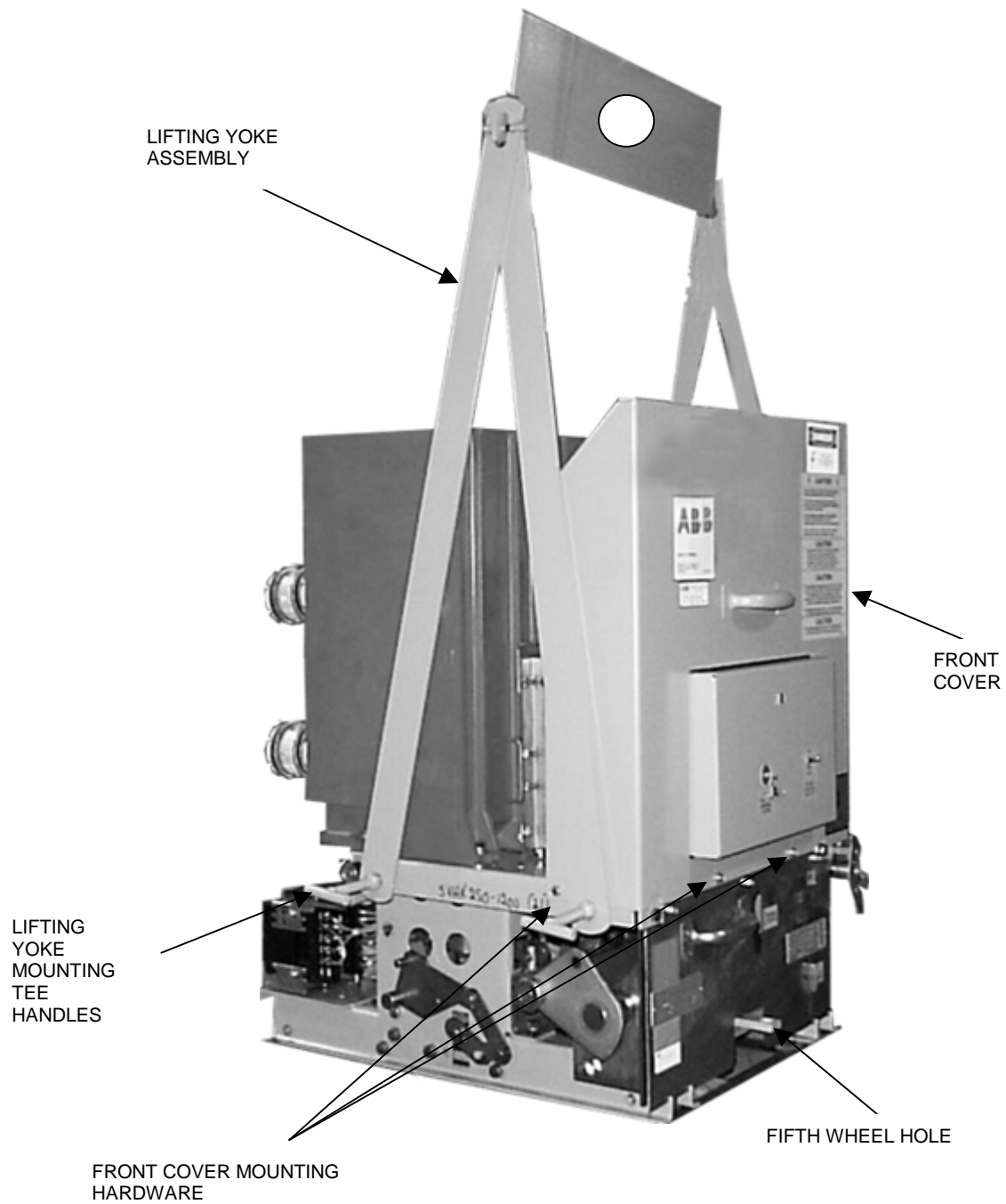
These devices are basically maintenance free for their normal operating life. Racking procedures are similar to the standard breaker as outlined (except that they only have a WITHDRAW AND CONNECT position), and all detailed operational instructions are attached to the devices.

## ***RENEWAL PARTS***

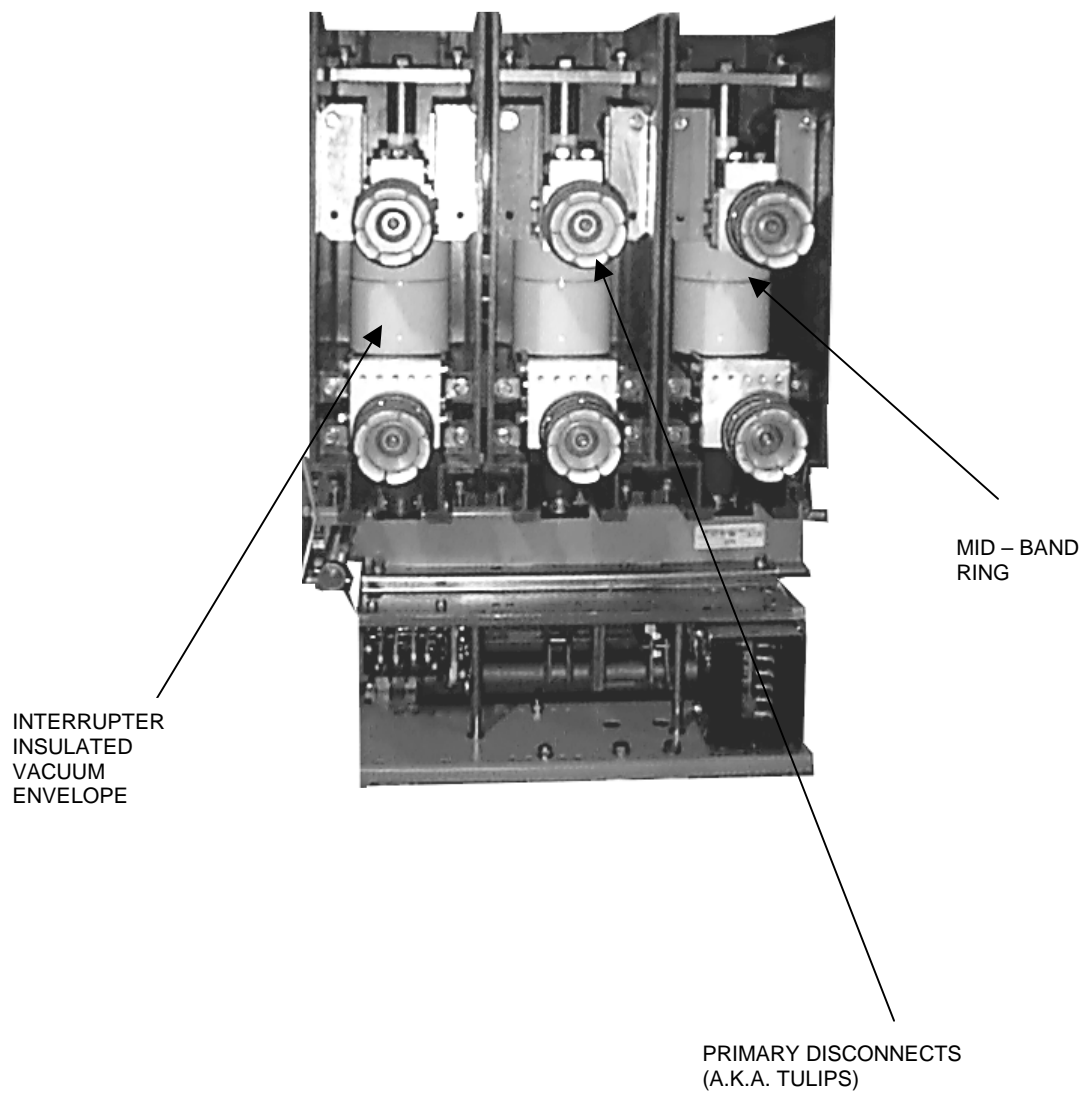
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Only those renewal parts that will be required to insure proper and timely maintenance for normal operation of the VHK vacuum circuit breakers are recommended to be stocked. Copies of the applicable Renewal Parts Bulletin for specific circuit breakers will be furnished on request from the Component Sales Department (407-323-8220).

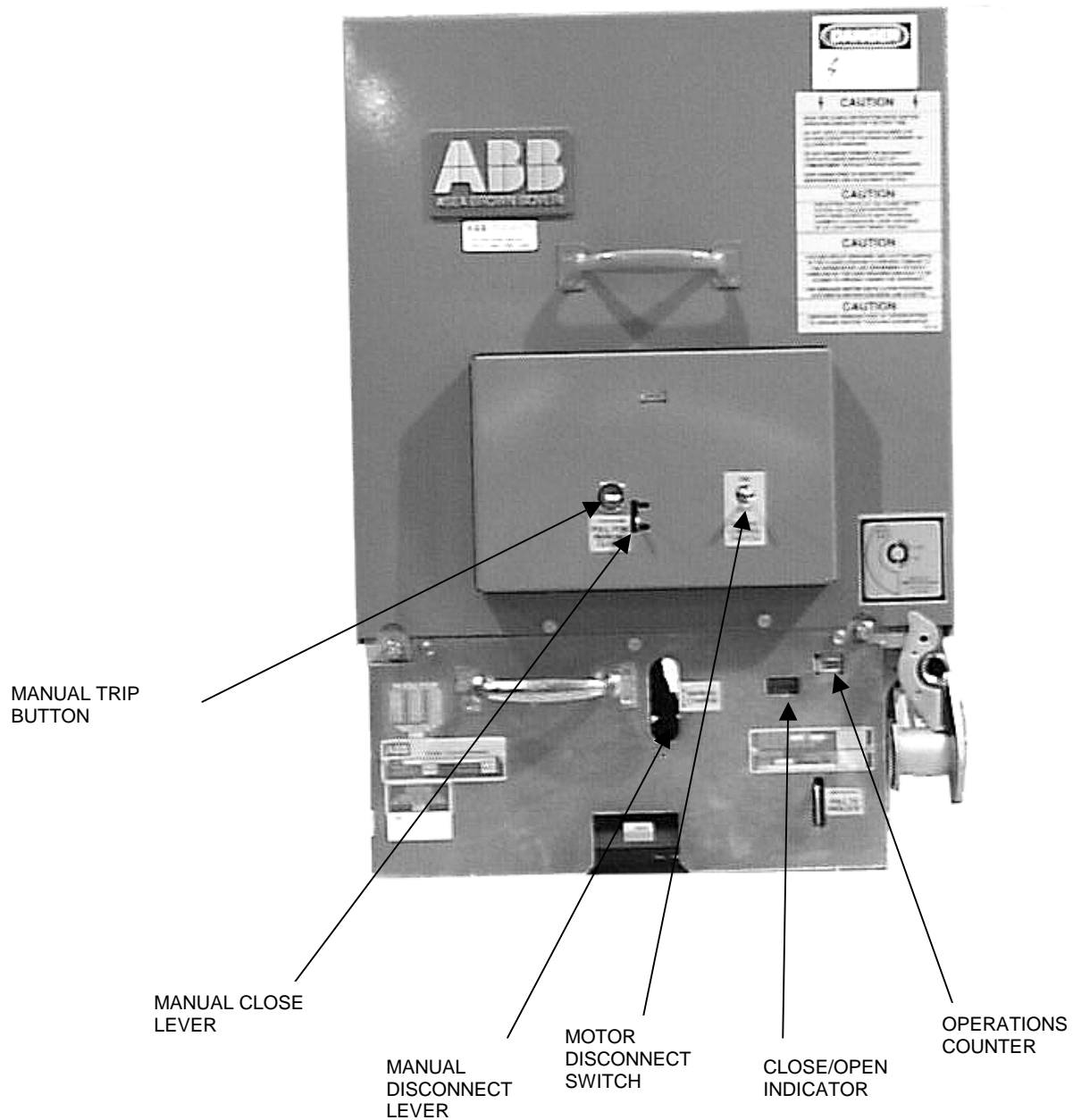
The minimum quantity of assemblies and items recommended in these bulletins are based upon accumulated tests and operating experience. Total assemblies are recommended for convenient replacement, when it is necessary to return the breaker to service as quickly as possible. The bulletins also contain specific part ordering instructions.



**CIRCUIT BREAKER ASSEMBLY WITH LIFTING YOKE INSTALLED**  
FIGURE A1

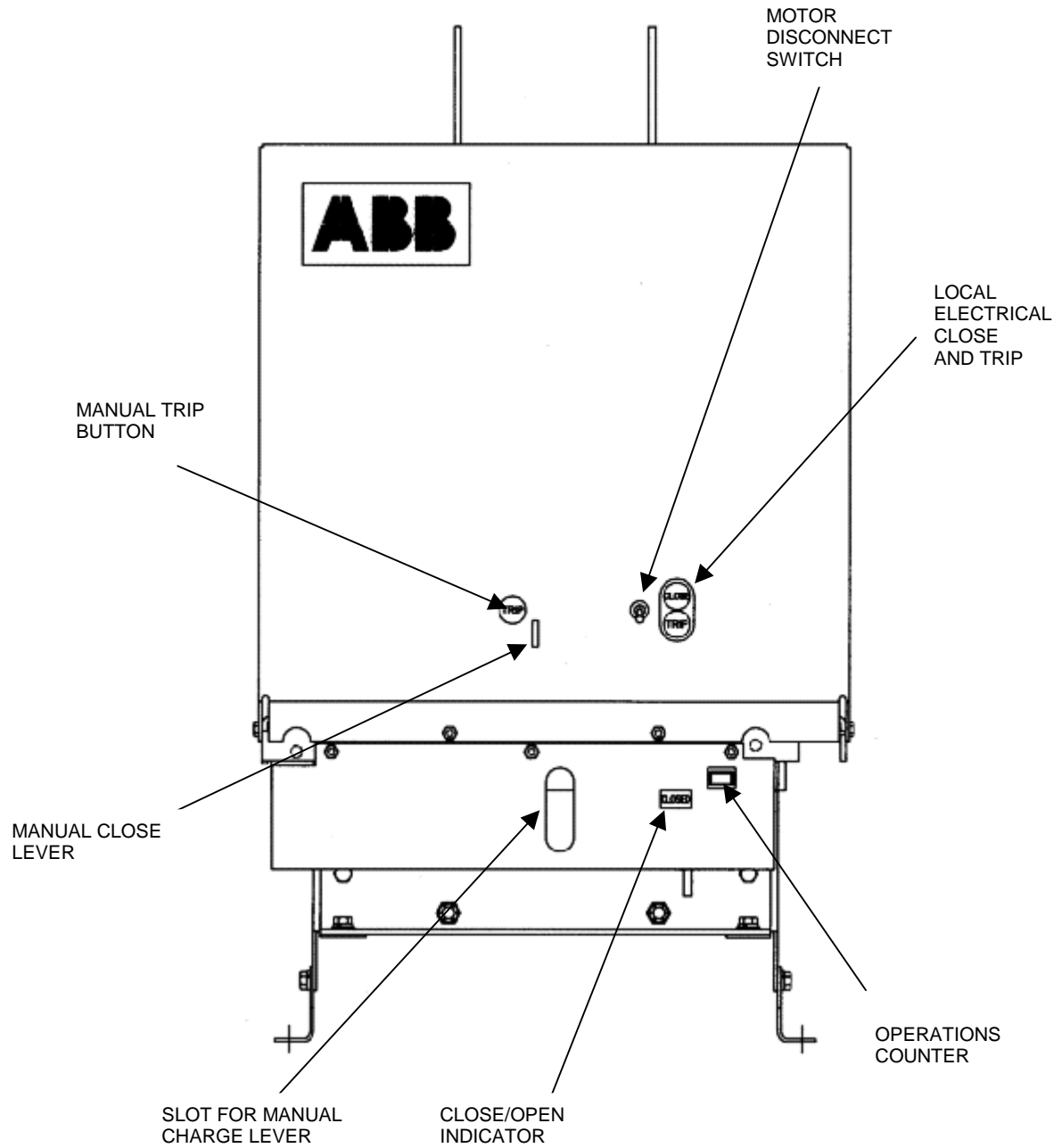


**CIRCUIT BREAKER REAR – MODEL 21**  
FIGURE A2



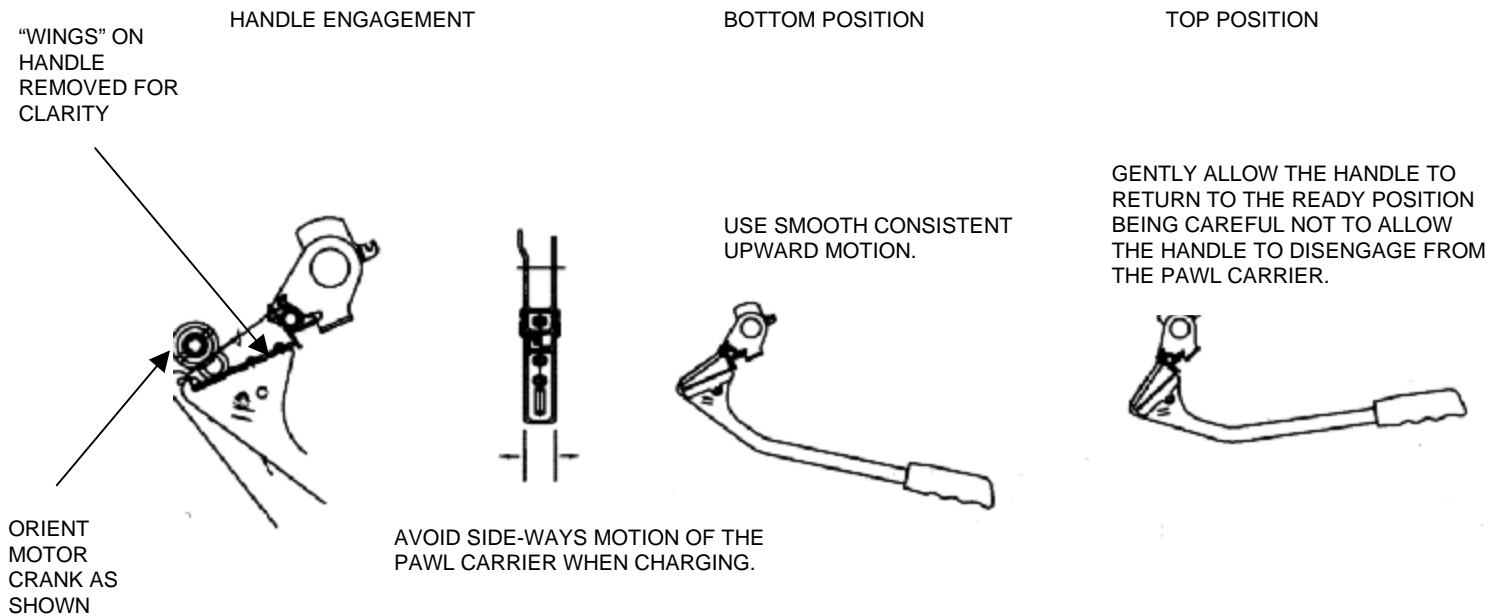
**FRONT CIRCUIT BREAKER PANEL – MODEL 21**  
FIGURE A3



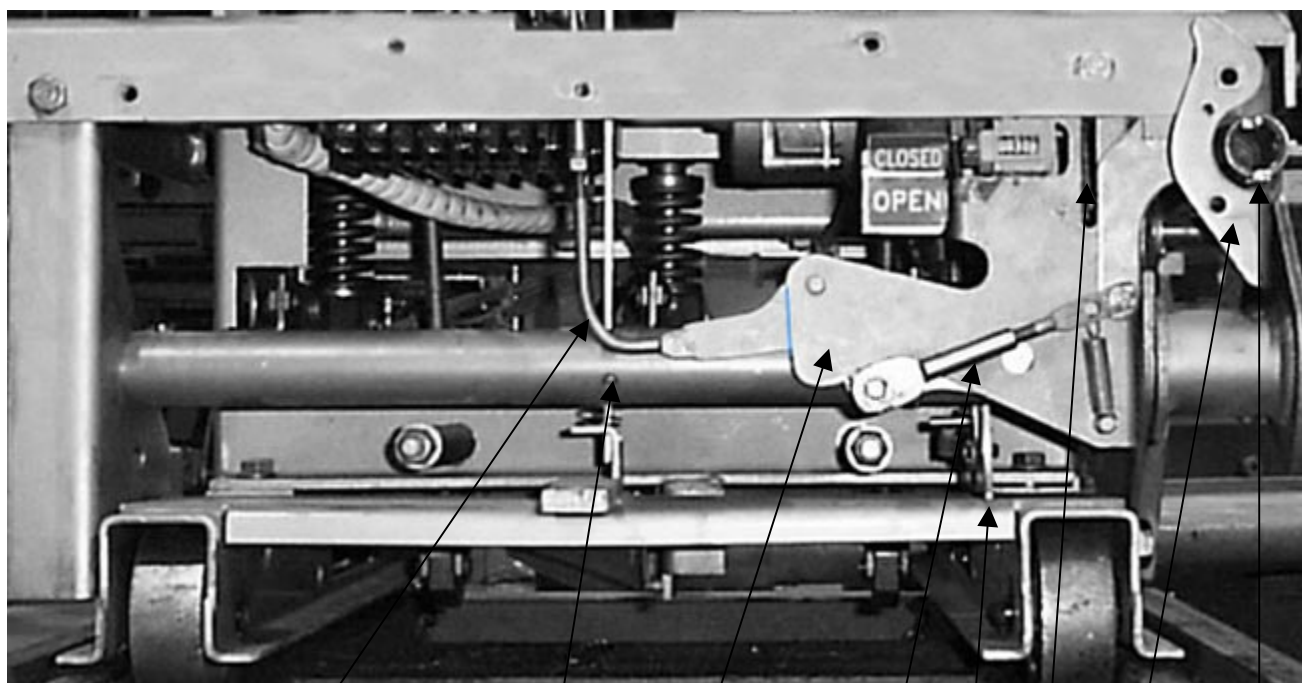


**FRONT CIRCUIT BREAKER PANEL & ACCESSORIES – MODEL 80**  
FIGURE A4

MANUAL CHARGING OF ELECTRICALLY OPERATED CIRCUIT BREAKERS  
FIGURE A5



1. REORIENT THE MOTOR UNTIL THE MOTOR CRANK IS IN THE POSITION AS SHOWN. FOR RYOBI STYLE MOTOR THE EXPOSED COMMUTATOR MAY BE PHYSICALLY ROTATED IN ORDER TO MOVE THE CRANK AS SHOWN.
2. INSERT THE MANUAL CHARGING HANDLE AS SHOWN.
3. VERIFY THAT THE BUMPS ON THE HANDLE ARE ENGAGED INTO THE CHARGING PAWL CARRIER.
4. HOLDING THE HANDLE PERPENDICULAR TO THE PAWL CARRIER, LIFT UP CAREFULLY. DO NOT ALLOW LATERAL MOTION OF THE HANDLE.
5. LISTEN FOR THE CLICK AND REPEAT 1 THRU 5 UNTIL THE BREAKER IS FULLY CHARGED. THIS IS INDICATED BY FREEWHEELING OF THE RACTCHET ASSEMBLY.



LINK TO TRIP  
LEVER

SPRING DISCHARGE  
ADJUSTING SCREW

BLOCKING LEVER  
LOCATED BEHIND  
PLATE

ADJUSTABLE  
LINK

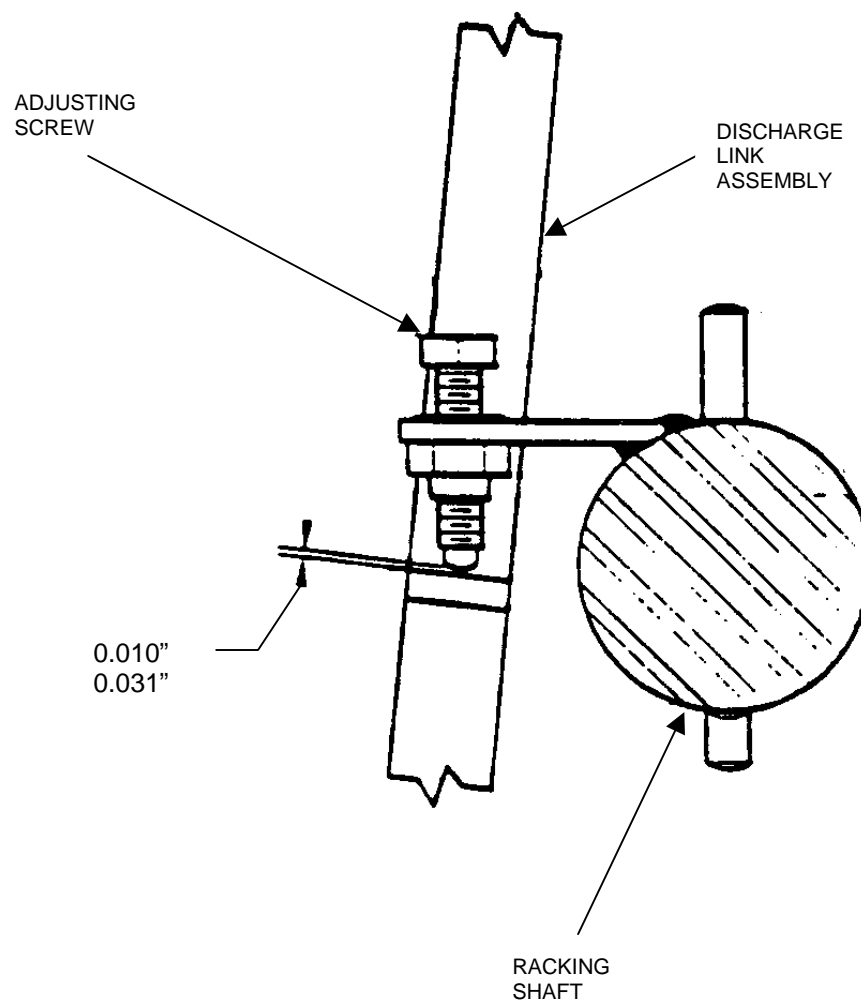
PADLOCK  
HASP

BLOCKING  
LOCK  
BRACKET

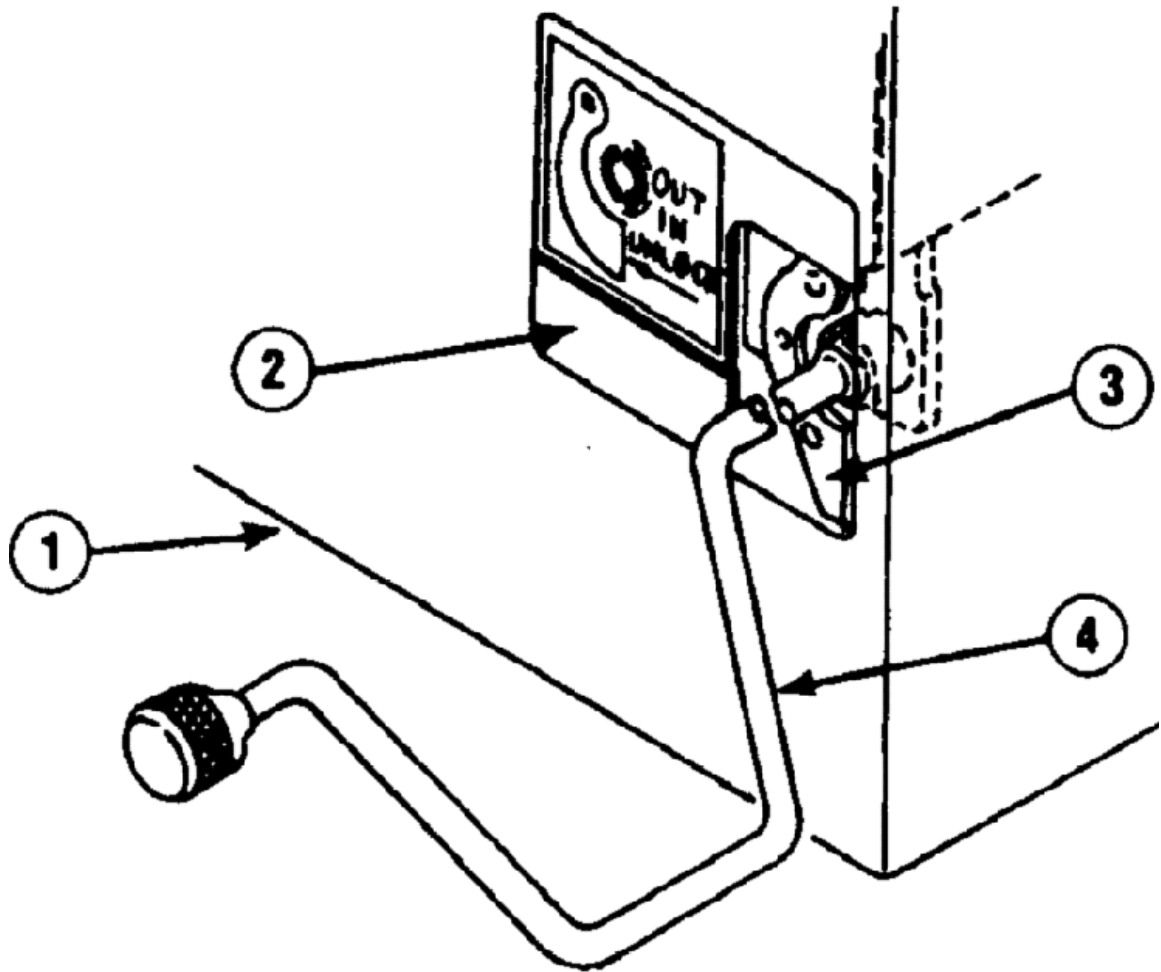
RELEASE  
LEVER

RACK  
SCREW

**RACKING MECHANISM**  
FIGURE A6

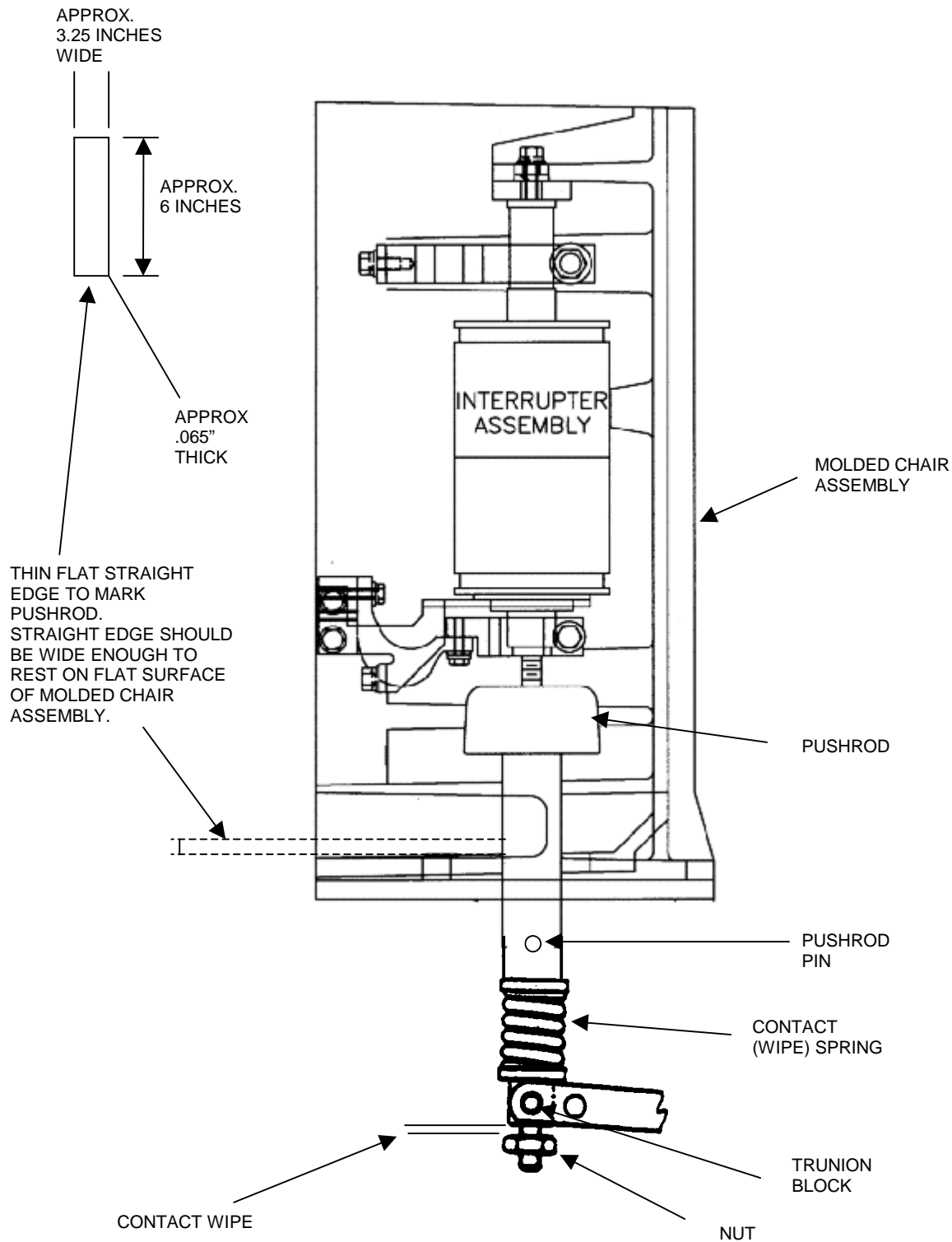


**RACKING MECHANISM (FINAL ADJUSTMENT)**  
FIGURE A7



- 1 – BREAKER CELL DOOR
- 2 – ACCESS DOOR TO RACKING MECHANISM
- 3 – RACK RELEASE LEVER
- 4 – RACKING CRANK

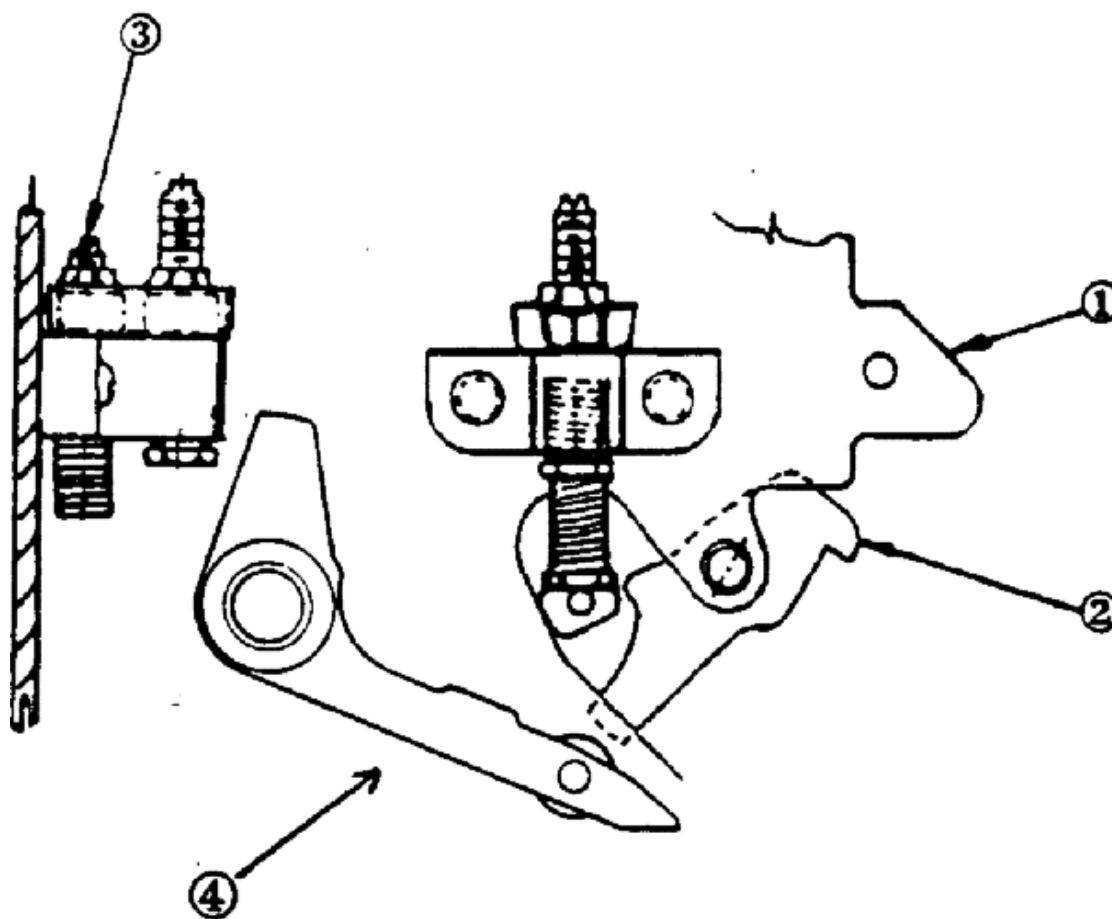
**METHOD OF RACKING CIRCUIT BREAKER**  
FIGURE A8



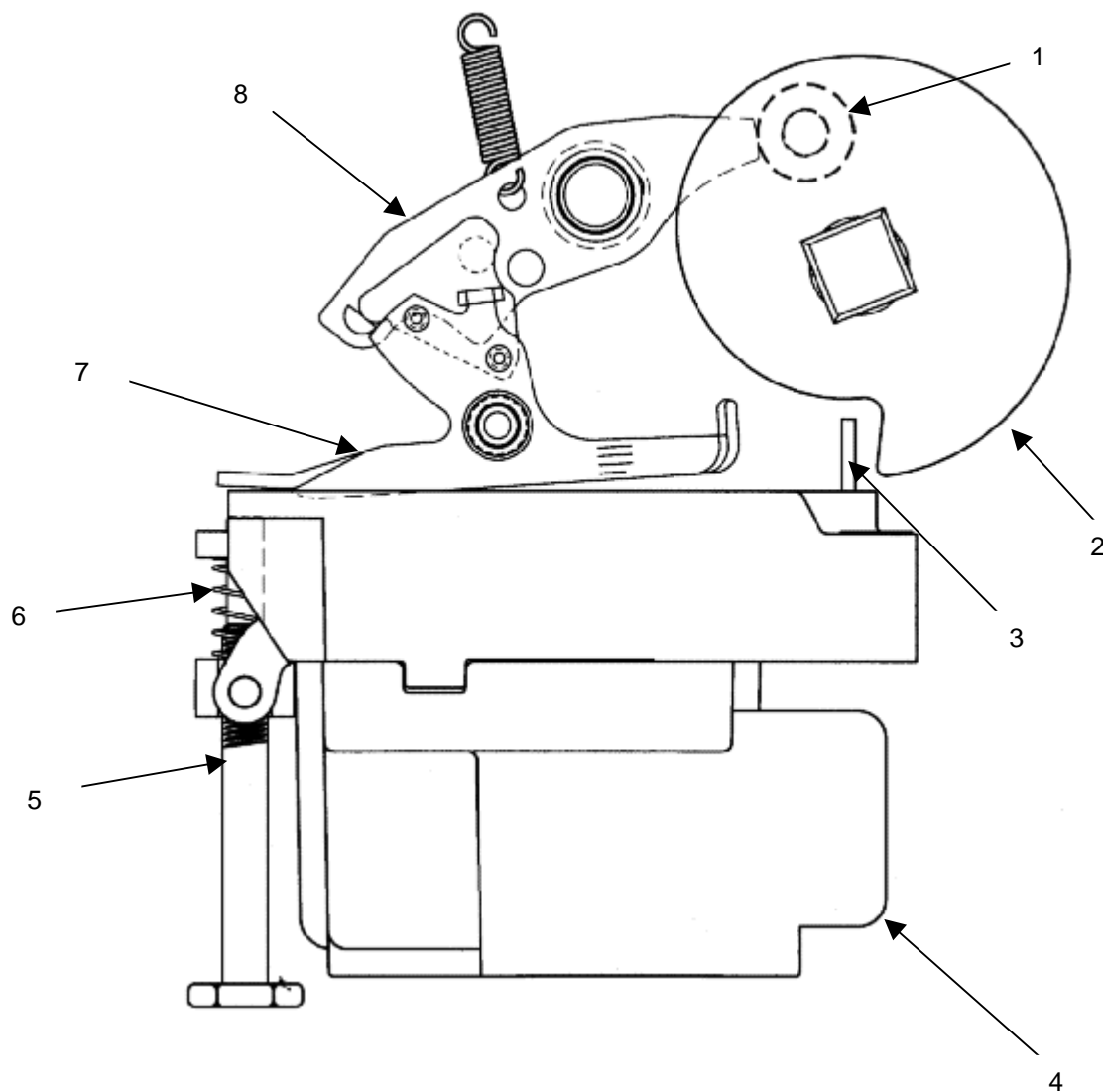
**CONTACT PRESSURE (MODEL 21 AND 80)**  
FIGURE A9



1. Mechanism Housing
2. Latch
3. Adjusting Screw
4. Primary Latch

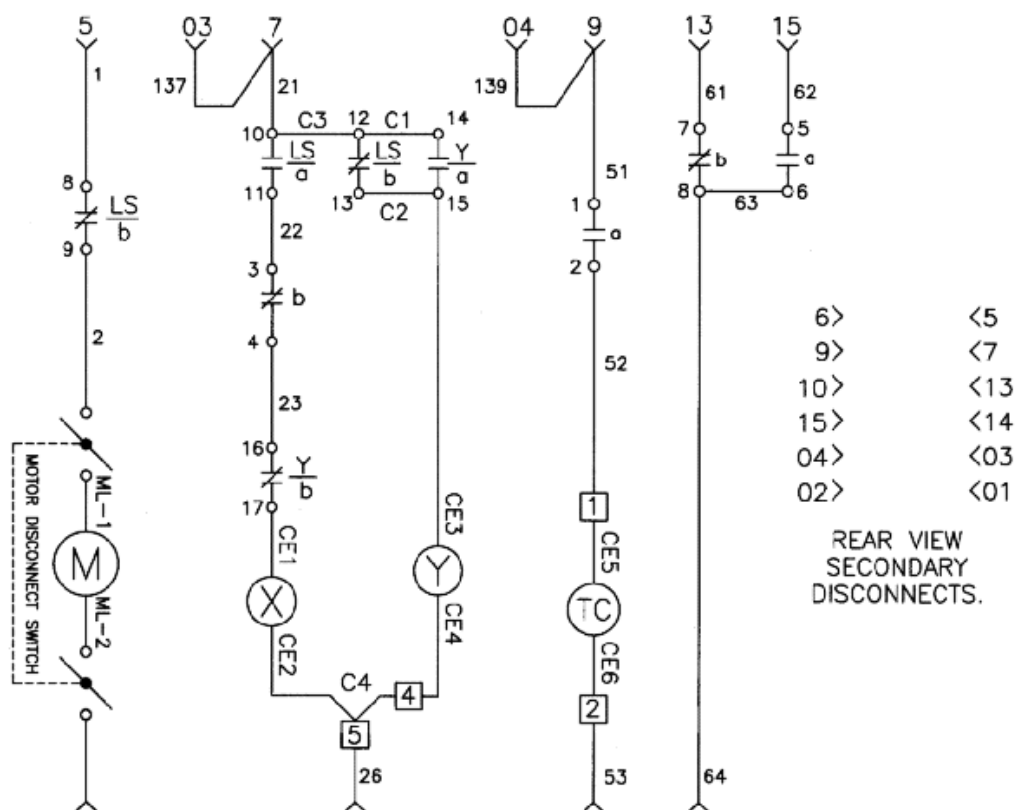


TRIP LATCH ENGAGEMENT ADJUSTMENT  
FIGURE A10



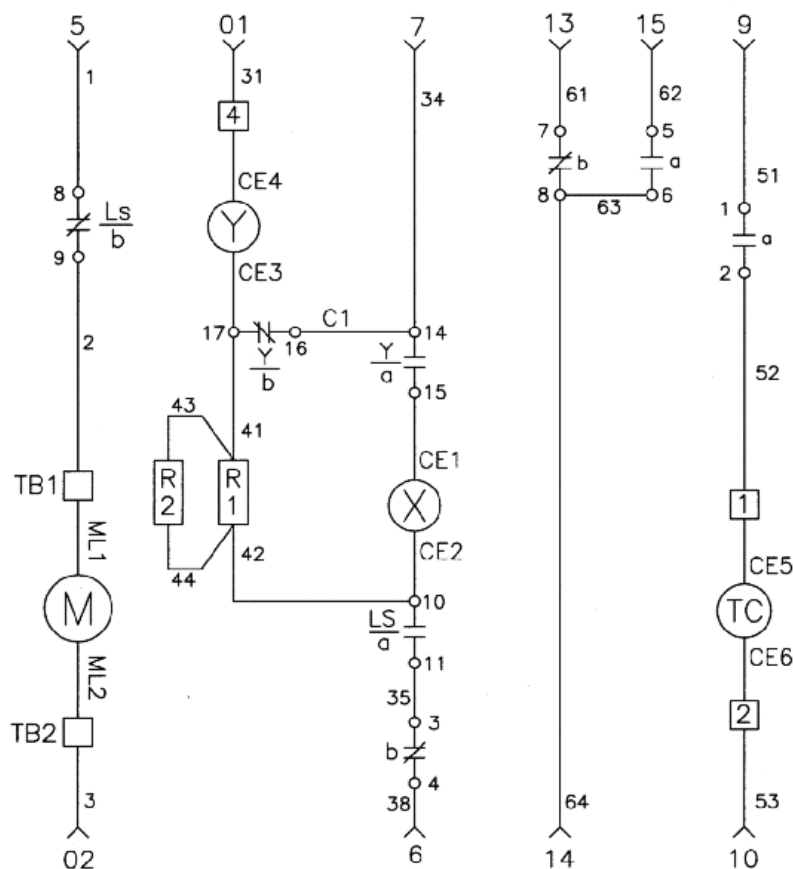
1. ROLLER, CLOSE LATCH
2. CHARGING CAM
3. ACTUATOR, LIMIT SWITCH
4. CONTROL DEVICE
5. CLOSE LATCH RELEASE ROD
6. SPRING, CLOSE LATCH RELEASE ROD
7. SECONDARY CLOSE LATCH
8. PRIMARY CLOSE LATCH

**CONTROL DEVICE ADJUSTMENT**  
FIGURE A11



- a- Auxiliary Switch Contact Closed When Breaker is Closed.
- b- Auxiliary Switch Contact Open When Breaker is Closed.
- LCb - Latch Check Switch Contact Closed When Breaker Operating Mechanism is Reset.
- LSa - Limit Switch Contact Open When Springs are Discharged. Closed When Springs are charged.
- LSb - Limit Switch Contact Closed When Springs Are Discharged. Open When Springs are Charged.
- TC - Shunt Trip Coil.
- X - Closing Latch Release Coil.
- Y - Control Relay Lockout Coil.
- Ya - Normally Open Relay Contact.
- Yb - Normally Closed Control Relay Contact.
- TB - Terminal Block Point.
- ML - Motor Lead.
- CE - Coil Lead End.
- C1,C2 - Terminal Jumper (Control Device).
- < - Female Secondary Disconnect Contact.

TYPICAL DC SCHEMATIC OF CONTROL CIRCUIT  
FIGURE A12



- c- Auxiliary Switch Contact Closed When Breaker is Closed.
- d- Auxiliary Switch Contact Open When Breaker is Closed.
- LCb - Latch Check Switch Contact Closed When Breaker Operating Mechanism is Reset.
- LSa - Limit Switch Contact Open When Springs are Discharged. Closed When Springs are charged.
- LSb - Limit Switch Contact Closed When Springs Are Discharged. Open When Springs are Charged.
- TC - Shunt Trip Coil.
- X - Closing Latch Release Coil.
- Y - Control Relay Lockout Coil.
- Ya - Normally Open Relay Contact.
- Yb - Normally Closed Control Relay Contact.
- TB - Terminal Block Point.
- ML - Motor Lead.
- CE - Coil Lead End.
- C1,C2 - Terminal Jumper (Control Device).
- c - Female Secondary Disconnect Contact.

**TYPICAL AC SCHEMATIC DIAGRAM OF CONTROL CIRCUIT**  
**FIGURE A13**

**Table A1 - Control Circuit Operating Voltage Range**

Nominal Control Voltage	Spring Charging Motor	Close Coil	Trip Coil	UNDERVOLTAGE	
				Pick-up Range	Drop Out Range
24 VDC	-	19 - 28 VDC	14 - 28 VDC	14 – 19 VDC	7 –14 VDC
48 VDC	38 – 56 VDC	38 – 56 VDC	28 – 56 VDC	29 – 38 VDC	15 – 29 VDC
125 VDC	100 – 140 VDC	100 – 140 VDC	70 – 140 VDC	75 – 100 VDC	38 – 75 VDC
250 VDC	200 – 280 VDC	200 – 280 VDC	140 – 280 VDC	150 – 200 VDC	75 – 150 VDC
120 VAC	104 – 127 VAC	104 – 127 VAC	104 – 127 VAC	69 – 92 VAC	35 – 69 VAC
240 VAC	208 – 254 VAC	208 – 254 VAC	208 – 254 VAC	140 –180 VAC	69 – 140 VAC

**Table A2 - Control Circuit Typical Current Values**

NOMINAL CONTROL VOLTAGE	SPRING CHARGING MOTOR* (AMPS)	CLOSE COIL (AMPS)	TRIP COIL (AMPS)	LOCKOUT COIL (AMPS)	UNDER VOLTAGE (AMPS)	N.E.C. FUSE (AMPS)
24 VDC	-	22.0	22.0	0.30	0.9	30
48 VDC	10.0	10.7	3.1	0.15	0.3	15
125 VDC	5.0	5.0	1.3	0.06	0.2	10
250 VDC	3.0	2.2	0.6	0.03	0.1	10
120 VAC	5.0	4.5	6.5	0.40	0.5	10
240 VAC	3.0	2.3	1.15	0.20	0.2	10

\* SPRING CHARGING MOTOR VALUES ARE FOR RYOBI MOTORS ONLY

TABLE A3 – VHK Operating Parameters

	5 VHK (X) 250 MOD 21 5 VHK-R 250 MOD 80	5VHK-R 250 MOD 80	7.5 VHK-R 500 MOD 80	15VHK-R 500 MOD 80	15VHK-R 750 MOD 80
♣ CLOSING TIME (MS)	30 - 50	30 - 50	30 - 50	30 - 50	30 - 50
OPENING TIME (MS)	14 - 24	18 - 28	18 - 28	18 - 28	18 - 28
CLOSING SPEED (FT/SEC)	2.0 - 5.0	2.0 - 5.0	2.0 - 5.0	2.0 - 5.0	2.0 - 5.0
OPENING SPEED (FT/SEC)	3.9 - 7.0	3.9 - 7.0	3.9 - 7.0	3.9 - 7.0	3.9 - 7.0
GAP (INCHES)	0.310 MIN	0.310 MIN	0.310 MIN	0.310 MIN	0.310 MIN
♣ WIPE (INCHES) (NEW BREAKER)	0.093 - 0.101	0.093 - 0.101	0.093 - 0.101	0.093 - 0.101	0.093 - 0.101
♥ MAXIMUM MV DROP	8 MAX (1200) 7 MAX (2000)	8 MAX (1200) 7 MAX (2000)	8 MAX (1200) 7 MAX (2000)	8 MAX (1200) 7 MAX (2000)	8 MAX (1200) 7 MAX (2000)
♥ MAXIMUM MICRO-OHMS	40 MAX (1200) 35 MAX (2000)	40 MAX (1200) 35 MAX (2000)	40 MAX (1200) 35 MAX (2000)	40 MAX (1200) 35 MAX (2000)	40 MAX (1200) 35 MAX (2000)

♣ IF CLOSING TIME IS OUT OF RANGE, CLOSING SPEED IS TO BE USED TO DETERMINE IF BREAKER PERFORMANCE IS ACCEPTABLE

♣ WIPE RANGES ARE FOR NEW BREAKERS ONLY. WIPE IS ALLOWED TO DECREASE TO 0.031".

♥ READING WITH 200 AMPS DC FLOWING. CIRCUIT BREAKER RESISTANCE IS ALLOWED TO INCREASE BY 100% FOR USED BREAKERS.





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**Distribution Systems Division**

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IEC Products & Systems  
After-market Components

Circuit Breaker Operations  
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201 Hickman Drive  
Sanford, FL 32771  
(407) 323-8220  
(407) 322-8934 (Fax)

2300 Mechanicsville Highway  
Florence, SC 29501  
(843) 665-4144  
(843) 667-5109 (Fax)

