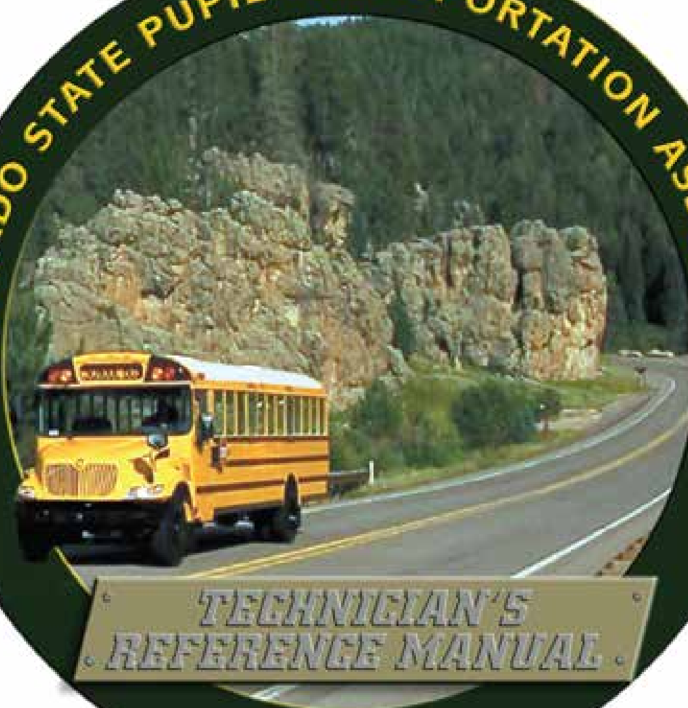
COLORADO STATE PUPIL TRANSPORTATION ASSOCIATION



TECHNICIAN'S REFERENCE MANUAL

Revised 2013

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PREVENTIVE MAINTENANCE

1. Purpose

What is preventive maintenance and why do we do it? Everyone has heard the sayings – "An ounce of prevention is worth a pound of cure" and "You can pay me now or you can pay me later." Both of these sayings capture the essence of preventive maintenance.

Stated simply, preventive maintenance is a series of inspections and adjustments of equipment, designed to catch problems while they're small (inexpensive) problems before they become big (expensive) problems. Scheduled repairs found during the preventive maintenance inspection process are easier and cheaper to perform than those that occur in an unscheduled repair, or breakdown.

What are the benefits to a school district in having a good preventive maintenance program? The two principal benefits are reduced operating costs and maximum equipment availability, or uptime.

Preventive maintenance inspections, if performed properly, will maximize equipment availability because the shop controls the diagnosis and repair of the unit. This significantly <u>prevents</u> equipment from breaking down and having breakdown repairs control the shop. The savings in operating costs are achieved because the expensive, catastrophic repairs, for the most part, are avoided.

2. Aspects of a P.M. Program

What does a P.M. program consist of? What are the "things" or elements of a P.M. program? There are at least five different components that make up a P.M. program, and following are brief descriptions of these components:

- **Servicing**

  A service is usually performed by a technician according to the schedule established by the district. It consists of performing the operations as stated on the P.M. inspection checklist.

- **Inspection**

  Inspections are twofold - they are performed by drivers/operators on a routine basis and periodically by a technician while servicing the unit.

  The driver/operator inspections are not as thorough as those of the technician, but they should be sufficient to detect most leaks, damage, and non-working or improperly working parts or systems (especially safety-related items). Most districts have a good pre-trip bus inspection program in place.

- **Detection**
  This is simply the notation of any defects that are found during the inspection procedure. The defects would be noted on the P.M. inspection checklist by the technician or on a driver's pre-trip inspection form. CDE regulations require that all defects be reported and that all repairs and maintenance be documented.

- **Correction**
  After defects or problems have been detected and noted, the next step is to repair them. The objective of a good P.M. program is to make the repairs before further damage occurs. This is where the major benefit of a good P.M. program occurs - at this point the shop schedules and manages the repair instead of vice versa.

- **Documentation**
  This is the last element of a P.M. program, and it's just as important as any of the others. A record of each P.M. inspection must be generated and retained for as long as the district owns the vehicle.

  This record may be in the form of a hand-written inspection checklist, a computer print-out (hard copy), or a stored record in a computer system. Records should be kept in a protected environment in case they are needed for future reference as per CDE procedures for record retention.

3. Participants in a P.M. Program

A successful preventive maintenance program has participants at several different levels within the organization. Below is a list of those participants and a brief description of the role each plays in the P.M. program:

- **Driver/Operator**
  This is the most important person in a successful P.M. program. He/She is the person most intimately acquainted with the operation and performance of their equipment/vehicle and should be the first to recognize that something is wrong with the unit. They are also the people who check their equipment/vehicles out every day and, as such, should again be the first to spot leaks, damage, etc. When these people are doing their job diligently, a P.M. program should be very

successful in catching small problems before they become big problems.

- **Training Department**

  These are the people, usually on the support vehicle side of the operation, who have the responsibility of seeing that their people are checking their vehicles out and writing them up like they're supposed to. If these people fail to support the objectives of the P.M. program and, in turn, fail to get their people to support the program, any district's P.M. program is destined to fail or at least be less successful than it could be.

- **Technician**

  This person is obviously very involved in any P.M. program. The technician is the person who performs the actual preventive maintenance service and inspection in the shop. This is also the person who makes any repairs that arise from the inspection or as a result of driver/operator inspections, although some shops prefer to have one technician do the service/inspection and another technician perform any necessary repairs or corrective action.

- **Shop Foreman/Lead Technician**

  This is the person who schedules and assigns the work in the shop, including the P.M. inspections. He often communicates directly with the driver/operators concerning their vehicles. He must be well acquainted with the skills and abilities of his technicians when assigning services and any corrective action that arises from those inspections.

- **Equipment/Maintenance Managers**

  These positions are usually found only in the larger districts. They have the responsibility of implementing and overseeing the overall preventive maintenance program.

- **Administration**

  The support of these people is vital to a successful P.M. program even though they are seldom involved with it. They must believe in and support the philosophy of preventive maintenance because it can often appear that money is wasted servicing vehicles on a regular basis that are operating perfectly at the time.

4. Developing a P.M. Program

Below are some suggested steps in developing a preventive maintenance program for your district.

- **Specify the P.M. Tasks and Establish Intervals**

  The first step is to identify and specify the service/inspection tasks that are to be performed and the intervals at which they will be performed. This is true for all types of equipment and buses.

  Normally, diesel buses will have similar intervals, as will gas buses. There are several sources available to aid in determining appropriate service levels and intervals – manufacturer's recommendations, oil analysis, and past experience of your own.

  A P.M. inspection checklist could have an A, B, and C inspection level, each at different intervals. Intervals can be based on mileage, hours, time, or fuel consumption. For example, most service intervals for buses are based on mileage, as compared to heavy equipment where the intervals are usually based on hours or fuel consumption. Time, as a service interval, usually serves to ensure that vehicles or equipment with low usage get into the shop at least every six months or whatever time frame is selected.

  Every class of equipment should have at least two types of interval assigned to it - time and one of the others. This will assure that all units are inspected on some sort of regular basis, even if usage is low. This is particularly important for spare buses. Once developed, a P.M. inspection checklist must be a constantly changing document. This is necessary to keep up with changes in vehicles, accessories, components, etc. For larger bus fleets, the P.M. checklist may well change (slightly) with each printing.

  One of the best tools for implementing and managing a preventive maintenance program is a fleet software program. These programs contain good preventive maintenance scheduling packages. Any district with 15 or more buses plus support vehicles might find a computerized system to be cost effective.

- **Assign Responsibilities**

Determine who is going to be responsible for which part of the P.M. program and assign those responsibilities accordingly.

There are two main groups involved here - drivers/operators and technicians. Basically, the bus drivers and operators of support vehicles and equipment will be responsible for the daily vehicle inspections, and the technicians will perform the P.M. service inspections.

This is also the point at which all driver supervisors, both bus and support vehicle, should become involved in the P.M. program. Disciplinary procedures could be established to ensure that P.M. inspections are performed properly by all parties as scheduled.

- **Examine Results**

  Analyze the outcomes and costs of the P.M. program.

  Identify the most frequently occurring repairs and adjust the P.M. checklist, if necessary, to reduce those repairs. Identify which types of buses and equipment cost the most and the least and use that information in the preparation of future equipment specifications. Compare scheduled repair costs with non-scheduled costs and decide if you're spending too much or not enough on preventive maintenance.

  Try to determine if frequently occurring repairs may be the result of poor or abusive driver/operator techniques or poorly or under-trained technicians. The evaluation and analysis of the preventive maintenance program should be a continuous and on-going project. P.M. programs should be in a constant state of fine-tuning and adjustment to meet on-going changes in equipment, drivers, training, usage, and economic conditions.

5. Using a Checklist

The use of a P.M. inspection checklist by a technician should be as fast and simple as possible. To help achieve that, an inspection checklist should be arranged in the most logical order possible so that a technician can work his way through the service without having to back track. Items on the checklist should be arranged in an order that permits the technician to work front to back (or vice versa) and side to side without having to re-trace his steps.

Accordingly, all items in the same area of the vehicle should be inspected and serviced at the same time, such as under the vehicle or in the engine compartment. This prevents a technician from having to raise the unit off the ground more than once or open and close the hood several times.

When a P.M. inspection checklist is used by a technician, two things must happen, and it's the shop foreman's responsibility to see that they do. **All applicable** items on the checklist **MUST** be checked, and the checklist **MUST** be signed by the technician(s) performing the service on completion of the service. Failure to do either or both of these things could possibly result in negative consequences for the transportation department in the future

6. Summary

Preventive maintenance is the most important thing a district can do to run buses, and other equipment, as effectively and efficiently as possible.

It is absolutely mandatory that buses undergo thorough inspections in a timely manner. No other vehicles, with the exception of airplanes, require as high a degree of preventive maintenance effort as a school bus.

If your district doesn't currently have a preventive maintenance program, contact another district that does or call the CDE School Transportation Unit for a reference. P.M. is what school buses are all about.

ADDITIONAL INFORMATION

Web Sites

www.cde.state.co.us/cdenutritran/transform

BODY, FRAME, AND ASSOCIATED EQUIPMENT

General Components .... Page #

BODY EXTERIOR

1. Exterior Lighting

- **License Plate Light**
  All buses shall be equipped with rear license plate illuminator. This lamp may be combined with one of the tail lamps.

- **Back-Up Lamps**
  Back-up lamps of 7 inches or 38.48 square inches, minimum shall be provided.

Inspect to ensure that:

- All lenses are clean.
- All lamps illuminate properly when appropriate controls and/or switches are activated.
- Switches should operate smoothly.
- Same type of lamp (LED or incandesant) on the same function such as, brake lights, reverse lights or turn signals.

Repair if any aspect of the standard or inspection fails.

NOTE: For LED lamps it is recommended by manufacturers that the number of inoperative diodes should not exceed 10 to 13 percent of the total assembly. However, as with any questionable defect, use your best judgment to decide if the LED assembly needs to be replaced.

For information on additional lighting see also Section 3 – Colorado Minimum Standards **or** Section 12 – Electrical of this manual.

2. Body and Chassis Color

All exterior metal shall be painted **National School Bus Yellow** with the exception of those areas listed below:

- The hood shall be painted **National School Bus Yellow**.
- Lettering and numbering shall be black.
- The front and rear bumpers shall be painted black.
- Refer to CDE standards.
- Rub rails shall be black. (May be yellow at purchaser's option).
- The background area for warning light system shall be black.
- The frame and all frame members shall be painted black.

Repair and/or re-paint any necessary areas.

NOTE: Districts that wax school vehicles should use a non-gloss wax on hoods.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

3. **Exterior Mirrors**

- **Rear-View Mirrors**
  The primary purpose of rear-view mirrors is to afford the driver an exterior view of the area along both sides and to the rear of the bus.

Prior to Dec. 2, 1993
Two adjustable mirrors shall be provided, one on the left and one on the right of the driver. Each mirror shall be not less than 50 square inches and shall be affixed to the body by brackets, which minimize vibration.

FMVSS 111 stated that school buses were required to have an outside rear-view mirror of unit magnification (i.e. flat mirror) on each side of the bus, to provide the driver with a view to the rear along both sides of the bus. The standard also required outside crossover mirrors mounted so as to provide the driver a view of the front bumper and the area in front of the bus.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

After Dec. 2, 1993
FMVSS 111 has been revised, and becomes effective Dec. 2, 1993. The standard states a specific test procedure for mirror placement and driver's vision. The new standard requires the driver to be able to see, either directly or through mirrors, certain specified areas in front of and along both sides of the bus. The new law is complicated and very lengthy (20 pages). The new law has been included in your Administrator's Manual.

Two Mirror Grids are included under the Additional Information part of this section.

For additional information see also FMVSS 111 (located in the Administrator's Manual).

Inspection Procedure

- Mirrors should be securely mounted. All fasteners should be of proper tightness.
- Mirrors should not have any damage or discoloration.
- Mounting, framing, and other related hardware should be damage free. Check for cracked brackets and/or worn, sloppy

mounting holes.

Repair or replace if any aspect of the appropriate standard or inspection fails.

Hardware and/or brackets may be repaired. The finished repair should be consistent with or be better than OEM and should be free from burrs or sharp edges. Defective mirrors must be replaced.

HINT: Appropriate sized nutzerts work well to repair sloppy mounting holes. If you choose to adjust your mirrors by using the mirror grids in the Additional Information part of this section, most 5-gallon pails are very close to the cylinder measurements. If using Bus-Boy mirrors, aim the arrow on top at the driver's eyes.

Mirror Requirement: See also Section 3 – Colorado Minimum Standards for additional information.

4. Front Bumper

The front bumper shall be at least 3/16 inches thick of pressed channel, one piece construction or optional 3-piece breakaway construction of a minimum of 8 inches in width after forming. Tow hooks (or eyes on transits) are required and shall not extend beyond the front bumper.

Front bumpers on Type A buses and small vehicles shall be appropriate to the GVW rating and are not required to have tow hooks.

Inspection Procedure

- Inspect all mounting hardware. No bolts or rivets may be missing and all must be tight. Mounting brackets should be damage and distortion free.
- Inspect bumper to ensure it is free from bends or other distortions. Damaged units will normally be replaced.

Repair if any aspect of the standard or inspection fails.

HINT: Bumpers and wheels tend to become scratched and unsightly during routine operations. Minimum effort and cost can ensure front and rear bumpers and all wheels are cleaned and painted when needed. This attention goes a long way in the overall appearance of a unit.

For additional information see also Section 3 – Colorado Minimum Standards in this manual.

5. Exterior Glass

All glass in windshield, windows, and doors shall be approved safety glass, so mounted that the permanent mark is visible, and of sufficient quality to prevent distortion of view in any direction as specified in FMVSS.

Glass in windshield shall be heat absorbent, laminated safety glass with 0.030 inch plastic inner-liner. Windshield shall be large enough to permit driver to see roadway clearly, shall be slanted to reduce glare, and shall be installed between front corner posts that are so designed and placed as to afford minimum obstruction to the driver's view of roadway.

Each full side window shall provide unobstructed emergency opening at least 9 inches high (12 inches after 10/1/93) and 22 inches wide, obtained by lowering of window. If full drop windows are used, they shall be blocked so that when in a down position the opening between the window header and top of glass is not more than 9 inches (12 inches after 10/1/93). For added information see also Section 3 – Colorado Minimum Standards.

Push-out type, split sash windows may be used. All exposed edges of glass shall be banded.

Inspection Procedure

- Check windshield for cracks, stone or shot marks. Windshield must not be pitted or sandblasted, if theses marks cause light reflection or glare.
- The path of windows starting with the driver's side window, moving clockwise to the windshield, and finally to the student door should be transparent and not dark tinted.
- All window latches and slide ways should be operable.
- All weather stripping and seals should be inspected for damage or deterioration.

Repair or replace if any aspect of the standard or inspection fails.

Windshields with cracks or marks in the wiper or mirror vision area should be replaced.

Replace all broken, distorted or defective glass.

Inoperable latches may be repaired or replaced. Latches and slides should work freely.

Silicone is the recommended lubricant for latches and slide ways.

Leaks in weather stripping or seals may be re-sealed. Badly damaged or deteriorated seals and weather stripping normally must be replaced.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

HINT: Some windows are designed to be kicked out at the corners in emergencies. After several years, the rubber mounting on these windows may become hard, creating difficulty in removing the windows using this method. You might consider replacing the rubber mounting for these windows if you suspect problems.

6. Identification

All Type A, B, C, D buses should conform to the following standards. Small vehicles are exempt from these requirements.

- The body shall bear the words "SCHOOL BUS" in black letters at least 8 inches high on both the front and rear of body. Lettering shall be placed as high as possible without impairment of its visibility. The lettering shall conform to Colorado Minimum Standards.

- School buses shall bear the name of the School District or company on each side in black, standard unshaded letters, 5 inches in height. If there is insufficient space due to the length of the name of the school district, terms such as community, consolidated, and district may be abbreviated.

- The manufacture's rated pupil seating capacity shall be printed to the left of the entrance door on the lower skirt in 2-inch characters. The word capacity may be abbreviated. (Example: Cap. 48.) The capacity shall be shown on the inside upper portion of the entrance door or inside above the windshield.

- The numbering of individual buses for identification purposes is permissible. Lettering and numerals shall be painted or may be pressure sensitive marking of similar performance quality.

- **"STOP"** shall be printed on the rear of the bus in letters at least 8 inches high. **"ON FLASHING RED"** shall be printed below **"STOP"**, in letters 5 inches high. Letters shall be placed in area(s) visible to approaching motorists.

Inspection Procedure

- Ensure all required markings conform to the standard and are readable.

Repair if any aspect of the standard or inspection fails.

HINT: Over time lettering and numerals will deteriorate on older buses. This can be remedied with either hand painting or vinyl lettering. Vinyl lettering can be obtained at art stores, department stores, or automotive detail centers.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

NOTE: Minimum Standards change every five years. Refer to appropriate Standards for the manufacturer's year of the vehicle.

7. **Rear Bumper**

- The rear bumper shall be of one piece, a heavy duty type of pressed steel channel, at least 3/16 inch of thickness and a minimum of eight inches wide (high) after forming.

NOTE: Starting Oct. 1, 1993, bumpers on Type A buses shall be 8 inches wide, and on type B, C, & D buses bumpers shall be 9 1/2 inches wide.

- No spaces, projections, or cut-outs that will permit a hand hold or foot hold shall be permitted.

- Forward facing ends of the bumper shall be enclosed by a designed protective device to ensure there are no sharp edges or projections likely to cause injury or snagging.

- A gasket shall be installed to close the opening between the top of the rear bumper and body.

- Type A school buses and small vehicles shall have rear bumpers applicable to the GVW rating and are not required to have tow hooks.

Inspection Procedure

- All mounting hardware is tight and no nuts, bolts, or rivets are missing. Brackets should be damage and distortion free.
- Bumper should be free from bends or distortions. Damaged units normally will be replaced.
- There should be no place in the rear area of a school bus that affords a hand hold or a foot hold. (For example, where kids could hitch a ride.)

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

8. **Stirrup Steps**

There shall be one stirrup step and suitable located handle on each side of front of body or equivalent mounting for necessary accessibility for cleaning windshield and lamps.

NOTE: Type A school buses are exempt from this requirement.

Inspection Procedure

- Inspect to ensure step and handle are securely mounted and provide access to windshield and lamp cleaning.

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

9. **Storage Compartment**

Also referred to as luggage compartments, the external compartments are a convenient place to stow tire chains, tow chains, and such tools as may be provided.

Inspection Procedure

- Ensure that external compartments are locked to prevent anyone from becoming trapped inside.

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

10. **Windshield Wipers and Washers**

The bus shall be equipped with windshield washers, which shall conform to FMVSS and body manufacturer's recommendation. A windshield wiping system, two speed or more, shall be provided.

The wipers shall be operated by one or more air or electric motors of sufficient power to operate wipers. If one motor is used, the wipers shall work in tandem to give full sweep of windshield.

All wiper controls shall be located within easy reach of the driver's direct view.

Inspection Procedure
Inspect to ensure that:

- Wiper control(s) function properly.
- Washer control(s) function properly and the reservoir is adequately filled and free from cracks or holes.
- Wiper blades are in serviceable condition and no other part of the wiper arm contacts any glass surface.
- When in the stopped position the wiper arms are out of the driver’s direct view.

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

BODY INTERIOR

1. Body Electrical Wiring

All wiring shall conform to current standards of SAE.

Circuits
Wiring shall be arranged in at least nine regular circuits, as follows:

- Head, tail, stop, and instrument panel lamps.
- Clearance lamps.
- Starter motor.
- Dome and step-well lamps.
- Ignition and emergency door signal.
- Turn signal lamps.
- Alternately flashing warning signal lamps.
- Horn.
- Heaters and defrosters.

Any of the above combination circuits may be subdivided into additional independent circuits.

All other electrical functions (such as electric-type windshield wipers) shall be provided with independent and properly protected circuits.

Each body circuit shall be color or number coded and a diagram of circuits shall be attached to the body in a readily accessible location. Number coding permitted only if the number is a permanent part of the insulation and is repeated at intervals of not more than 6 inches.

A separate fuse or circuit breaker shall be provided for each circuit except the starter motor and ignition circuits.

Whenever wires pass through a body member, additional protection in the form of appropriate type of insert shall be provided.

Wires not enclosed within body shall be enclosed in protective jacket and fastened securely at intervals of not more than 18 inches. All joints shall be soldered or joined by equally effective connectors.

The protective jacket shall be assembled to provide maximum protection against moisture and dust.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

HINT: After any wiring repair, materials should be restored to ensure they are properly insulated and secured.

2. **Service Door**

The service door is the door routinely used to load and unload passengers.

Service door shall be power or manually operated, under control of the driver, and so designed to afford easy release and to prevent accidental opening. When a manual lever is used, no parts shall come together so as to shear or crush fingers.

Service door shall be located on right side of bus opposite driver and within driver direct view.

Power operated doors must be equipped with an emergency release, readily accessible in the door area, so that the door may be opened in the case of emergency or power failure. The release shall be plainly labeled.

There shall be a head bumper pad installed on the inside at the top of the entrance door. This pad shall be approximately 3 inches in width, at least 1 inch thick, and extend across the entire top of the entrance door opening.

***NOTES:** Type A,B,C,D buses shall have a service door with a minimum horizontal opening of 24 inches and vertical opening of at least 54 inches, (68 inches after Sept. 1, 1993).

Type A & B buses may have a door to the immediate left of the driver.

Small vehicle doors shall be OEM design.

Inspection Procedure

- The mechanism (either power or manual) to open and close the door should work smoothly and with sufficient ease so as to prevent driver arm fatigue.

- Ensure mechanism prevents accidental opening of door. All moving parts related to the service door should be free from excessive slack, play, or wear. (As this inspection is performed the technician should be considering the possibility of excessive slack or wear as possibly causing the door to jam or otherwise malfunction.) i.e.; hinges, handle bushings, etc.

- The mechanism on the service door controls that activate and de-activate the red-flashing 8-way lights and stop arm must be checked to ensure that it is operating correctly. Inspect contact areas for excessive wear and/or misalignment. (If the system is activated and operating correctly, opening the door will cause the yellow or amber 8-way lights to cancel and the red 8-way lights and stop arm will automatically activate; when the door is closed the red 8-way lights and stop arm will automatically cancel.)

- Ensure no moving parts could shear or crush fingers.

- Ensure all flexible seals are serviceable and not badly torn or missing.

- If so equipped, the school bus vandal locks should be inspected to ensure that they are operable as designed, with a starter lockout system and an audible warning system attached to any emergency exits.

- Inspect the head bumper pad to ensure it is securely mounted and in serviceable condition.

- On power operated doors ensure that the emergency release operates as designed and is clearly labeled (whether the power is on or off).

Repair if any aspect of the standard or inspection fails.

NOTES: Service door linkage hardware may be adjusted to reduce slack.

Hinges and other working parts may be lubricated, preferably with a silicone base lubricant to reduce dirt attraction.

Defective seals, switches, or excessively worn parts must normally be replaced.

Adjust air doors properly to prevent the doors from opening or closing too fast, risking injury.

For additional information see also FMVSS 205 or Section 3 – Colorado Minimum Standards of this manual.

3. Emergency Exits

Type A, B, C, & D buses shall be equipped with emergency exits in accordance with the following:

- Emergency exits shall be equipped with a slide-bar latch (after Oct. 1, 1993, a 3 point latch), and shall have a minimum stroke of one inch. Emergency door latch shall be equipped with suitable electric plunger-type switch connected to a buzzer located in the driver's compartment.

The switch shall be enclosed in a metal case and wires leading from the switch shall be concealed in the bus body. The switch shall be so installed that the plunger contacts the farthest edge of the slide bar in such a manner that any movement of the slide bar will immediately close the switch circuit and activate the buzzer. A separate interior handle shall be provided to pull the door shut from the inside.

- The exterior door handle shall be of permanent hitch-proof design and mounted with enough clearance to permit opening without touching door surface and may be equipped with a lock, which will not permit opening from outside.

- All emergency door openings shall be completely weather-stripped.

- Operation instructions for opening door shall be lettered or have a decal on the inside of the emergency door.

- Emergency doors shall bear the words "EMERGENCY EXIT" both inside and outside in letters at least 2 inches high. Words shall be placed directly above the door or on the upper portion of the door.

- There shall be a head bumper pad installed over the emergency door on the inside of the body. This pad shall be approximately 3 inches high, at least 1 inch thick and extend across the entire top of the emergency door opening. Padding shall be of the same materials as the padding used over the service door.

- Reflective tape around doors and windows as per CDE Minimum Standards.

Side Emergency Exit Door

If the engine or storage compartment is so located as to make it impossible to place a door in the center of the rear of the bus, the emergency door shall be located in the rear half of the bus body. The door shall not be located to reduce the size of the wheel well. The door shall be hinged on the front side.

Emergency Window Exit

If the engine compartment is so located as to require a side emergency door, an emergency window shall be installed in the rear of the bus and shall be no smaller than 16 inches in height and 54 inches in width.

The emergency window must be hinged from the top and provided with a hold-open control to ensure against accidental closing during an emergency. The emergency window in the rear shall be equipped with a latch on the inside and a handle of hitch proof design, which will permit opening from the outside.

All emergency windows shall bear words "EMERGENCY EXIT" in letters at least 2 inches high both inside and outside the windows. Lettering shall be placed no more than three inches above windows.

All emergency windows shall be equipped with a buzzer. When not fully latched, it shall activate a signal buzzer audible to the driver.

NOTE: Emergency doors for type A and B buses shall comply with current FMVSS for appropriate vehicular weight rating. Warning buzzer and other safety related items are the same for all type buses. Small vehicles are exempt from this standard.

Inspection Procedure

- Ensure that opening and closing mechanisms operate in accordance with the standard from inside and outside the bus.

- Ensure all warning devices operate as designed, including roof escape vents. Warning devices are designed to provide warning for the bus operator in two primary areas:

  That the door is open when it should not be.
  That the door is locked when it should not be.

- Inspect contact points on all warning devices and switches for excessive wear and/or misalignment.

- Ensure interior and exterior door handles are in good condition and do not have excessive play.

- Ensure weather-stripping is serviceable and is not torn or missing.

- Ensure all instructions and identification markings are in accordance with the applicable standards and are readable.

- Ensure interior handle guard is securely mounted.

- Inspect the head bumper pad to ensure it is securely mounted and in serviceable condition.

- If so equipped, inspect the emergency exit window to ensure all applicable warning devices operate as designed, that it opens and closes smoothly, and that required markings are readable.

- Check starter/door interlock for proper operation. The vehicle should not be capable of starting if the rear or side emergency exits are locked.

Repair if any aspect of the standard or inspection fails.

NOTES: Hinges and other working parts may be lubricated, preferably with a silicone-based lubricant to reduce dirt attraction.

Defective seals, switches, or excessively worn parts must normally be replaced.

Leaks in weather-stripping or seals may be re-sealed. Badly damaged or deteriorated seals and weather-stripping normally must be replaced.

HINT: If a door locking mechanism is added to the emergency exits, it must meet the same requirements as an OEM style lock. This means that all warning and starter interlock devices must also be installed and in good working order.

For additional information see also FMVSS 205 or Section 3 – Colorado Minimum Standards of this manual.

4. Emergency Equipment

Fire Extinguisher

The bus shall be equipped with at least one pressurized 5-pound dry-chemical fire extinguisher of a type approved by UL, with a total rating of not less than 2A10BC. The operating mechanism shall be sealed with a type of seal that will not interfere with use of the fire extinguisher.

The fire extinguisher shall be mounted in the extinguisher manufacturer's bracket (automotive type) and located in the driver's compartment in full view of and readily accessible to the driver.   A pressure gauge shall be so mounted on the extinguisher as to be easily read without removing extinguisher from its mounted position.

Small vehicles shall have one 2 1/2 pound extinguisher, rated at 1A10BC.

Inspection Procedure

- Pressure gauge should indicate proper charge and be readable without removing extinguisher from the bracket.

- The bracket should be securely mounted and should securely hold the extinguisher in place.
- Inspect operating mechanism seal.

Repair or replace if any aspect of the standard or inspection fails.

It is recommended that fire extinguisher be periodically removed from the bracket, turned upside-down and tapped with a rubber mallet to ensure that the powder inside the extinguisher is not compacted. Compacted powder in a fire extinguisher can render it inoperable.

NOTE: It is recommended that an extinguisher technician inspect all fire extinguishers used in pupil transportation vehicles not less frequently than once a year.

First Aid Kit
Buses and small vehicles shall carry a minimum of one 24 unit first aid kit, which shall either be mounted securely in full view, or the location plainly indicated by appropriate markings in the driver's compartment. The kit(s) shall be mounted in such a manner that they can be removed from the bus if necessary.

First Aid Kit Requirements
See also Section 3 – Colorado Minimum Standards of this manual.

Body Fluid Kit Requirements
See the Minimum Standards items chart for Colorado School Buses elsewhere in the manual.

Inspection Procedure

- Inspect to ensure kit includes all the proper contents.
- Brackets should be securely mounted and should hold the kit(s) securely in place.

HINT: A simple method of sealing first aid kits is to use a plastic tie on the latches, similar to the ties used on fire extinguishers.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

Emergency Reflectors
Buses and small vehicles shall be equipped with three red and orange emergency triangle reflectors in compliance with FMVSS 125, contained in a securely mounted case.

If the emergency triangle reflector case is mounted in the passenger compartment of a small vehicle it shall be securely mounted.

Inspection Procedure

- Ensure case contains 3 reflectors and is securely mounted.
- Reflectors should be physically checked to ensure they operate as designed.

Repair if any aspect of the standard or inspection fails.

HINT: Emergency reflectors are normally stored in plastic boxes attached to the floor or elsewhere in the vehicle. The lid latches on these boxes break over time, resulting in an open box whereby the triangle reflectors could fly out in the event of an accident. It is recommended that a metal band type device be used to secure the lid of the box (it may also be used to secure the box to the vehicle). The latch of such a metal band must be easily opened to afford access to the triangle reflectors. A seal similar to that described in the first aid kit section of this manual may also be employed on the reflector storage box. For ease of identification, your district should try to choose a general location on each bus that would be familiar to every driver.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

5. Floor Covering and Steps

Aisle floor covering shall be ribbed. Cove molding shall be used along the side walls and rear corners and all floor seam separations shall be covered with durable metal stripping.

Entrance steps shall have an integral white nosing of at least 1 1/2 inches or be diagonal striped. Tread area shall be of non-skid material and sealed to prevent water from getting underneath the step tread.

A secured and insulated plate shall be provided for access to the fuel tank sending unit.

Inspection Procedure

Inspect to ensure that:

- All moldings are securely fastened and no fasteners are missing.
- Steps are clean and nosing and/or stripes are easily seen.
- Tread area is securely adhered.
- Fuel sender access cover is secured and in good condition.

Repair if any aspect of the standard or inspection fails.

For further information see also Section 3 – Colorado Minimum Standards of this manual.

6. Grab Rails

Grab rails are furnished to assist with the loading and unloading of passengers. When the weather is icy or wet they become even more critical.

Inspection Procedure
Inspect to ensure that:

- The grab rail is securely anchored at both ends.
- The grab rail is free from burrs, cracks, and anchor bolts that may snag clothing.
- Check the grab rail clearance at each end, and along its path, to ensure that there is sufficient clearance so as not to snag clothing.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

7. Interior Lighting

Interior Lamps
Interior lamps shall be provided which adequately illuminate the aisle. A separate lamp shall be provided in the step well.

Step Well Lamp
A service door switch lighting the lamp when the door is open, and not lighting the lamp when the door is closed shall control the step well light.

Inspection Procedure
Inspect to insure that:

- All lenses are clean.
- All lamps illuminate properly when appropriate controls and/or switches activated.
- Switches should operate smoothly.

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

8. Interior Mirrors

The primary purpose of the interior mirror is to afford the bus driver a view of the passenger area.

The interior mirror shall be either clear view laminated glass or clear view glass bonded to a backing which retains the glass in the event of breakage. The mirror shall have rounded corners and protected edges. Type A buses shall have a minimum of a 6" x 16" mirror and type B, C, and D buses shall have a minimum of a 6" x 30" mirror.

Small vehicles must have standard manufacturer's interior mirror.

Small vehicles must have OEM exterior mirrors, on both the left and right side (or mirrors which exceed OEM), which met current FMVSS appropriate to the GVW rating.

Inspection Procedure

- Mirror should be securely mounted so as to minimize vibration and should not be in a bind causing distorted images or breakage.
- Check all fasteners for tightness.
- Mirror should not have any damage or discoloration, and should afford a clear, non-distorted view of the vehicle's interior.
- Mounting, framing, and other related hardware should be damage free.

Repair or replace if any aspect of the standard or inspection fails.

NOTE: Hardware and/or brackets may be repaired. The finished repair should be consistent with or better than OEM and should not have burrs or sharp edges. Defective mirrors must be replaced.

For additional information see also Section 3 – Colorado Minimum Standards in this manual.

9. Driver's Seat

All Type A,B,C and D buses must conform to these standards. Small vehicles must be equipped with standard manufacturers' seats.

Starting July 1, 1979

The driver's seat must be securely fastened to the floor and equipped with a seat belt as follows: a locking retractor type seat belt with the button type latch mounted on the right side shall be provided for the driver.

Each belt section shall be booted so as to keep the belt and buckle off the floor and within easy reach of the driver. The belt shall be anchored in such a manner or guided at the seat frame so as to prevent the driver from sliding sideways from under the belt.

Starting Oct. 1, 1993

A type 2 lap belt/shoulder harness seat belt shall be provided for the driver. The assembly shall be equipped with an emergency locking retractor (ELR) for the continuous belt system. The lap portion of the belt shall be guided or anchored where practical to prevent the driver from sliding sideways under it.

Inspection Procedure

- The minimum distance between the closest part of the seat back and the steering wheel is 11 inches.
- The seat pedestal is securely fastened to the floor, and centered to the steering column.
- The seat belt conforms to the standards and the latch mechanism works properly.
- The seat belt is secured to the floor and that when properly adjusted across the lap there is no excessive slack in the belt.
- All seat adjustments should be operational.
- Check seat belt webbing for fraying or discoloration.

Repair if any aspect of the standard or inspection fails.

NOTE: All hardware may be repaired. Federal law prohibits repairs or modifications to the seat belt assembly.

For additional information see also FMVSS 222 or Section 3 – Colorado Minimum Standards of this manual.

10. Passenger Seats and Restraining Barriers

All Type A,B,C and D buses shall conform to this standard. All seating and restraining barrier design and construction must meet the provisions of FMVSS 222.

All seats shall be forward facing and shall be securely fastened to that part of the school bus body, which supports them.

No bus shall be equipped with jump seats or portable seats. Jump seats are seats that must be raised or lowered manually. Seats that rise automatically are acceptable.

Forward-most pupil seat on the right side of the bus shall be located so as not to interfere with driver's vision, not farther forward than the barrier behind driver or rear of driver's seat when adjusted to its rear-most position.

Seat Material shall comply with FMVSS 302 and shall have a finished weight of not less than 42 oz. rating.

Passenger Seat Cushion retention system shall be employed to prevent passenger seat cushions from disengaging from seat frames in event of accident. Each seat cushion retention system shall be capable of withstanding vertical static load equal to minimum of five times weight of cushion.

Small Vehicles must be equipped with OEM seats. Small vehicle seating capacity shall conform to OEM rated capacity but IN NO EVENT may the seating capacity of small vehicles used for pupil transportation exceed the manufacturer's rating, including driver.

For additional information see also FMVSS 222 or Section 3 – Colorado Minimum Standards of this manual.

Inspection Procedure

- All seats must be forward facing and securely fastened to the bus body and/or floor.
- Ensure that seat cushion retention system prevents cushions from disengaging from seat frame. Test by lifting the cushion by hand.
- Ensure that there are no burrs or sharp edges exposed on seat frames or hardware.
- Ensure that the foam cushions and backs are fully intact to protect the occupants.

Repair if any aspect of the standard or inspection fails.

11. Seat Belt/Lap Belt

Inspect belts for discoloration and general appearance.

Remove and clean any belts that are excessively soiled.

Replace all belts that show signs of raveling, fraying, cuts, etc., which may be caused by excessive wear or vandalism.

Inspect all belts so that they adjust properly and freely.

Check latch/release operation. Inspect for metallic corrosion on metal components.

Carefully inspect latches and buckles for obstructions, and that latches and buckles are not cracked or broken.

Inspect all mounting hardware for any burrs and sharp edges or missing hardware.

Inspect all retracting devices for proper operation. Also inspect all retracting cover guards for deficiencies.

NOTE: Federal law prohibits modification or repairs to seat belt assemblies.

HINT: When cleaning seat belts, do not use solvent-based cleaners.

12. Interior Storage Compartments

A metal container of adequate strength and capacity for the storage of tire chains, tow chains, and such tools as may be provided. Such storage container may be located inside the passenger compartment.

It shall have a cover other than the seat cushion. The cover shall be securely fastened to the storage compartment in such a manner as to prevent the contents from spilling in case the bus overturns.

Inspection Procedure

- Inspect to ensure inside storage compartments are securely mounted to bus floor and that the lid is in place and securely fastened. It is recommended that storage compartments be bolted to the floor.

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

13. Sunshield

An interior transparent, adjustable, double bracketed sun visor shall be installed. The visor must not be less than 6 inches wide and 30 inches long.

Inspection Procedures

- Sunshield should meet the standard and should be installed in a position convenient for use by the driver.
- Brackets and related hardware should be damage free and securely mounted.
- Sunshield should be adjustable by the driver without having to use tools.

Repair if any aspect of the standard or inspection fails.

Brackets and hardware may be repaired or replaced. Finished work should not have burrs or sharp edges.

Defective or badly scratched sunshields must be replaced.

NOTE: Sunshields can be replaced with smoke-colored Plexiglas or Lexan which are available at glass shops.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

14. Ventilation

The bus shall be equipped with a two-speed powered exhaust roof ventilator, mounted approximately two-thirds of the way back from the front roof header. Type A school buses are excepted from this requirement.

NOTES: This requirement applies to school buses manufactured on or after July 1, 1979, only.

After Oct. 1, 1993, two roof escape hatches may be substituted in the place of a powered roof ventilator.

After Feb. 1, 1999, vehicles over 20 feet long must have a multiple speed roof vent.

Inspection Procedure
Inspect to ensure vent controls operate as designed.

Repair if any aspect of the standard or inspection fails.

For additional information see also Section 3 – Colorado Minimum Standards of this manual.

FRAME

1. Frame Members Inspection

The frame should be the original manufacturer's frame. It should be free from distortions, cracks, and welds. Federal Motor Carrier lists the following as sufficient to remove a vehicle from service:

Frame Members

- Any cracked, broken, loose, or sagging frame member.
- Any loose or missing fasteners including fasteners attaching functional components such as engine, transmission, steering gear, suspension, and body parts.

Tire and Wheel Clearance

- Any condition, including loading, that causes the body or frame to be in contact with a tire or any part of the wheel assemblies.

2. Insulation

Insulating material of at least 1/4-inch thickness shall be placed between the bus body and the main frame rails of the chassis, all the main cross-sills, and the intermediate members. The materials shall have the quality of automotive tire sidewall and shall be attached so that it will not move under severe operating conditions.

3. Bus Body to Frame Attachment

The bus body shall be attached to the chassis frame in such a manner as to prevent shifting or separation of the body from the chassis under severe operating conditions.

The bus body frame shall be attached and sealed to the chassis cowl to prevent entry of moisture and gases (Type A, B, & C buses).

Inspection Procedure

- Ensure that the insulating material is in place at all contact points between the body and the chassis frame.
- Check all mountings for proper alignment and tightness.
- Spring loaded mounts should be checked for broken springs or bolts.
- Flat iron mounts with nuts inside enclosed stringers are not repairable.

Repair if any aspect of the standard or inspection fails.

4. Bumpers

See Front Bumper and Rear Bumper earlier in Section 6 – Body.

HINT: Rust or signs of wear will indicate movement of body mounts. Some spring type mounts may be lubricated if a popping noise has been noticed on occasion.

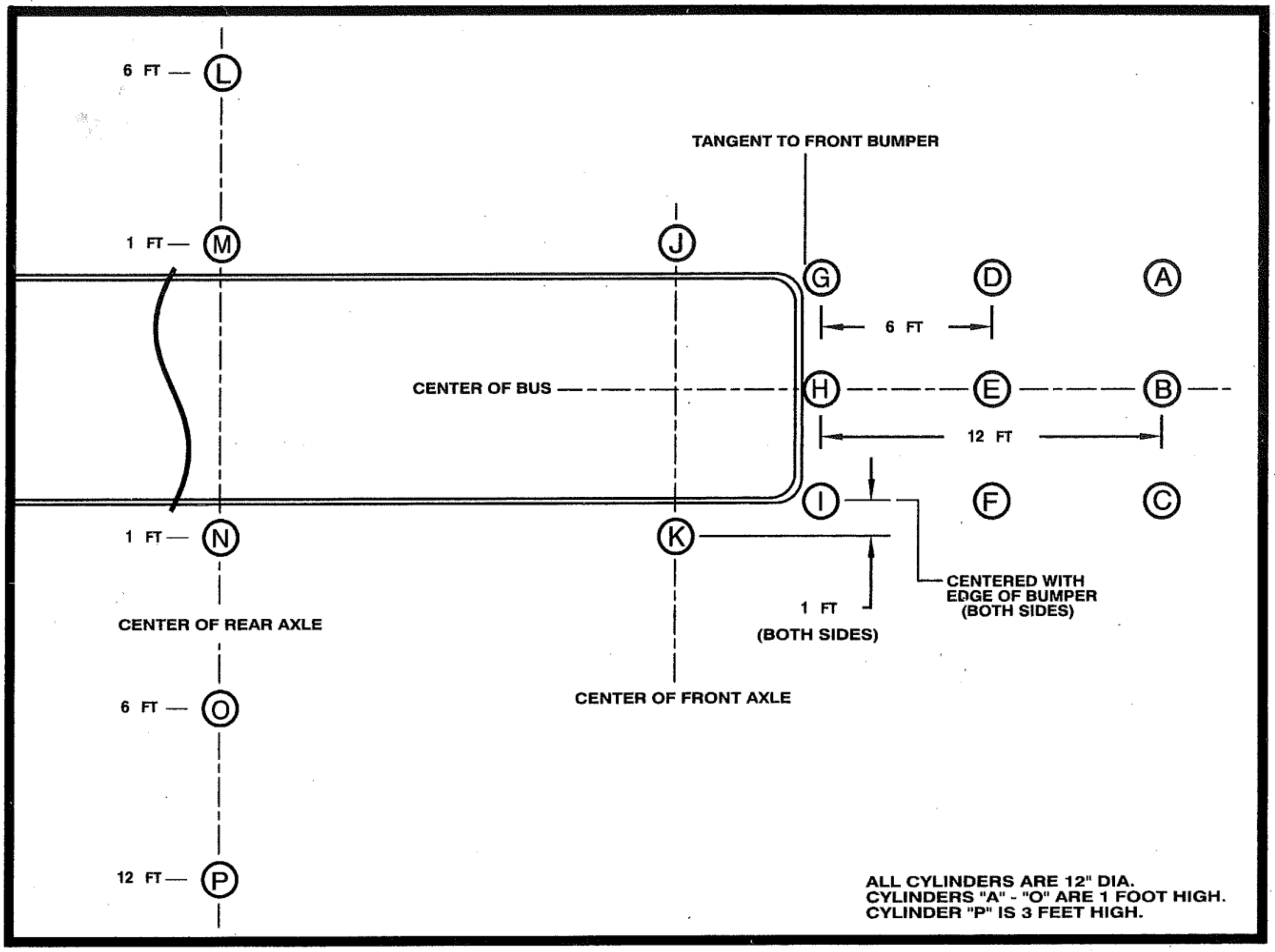
For Additional information see also Section 3 – Colorado Minimum Standards or Section 19 – Steering and Suspension of this manual.

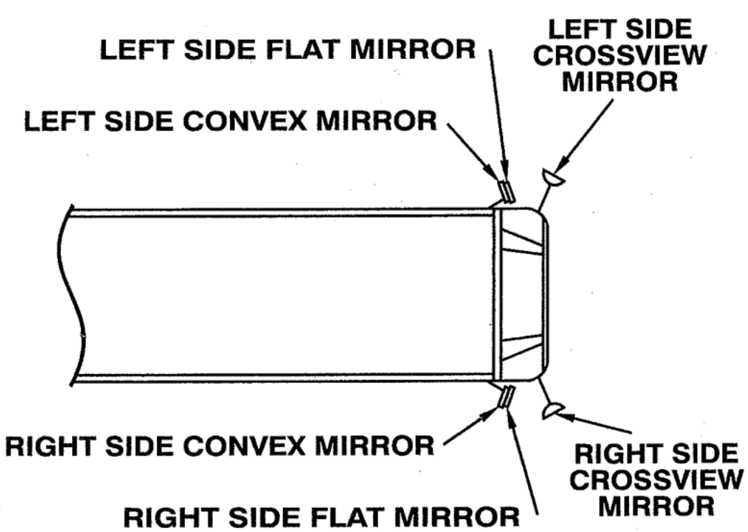
ADDITIONAL INFORMATION

1. Web Sites

www.blue-bird.com
www.internationaltrucks.com
www.thomasbus.com

FMVSS.111 MIRROR ADJUSTMENT





REAR VIEW MIRRORS (SYSTEM A)

USED TOGETHER, THE LEFT SIDE FLAT MIRROR AND LEFT SIDE CONVEX MIRROR MUST PROVIDE A VIEW OF CYLINDER "M" AND, CONTINUING FROM THERE, 200 FEET REARWARD OF THE MIRROR SURFACE.

USED TOGETHER, THE RIGHT SIDE FLAT MIRROR AND RIGHT SIDE CONVEX MIRROR MUST PROVIDE A VIEW OF CYLINDER "N" AND, CONTINUING FROM THERE, 200 FEET REARWARD OF THE MIRROR SURFACE.

CROSSVIEW MIRRORS (SYSTEM B)

ANY OF THE CYLINDERS "A" - "P" CAN BE VIEWED USING EITHER OF THE CROSSVIEW MIRRORS, BUT ALL MUST BE VISIBLE.
ONLY THOSE CYLINDERS THAT THE DRIVER CAN VIEW BY DIRECT VISION AND ARE FORWARD OF THE FRONT BUMPER MAY BE EXCLUDED.

Thomas BUILT BUSES We Move People.

THE THOMAS MIRROR SYSTEMS, WHEN PROPERLY ADJUSTED, COMPLY WITH ALL REQUIREMENTS OF FMVSS. 111. THOMAS BUILT BUSES, INC. ASSUMES NO RESPONSIBILITY FOR HARMS CAUSED BY MIRRORS NOT ADJUSTED PROPERLY.

BRAKE SYSTEMS

MECHANICAL AND COMMON COMPONENTS

Brakes are the most significant safety element of any school bus, or transportation vehicle. We encourage all school districts to exceed the standards set forth by the Federal Motor Vehicle Safety Standards, or the Federal Motor Carrier Safety Regulations. Remember, if you have any doubt in your mind as to whether any item is safe, clear your doubts and repair the item. You and the children involved will rest easier knowing that they are in the safest vehicle on the road!

1. **Brake Pedals and Linkage**

   The brake pedal should be in good condition. It should not be bent, cracked, or distorted in any manner.

   If the pedal was equipped with a rubber cover, it should be on the pedal and in good condition.

   The linkage between the pedal and the master cylinder (foot valve in an air system), should be in proper adjustment. Check the appropriate technical manual for free play or end play

   All pins and rods should be free from cracking, bending, or any distortion.

2. **Parking Brakes and Linkage**

   Hydraulic System

   - The hand or foot lever should be operational, and free from binding.
   - Cables, cable mounting, and all linkage should be operational, and free from binding.
   - **The parking brake should hold the vehicle while attempting to pull <u>FORWARD</u> in third gear with a manual transmission, or drive with an automatic transmission. DO NOT EXCEED 1000 RPM.**

NOTE: Some transmission mounted parking brakes may not hold for this test due to the torque of the engine.

- Check the transmission mounted parking brake drum using the same methods you would use on an axle mounted drum.

Air System

- The parking brake valve shall be operational, within easy reach of the driver, and shall not have any accessories attached to it.
- All related air valves in the parking brake system shall be fully operational.

- **The parking brake should hold the vehicle while attempting to pull FORWARD in third gear with a manual transmission, or drive with an automatic transmission. DO NOT EXCEED 1000 RPM.**
- The emergency system of the parking brake shall allow the spring brakes to automatically apply if the air pressure drops below 40 psi.

3. Warning Systems and Gauges

All components of the warning system shall be operational and within DOT guidelines.

The audible warning buzzer shall sound.

The visual warning lights shall be functional and visible.

All switches shall be operational and operate within DOT guidelines.

If the vehicle is equipped with an ABS system, all warning systems or gauges must be operational.

4. Brake hoses, Lines, and Cables

All hoses, lines, or cables shall be in good operable condition.

All hoses, lines, or cables shall be properly routed, mounted, or anchored.

All hoses, lines, or cables shall be free from worn areas, chaffing, cracks, fraying or leaks whichever may apply.

All fittings, lines, hoses, and tubing shall be DOT approved.

5. Documenting Brake Measurements

Record which wheel(s) is pulled by writing the measurements in the appropriate box.

Document all the information in the box, indicate which wheel was pulled the previous year.

The sample table given below is the same table that will be used for the annual inspection.

Record stroke reading (air brake system) (applied method) **LF**_________ **RF**_________ **LR**_________ **RR**_________
Record top and bottom brake shoe/pad lining readings (minimum reading) **TLF__________**/32 **TRF_________**/32 **TLR__________**/32 **TRR_________**/32 **BLF__________**/32 **BRF_________**/32 **BLR__________**/32 **BRR_________**/32
Previous Annual Inspection Drum/Rotor reading **LF**__________**RF**__________**LR**__________**RR**___________ Current Drum/Rotor reading **LF**__________**RF**__________**LR**__________**RR**___________ Manufacturer spec. **LF**__________**RF**___________**LR**_________**RR**___________

It is important to keep in mind that brake drums should **NEVER** exceed the drum manufacturer's maximum diameter. When machining drums you should maintain a 0.030 of an inch cushion under the maximum diameter.

When performing the annual inspection, variables such as annual mileage, next PM inspection date, life expectancy, etc. should be considered when determining whether or not to replace drums or shoes.

NOTE: Remember, the goal is to **NEVER** exceed the drum manufacturer's maximum diameter.

AIR BRAKE SYSTEMS

1. Air Valves

The parking brake valve shall be operational as explained on page 7.2.

ALL VALVES in the primary system shall be operational.

ALL VALVES in the secondary system shall be operational.

ALL VALVES should be clean, leak free, and securely mounted.

2. Compressor and Governor

With engine running at cut-out pressure, bleed air pressure down until compressor engages and note that pressure.

Inspection Procedure

- Record the operating pressures of the governor (the cut-in and the cut-out pressures).

NOTE: The cut-out pressure for the governor should be set as close as possible to 120 psi or to current manufacturers' specifications. The minimum cut-in pressure is 85 psi.

- The drive belt shall be in good condition and in proper adjustment. (where applicable)
- The compressor mounting shall be tight, free of cracks, and all bolts must be in place.
- The compressor intake filter shall be clean and unobstructed.
- The air, coolant, and oil lines shall be free of wear spots, cracks, chaffing, and should be properly mounted and routed.
- The compressor shall fill the complete system from 0 - 120 psi in 4 minutes or less at 1200-1500 RPM.

3. Reservoirs, Tanks, and Mounting

All tanks, or tank sections, shall be equipped with a proper drain.

The tanks shall be properly mounted, with the mounting secure and free of cracks, breakage, or severe distortion.

All tanks should be in good general condition, and free of leaks.

The wet tank shall be equipped with a safety valve if the air dryer is not equipped with one.

The wet tank shall be equipped with an ejection, or spitter, valve if the system is not equipped with a dryer.

4. Air Dryer

An air dryer shall be properly mounted in the proper location in the system, just prior to the wet tank. The mountings shall be secure and free from cracks, breakage, or severe distortion.

The air dryer shall be in good operating condition, with the drying compound free of contaminants or oil.

The heating element shall be operational (if equipped).

The air dryer shall be equipped with a safety valve if the wet tank is not equipped with one.

5. Air Chambers (Brake Pots)

The purpose of the air chambers is to maintain proper brake balance. It is recommended that chambers be replaced in pairs. The air chambers shall be of proper and equal size for each axle (preferably from the same manufacturer). The air chambers shall be properly mounted, with the mounting free from cracks, breakage, or distortion.

The chambers shall be free from cracks, dents, rust, and leakage.

The chamber clamps shall be tight, and free from cracks or breakage.

The connectors and lines for each chamber shall be tight, free from leaks, bending, or twisting and shall be properly routed and mounted.

NOTE: It is not recommended that brake chambers be overhauled or serviced. If a chamber is questionable it should be replaced. If you are having problems with ice or dirt building up inside a chamber, a weather seal is available to keep foreign matter from entering the chamber through the rod end.

6. Slack Adjusters

Record the slack adjuster stroke (after adjustment of manual slacks) of all four wheels on the PM form.

Appendix G states:

> (5) Readjustment limits. (a) The maximum pushrod stroke must not be greater than the values given in the tables below and at

§393.47(e). Any brake stroke exceeding the readjustment limit will be rejected. Stroke must be measured with engine off and reservoir pressure of 80 to 90 psi with brakes fully applied. Refer to Appendix G later in this section.

The splines shall be in good condition.

The clevis pins and holes shall be in good condition.

The adjusting locknut shall be operational on manual slack adjusters.

Automatic slack adjusters shall be in good working order. Check the appropriate manufacturer's manual for adjustment, and testing procedure.

The slack adjusters shall be mounted so as to provide a proper applied angle of less than 90 degrees when fully applied. For a diagram of this, see also Additional Information at the end of this section.

7. S-Cams and Bushings

The S-cam shall not have any play exceeding the manufacturer's specifications.

The S-cam seals should be intact and properly installed so as to not let grease escape to the shoe end of the S-cam.

8. Foundation Brake Hardware

All springs shall be of proper tension. It is recommended that the springs be replaced when replacing the shoe lining.

The rollers should be free of cracks, flat spots, or rust that may cause the rollers not to roll. Must match S-Cam application for the vehicle. Pictured below is an S-Cam with tapered rollers that is commonly found on air brakes.

The anchor pins should be intact, with all the correct washers, springs, and spring washers in proper placement. Replace any pins, washers, springs, spring washers, snap rings, or C-clips that are damaged.

The backing plates should be free from cracks, breakage, or severe distortion that may cause interference of the brake actuation.

9. Shoes or Pads (Lining)

All brake pad lining shall be measured at the thinnest point, and shall be measured from the pad base, not the rivets. The pad lining shall not be less than 1/8" at the thinnest point.

All brake shoe lining shall be measured at the shoe center, and shall be measured from the shoe base, not the rivets. The shoe lining shall not be less than 1/4".

All shoe or pad lining shall be free from cracks or breakage.

All shoe or pad lining shall be free from contamination that may cause slippage of grabbing.

All shoe or pad lining shall not be loose from the base, or have loose or missing rivets.

NOTE: Replace lining if existing lining will not last until next annual inspection.

10. Drums or Rotors

Inspection Procedure

- All four wheels will be removed and measurements taken on all drums and shoes and all appropriate measurements shall be documented. (see the table on page 4)
- List the manufacturer's maximum allowable specification.

(Example: 15 inch drum - the maximum allowable would be 15.120", or a 16.5 inch drum – the maximum allowable would be 16.620").

- The drums shall not have any external crack or cracks that open upon brake application. (Do not confuse short hairline heat cracks with flexural cracks.) See Appendix G later in the brake section of this manual.
- Drums or rotors shall not be heat discolored.
- Drums shall not be belled, or out of round past the manufacturer's specs.
- Rotors shall not be out of parallelism or run out.
- During the annual inspection, all foundation brakes shall be visually inspected.

NOTE: Drums and rotors shall be measured in at least two places. The appropriate tools for measurements are listed in Section 23 – Tool List of this manual. A lip type brake micrometer will not measure the amount of bell that a brake drum has. A standard micrometer will not measure the grooves worn into a rotor.

NOTE: Any school transportation vehicle with less than 4,000 miles since the previous annual inspection shall have two wheels removed for inspection, which is different from those removed for the previous inspection. Removing all four drums for inspection on vehicles with under 4,000 miles has been deemed unnecessary.

HYDRAULIC BRAKE SYSTEMS

1. Master Cylinder

The master cylinder shall be properly mounted. The mounting shall be secure, free from cracks, breakage, or distortion.

The master cylinder shall be free of leaks. (Remember the dust seal must not leak dirt or contaminants.)

The master cylinder shall be free of any visible damage.

The master cylinder shall have a brake pedal reserve as per the manufacturer's specifications.

The attaching lines shall be free of leaks, bending, twisting, or breakage. The lines must be properly routed and secure where appropriate.

NOTE: It is recommended that any leaking master cylinder should be replaced and not rebuilt. A remanufactured master cylinder is a suitable replacement.

2. Wheel Cylinders or Calipers

The wheel cylinders/calipers shall be properly mounted. The mounting shall be secure, free from cracks, breakage, or distortion.

The wheel cylinders/calipers shall be free of leaks.

The wheel cylinders/calipers shall be free of any visible damage.

The attaching lines or hoses shall be free of leaks, bending, twisting, or breakage.

The lines or hoses must be properly routed and secure where appropriate.

NOTE: It is recommended that any leaking wheel cylinder/caliper should be replaced and not rebuilt. A remanufactured wheel cylinder/caliper is a suitable replacement.

3. Brake Fluid

The brake fluid shall be of a DOT approved type, and shall be of the manufacturer’s specifications (Do NOT mix fluid types).

The fluid shall be free of contamination.

The fluid shall be at the appropriate level as per the manufacturer’s specifications.

Test strips or electronic measuring device are available for moisture test of brake fluid.

4. **Hydraulic Brake Valves**

All brake valves shall be operational.

All brake valves shall be properly installed and securely mounted where appropriate.

All lines or hoses, and fittings, shall be properly installed, and shall be free from worn spots, bending, twisting, or breakage. All connections shall be free of leakage.

5. **Foundation Brake Hardware**

All springs shall be of proper tension. It is recommended that the springs be replaced when replacing the shoe/pad lining.

The anchor pins should be intact, with all the correct washers, springs, and spring washers in proper placement. Replace any pins, washers, springs, spring washers, snap rings, or C-clips that are damaged.

The backing plates should be free from cracks, breakage, or severe distortion that may cause interference of the brake actuation.

The self-adjusting mechanisms shall be fully operational. The cable (if applicable) shall be free from fraying. All other linkage shall be free from binding, bending, cracks, or breakage.

The axle seals shall not be leaking as to contaminate the lining causing slippage or grabbing.

6. **Shoes or Pads (Lining)**

All brake pad lining shall be measured at the thinnest point, and shall be measured from the pad base, not the rivets. The pad lining shall not be less than 1/16" at the thinnest point.

All brake shoe lining shall be measured at the shoe center, and shall be measured from the shoe base, not the rivets. The shoe lining shall not be less than 1/16".

All shoe or pad lining shall be free from cracks or breakage.

All shoe or pad lining shall be free from contamination that may cause slippage of grabbing.

All shoe or pad lining shall not be loose from the base, or have loose or missing rivets.

7. Drums or Rotors

During the annual inspection, all foundation brakes shall be visually inspected.

All four wheels will be removed and measurements taken on all drums and shoes and all appropriate measurements shall be documented.

Any school transportation vehicle with less than 4,000 miles since the previous annual inspection shall have two wheels removed for inspection, which is different from those, which were removed for the previous inspection. Removing all four drums for inspection on vehicles with under 4,000 miles has been deemed unnecessary.

Inspection Procedure

- All brakes are to be visually inspected with all four drums removed and the appropriate measurements taken. **(See the table on page 3)**
- List the manufacturer's maximum allowable specification. (Example: 13-inch drum - the maximum allowable would be 13.090")
- The drums shall not have any external crack or cracks that open upon brake application. (Do not confuse short hairline heat cracks with flexural cracks.) **See Appendix G later in the brake section of this manual.**
- Drums or rotors shall not be heat discolored.
- Drums shall not be belled, or out of round past the manufacturer's specs.
- Rotors shall not be out of parallelism or out of round past the manufacturer's specs.

NOTES: Drums and rotors shall be measured in at least 2 places. The appropriate tools for measurements are listed in Section 23 – Tools List of this manual. A lip type brake micrometer will not measure the amount of bell that a brake drum has. A standard micrometer will not measure the grooves worn into a rotor.

8. Booster Systems

Vacuum Booster

- Shall be operational as per manufacturer specifications.
- The one-way check valve shall be in good operating condition.

- The warning system shall be intact and fully operational (if equipped).

Hydraulic Booster

- The drive belt shall be in good condition, and properly adjusted (if equipped).
- All lines, hoses, and fittings shall be in good condition. They should be free from bending, twisting, cracking, and leaks. All lines should be routed and anchored properly (if equipped).
- The warning system shall be intact and fully operational (if equipped).

Electric Booster

- All connections and wire shall be in good condition. The wiring should be routed and mounted properly to prevent rubbing or chaffing of the wire.
- The electric motor should be securely mounted. The mounting should be free from cracks, breakage, or distortion.
- All warning labels should be easily visible by the driver.
- The warning system shall be intact and fully operational (if equipped).

9. Switches

All switches shall be in good operating condition. They should be securely mounted and adjusted properly (if equipped).

ADDITIONAL INFORMATION

1. Web Sites

www.accuridewheelendsolutions.com
www.bendix.com
www.daytonparts.com
www.meritor.com
www.mgmbrakes.com
www.navistar.com
www.spicerbrakes.com
www.wabco-auto.com

2. Federal Motor Carrier Appendix G to Subchapter B
(current as of Feb. 23, 2012)

Brake System.
a. Service brakes.
(1) Absence of braking action on any axle required to have brakes upon application of the service brakes (such as missing brakes or brake shoe(s) failing to move upon application of a wedge, S-cam, cam, or disc brake).
(2) Missing or broken mechanical components including: shoes, lining, pads, springs, anchor pins, spiders, cam rollers, push-rods, and air chamber mounting bolts.
(3) Loose brake components including air chambers, spiders, and cam shaft support brackets.
(4) Audible air leak at brake chamber (Example-ruptured diaphragm, loose chamber clamp, etc.).
(5) Readjustment limits. (a) The maximum pushrod stroke must not be greater than the values given in the tables below and at §393.47(e). Any brake stroke exceeding the readjustment limit will be rejected. Stroke must be measured with engine off and reservoir pressure of 80 to 90 psi with brakes fully applied.

Clamp-Type Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit (Standard Stroke)	Brake Readjustment Limit (Long Stroke)
6	4 1/2 in.	1 1/4 in.	
9	5 1/4 in.	1 3/8 in.	
12	5 11/16 in.	1 3/8 in.	1 3/4 in.
16	6 3/8 in	1 3/4 in.	2 in.
20	6 25/32 in.	1 3/4 in.	2 in. (50.8 mm). 2 1/2 in. (63.5 mm)*
24	7 7/32 in.	1 3/4 in.	2 in. (50.8 mm). 2 1/2 in. (63.5 mm)**
30	8 3/32	2 in.	2 1/2 in.

	in.		
36	9 in.	2 1/4 in.	

* For type 20 chambers with a 3-inch (76 mm) rated stroke.
** For type 24 chambers with a 3-inch (76 mm) rated stroke.

Bendix DD–3 Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit
30	8 1/8 in.	2 1/4 in.

Bolt-Type Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit
A	6 15/16 in.	1 3/8 in.
B	9 3/16 in.	1 3/4 in.
C	8 1/6 in.	1 3/4 in.
D	5 1/4 in.	1 1/4 in.
E	6 3/16 in.	1 3/8 in.
F	11 in.	2 1/4 in.
G	9 7/8 in.	2 in.

Rotochamber-Type Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit
9	4 9/32 in.	1 1/2 in.
12	4 13/16 in.	1 1/2 in.
16	5 13/32 in.	2 in.
20	5 15/16 in.	2 in.
24	6 13/32 in.	2 in.
30	7 1/6 in.	2 1/4 in.
36	7 5/8 in.	2 3/4 in.
50	8 7/8 in.	3 in.

(b) For actuator types not listed in these tables, the pushrod stroke must not be greater than 80 percent of the rated stroke marked on the actuator by the actuator manufacturer, or greater than the readjustment limit marked on the actuator by the actuator manufacturer.

(6) Brake linings or pads.(a) Lining or pad is not firmly attached to the shoe;(b) Saturated with oil, grease, or brake fluid; or(c) Non-steering axles: Lining with a thickness less than 1/4 inch at the shoe center for air drum brakes, 1/16 inch or less at the shoe center for hydraulic and electric drum brakes, and less than1/8inch for air disc brakes.(d) Steering axles: Lining with a thickness less than 1/4 inch at the shoe center for drum brakes, less than 1/8 inch for air disc brakes and 1/16 inch or less for hydraulic disc and electric brakes.

(7) Missing brake on any axle required to have brakes.

(8) Mismatch across any power unit steering axle of:(a) Air chamber sizes.(b) Slack adjuster length.

Wedge Brake Data—Movement of the scribe mark on the lining shall not exceed 1/16 inch.

b. Parking Brake System. No brakes on the vehicle or combination are applied upon actuation of the parking brake control, including driveline hand controlled parking brakes.

c. Brake Drums or Rotors.

(1) With any external crack or cracks that open upon brake application (do not confuse

short hairline heat check cracks with flexural cracks).

(2) Any portion of the drum or rotor missing or in danger of falling away.

d. Brake Hose.

(1) Hose with any damage extending through the outer reinforcement ply. (Rubber impregnated fabric cover is not a reinforcement ply). (Thermoplastic nylon may have braid reinforcement or color difference between cover and inner tube. Exposure of second color is cause for rejection.

(2) Bulge or swelling when air pressure is applied.

(3) Any audible leaks.

(4) Two hoses improperly joined (such as a splice made by sliding the hose ends over a piece of tubing and clamping the hose to the tube).

(5) Air hose cracked, broken or crimped.

e. Brake Tubing.

(1) Any audible leak.

(2) Tubing cracked, damaged by heat, broken or crimped.

f. Low Pressure Warning Device missing, inoperative, or does not operate at 55 psi and below, or 1/2 the governor cut-out pressure, whichever is less.

g. Tractor Protection Valve. Inoperable or missing tractor protection valve(s) on power unit.

h. Air Compressor.

(1) Compressor drive belts in condition of impending or probable failure.

(2) Loose compressor mounting bolts.

(3) Cracked, broken or loose pulley.

(4) Cracked or broken mounting brackets, braces or adapters.

i. Electric Brakes.

(1) Absence of braking action on any wheel required to have brakes.

(2) Missing or inoperable breakaway braking device.

j. Hydraulic Brakes. (Including Power Assist Over Hydraulic and Engine Drive Hydraulic Booster).

(1) Master cylinder less than 1/4 full.

(2) No pedal reserve with engine running except by pumping pedal.

(3) Power assist unit fails to operate.

(4) Seeping or swelling brake hose(s) under application of pressure.

(5) Missing or inoperative check valve.

(6) Has any visually observed leaking hydraulic fluid in the brake system.

(7) Has hydraulic hose(s) abraded (chafed) through outer cover-to-fabric layer.

(8) Fluid lines or connections leaking, restricted, crimped, cracked or broken.

(9) Brake failure or low fluid warning light on and/or inoperative.

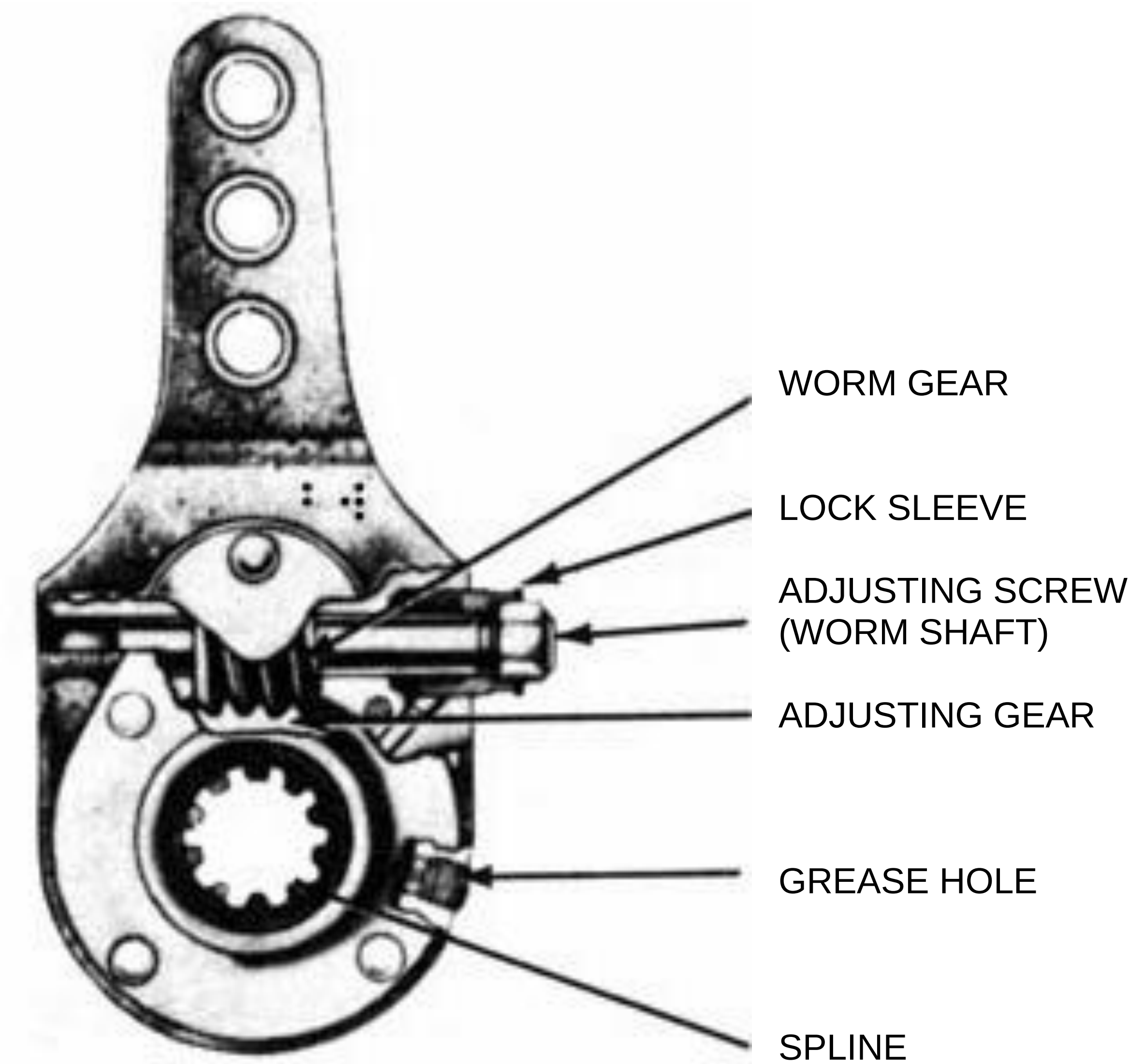
k. Vacuum Systems. Any vacuum system which:

(1) Has insufficient vacuum reserve to permit one full brake application after engine is shut off.

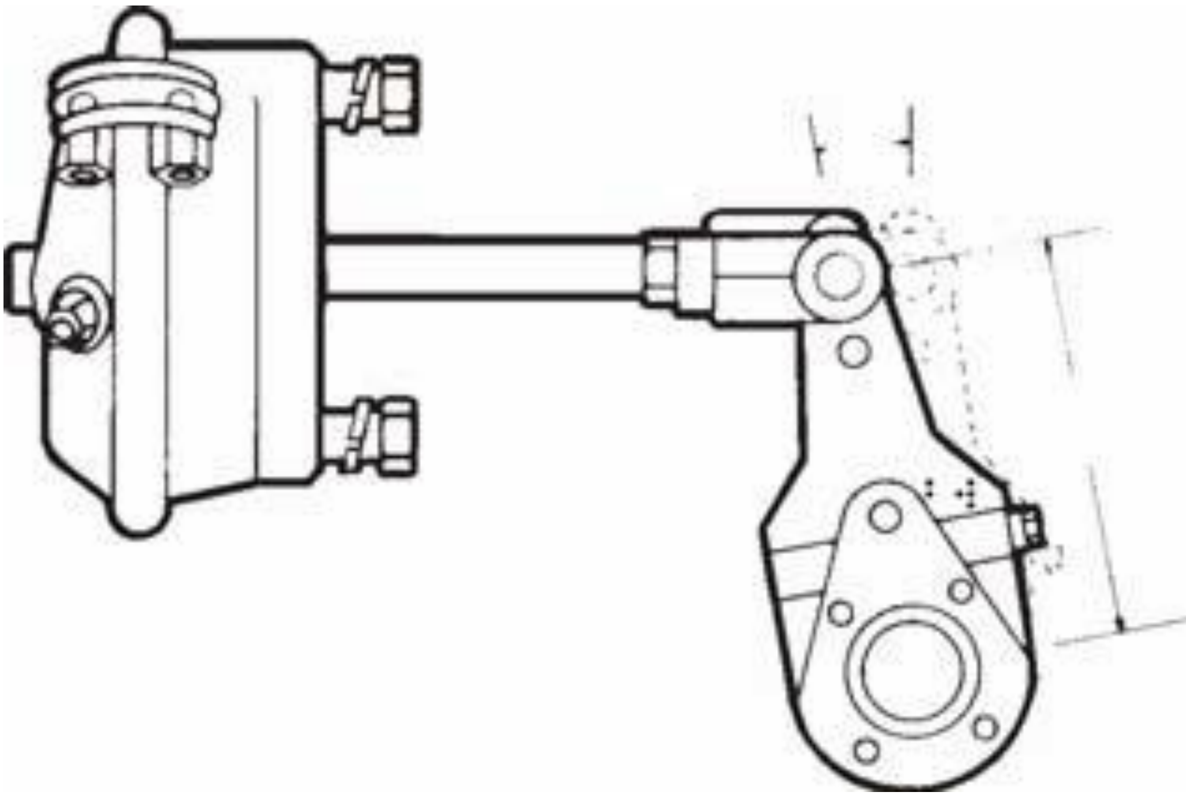
(2) Has vacuum hose(s) or line(s) restricted, abraded (chafed) through outer cover to cord ply, crimped, cracked, broken or has collapse of vacuum hose(s) when vacuum is applied.

(3) Lacks an operative low-vacuum warning device as required.

3. Diagrams


WORM GEAR
LOCK SLEEVE
ADJUSTING SCREW
(WORM SHAFT)
ADJUSTING GEAR
GREASE HOLE
SPLINE

The slack adjuster should be adjusted with the threaded clevis or yoke and the adjuster screw, so that the brake chamber push rod is at a 90 degree angle with the slack adjuster arm in the brake full applied position. Then, consult the data chart for specifications on the particular type brake chamber in question.



BEARINGS, TIRES, AND WHEELS

BEARINGS

1. **Purpose**

   The bearings are an effective way of distributing the weight of the vehicle over a small area, and still allow the wheels to roll.

2. **Inspection**

   Wheel bearings should be checked any time the hub is removed. Follow OEM inspection procedures. Check the bearings and seals for any sign of wear or deterioration.

NOTE: Always check the appropriate service manual for the correct procedure.

TIRES

1. Purpose

Modern pneumatic tires provide traction for moving and stopping the vehicle. Properly inflated, today's tires will absorb irregularities in the road surface, give a safe and comfortable ride, and provide a reassuring grip to the road at all speeds.

2. Inspection Procedure

Excessive or uneven tread wear results from under inflation, rapid stops, fast acceleration, misalignment, and unbalanced conditions. Road surface condition will also affect tire life. Gravel roads and rough-finished concrete will wear tires quickly. Smooth concrete and asphalt surfaces aid in promoting maximum tire life. Normal wear causes the tire tread to be reduced evenly and smoothly. Types of abnormal wear include:

- Spotty Wear
- Over inflation Wear
- Under inflation Wear
- Toe-in Wear
- Toe-out Wear
- Incorrect Camber Wear
- Cornering Wear

NOTE: Most tire manufacturers have manuals with pictures of examples for the tire wear listed above.

3. Tire Wear Patterns

- **Toe Wear**
  The typical wear pattern that develops from excessive toe is a feather edged scuff across the crown. Excessive toe is usually seen on both steer tires.

- **Camber Wear**
  If the spindle has excessive positive camber, the tire will scrub off the outside shoulder. If the spindle has excessive negative camber, the tire will scrub off the inside shoulder. Camber wear is usually seen on just one tire.

- **Cupping Wear**
  Any loose or worn component in the steering or suspension systems can cause odd wear, cupping, and flat spots. Check for loose wheel bearings, excessive steering gear lash, worn tie rod ends, and worn

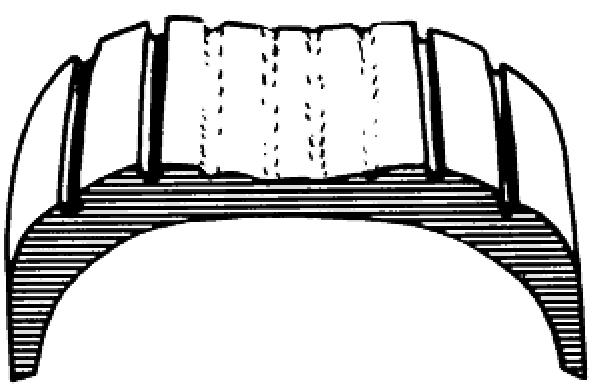
kingpins. Check for worn shock absorbers. Check for improper tire inflation or balancing.

- **Flat Spotting Wear**
  Localized wear across the tread width. Causes include brake lockup, brake imbalance, out of round brake drums, axle hop or skip. A tire being parked on a surface containing hydrocarbon oils, chemicals, and solvents can also cause this type of wear pattern. The affected area of the tread will wear more rapidly, leaving a flat spot.

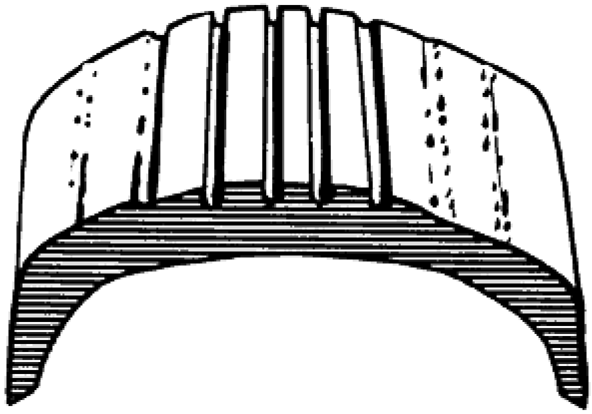
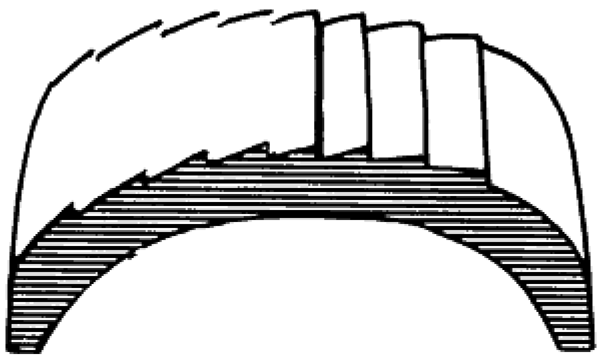
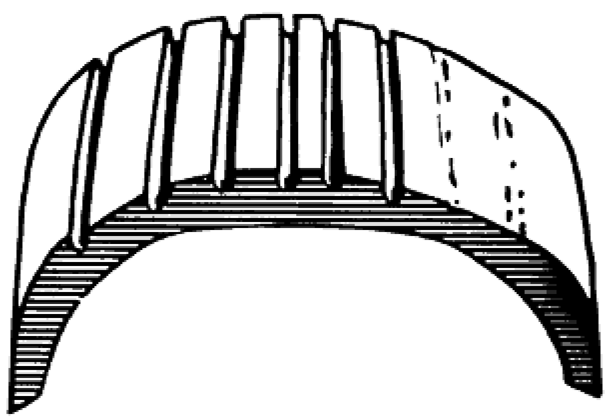
- **Diagonal Wear**
  Localized wear diagonally across the tread width. Side forces imposed by a combination of toe and camber create diagonal stress in the footprint of the tire. Localized wear patterns tend to follow this same direction creating diagonal wear. Causes include excessive toe setting, axle misalignment, excessive steering system elasticity, incorrect steering angle in turns, and excessive camber setting.

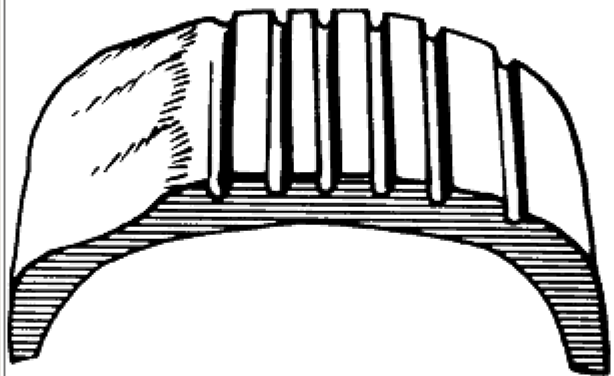
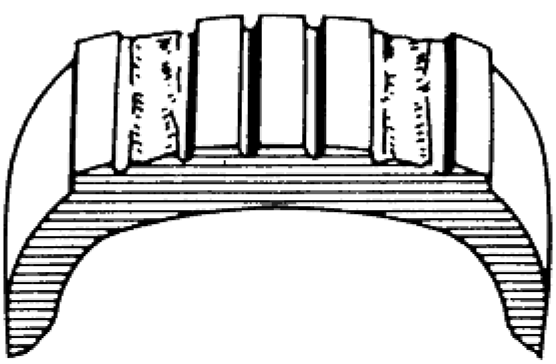
4. How To Read Tire Wear

The way your tires wear is a good indicator of other parts of your car. Abnormal wear patterns are often caused by the need for simple tire maintenance, or for front end alignment. Tires should be inspected at every opportunity; once a week isn't too often. Learning to read the early warning signs of trouble can prevent wear that shortens tire life or indicates the need for having other parts of the car serviced. Tires should be inspected 3 ways. First, visually examine all 4 tires; second, feel the tread by hand to detect wear such as feathering and third, check all 4 tires with a pocket type pressure gauge.



Over Inflation
Excessive wear at the center of the tread indicates that the air pressure in the tire is consistently too high. The tire is riding on the center of the tread and wearing it prematurely. Many times, the "eyeball" method of inflation (pumping the tires up until there is no bulge at the bottom) is at fault; tire inflation pressure should always be checked with a reliable tire gauge. Occasionally, this wear pattern can result from outrageously wide tires on narrow rims. The cure for this is to replace either the tires or the wheels.

	**Under Inflation** This type of wear usually results from consistent under inflation. When a tire is under inflated, there is too much contact with the road by the outer treads, which wear prematurely. Tire pressure should be checked with a reliable pressure gauge. When this type of wear occurs, and the tire pressure is known to be consistently correct, a bent or worn steering component or the need for wheel alignment could be indicated. Bent steering or idler arms cause incorrect toe-in and abnormal handling characteristics on turns.
	**Feathering** Feathering is a condition when the edge of each tread rib develops a slightly rounded edge on one side and a sharp edge on the other. By running your hand over the tire, you can usually feel the sharper edges before you'll be able to see them. The most common cause of feathering is incorrect toe-in setting, which can be cured by having It set correctly. Occasionally toe-in will be set correctly and this wear pattern still occurs. This is usually due to deteriorated bushings in the front suspension, causing the wheel alignment to shift as the car moves down the road.
	**One Side Wear** When an inner or outer rib wears faster than the rest of the tire, the need for wheel alignment is indicated. There is excessive camber in the front suspension, causing the wheel to lean too much to the inside or outside and putting too much load on one side of the tire. The car may simply need the wheels aligned, but misalignment could be due to sagging springs, worn ball joints, or worn control arm bushings. Because load has a great affect on alignment, be sure the car is loaded the way it's normally driven when you have the wheels aligned; this is particularly important with independent rear suspension cars.

	**Cupping** Cups or scalloped dips appearing around the edge of the tread on one side or the other, almost always indicate worn (sometimes bent) suspension parts. Adjustment of wheel alignment alone will seldom cure the problem. Any worn component that connects the wheel to the car (ball joint, wheel bearing, shock absorber, springs, bushings, etc.) can cause this condition. Worn components should be replaced with new ones. The worn tire should be balanced and possibly moved to a different location on the car. Occasionally, wheels that are out of balance will wear like this, but wheel imbalance usually shows up as bald spots between the outside edges and center of the tread.
	**Second-rib Wear** Second-rib wear is normally found only in radial tires, and appears where the steel belts end in relation to the tread. Normally, it can be kept to a minimum by paying careful attention to tire pressure and frequently rotating the tires. Some car and tire manufacturers consider a slight amount of wear at the second rib of a radial tire normal, but that excessive amounts of wear indicate that the tires are too wide for the wheels. Be careful when having oversize tires installed on narrow wheels.

WHEELS

1. Inspection Procedure

Rim and Wheel Maintenance During a Tire Inspection

Check all metal surfaces thoroughly while making tire inspections, including the areas between the duals and on the inboard side of the wheel. Watch for:

- Excessive rust or corrosion build-up.
- Cracks in metal.
- Bent flanges, resulting from road obstructions.

Pull damaged rims or wheels.

Replace damaged parts.

NOTE: Insure that replacements are made with the proper size and types of rims.

Inflate tires only to recommended air pressure.

HINT: Be alert to the fact that there are at least two rim widths, 7 ½ " and 8 ¼ ". Be careful not to mix rim widths on the same axle and use the proper size tire for the proper rim. There are hub piloted and lug piloted rims.

Rim and Wheel Maintenance During Tire Changes

Check for cracks in the rim base, in the back flange, and in the gutter areas. These are caused by deep rim tool marks, overloading, overinflating tires, and using larger than recommended tire sizes.

Check for cracks in the wheel disc, between the stud holes or hand holes. These are caused by loose wheel nuts, improper installation procedures, and the use of incorrect sizes or types of attaching parts.

Check for cracks through the side ring, spreading laterally through the entire section. These are caused by improper mounting and dismounting techniques, and impact with road obstructions.

Bead seating areas of the rim should be free of rust and rubber deposits. This is especially important for drop-center tubeless rims, because the 15-degree bead seat is the air-sealing element.

Paint the rim by brush or spray with fast-drying metal primer. Surfaces should be clean and dry prior to painting. Insure that any bare metal areas on the outside or the tire side of the rim are covered. This is especially important on drop-center tubeless rims, because warm and sometimes moist air is in constant contact with the metal surface on the tire side of the rim.

Lubricate the tire side of the rim base just prior to mounting the tire. Avoid the use of any lubricant, which contains water, or solvent that is injurious to rubber. A combination lubricant and rust preventive compound is preferable. This protective measure is of particular importance with drop-center tubeless rims, as the air inside the tire is contained by the tire-side rim surface.

Inflate tires only to recommended air pressure.

NOTE: For Dayton style wheels used on pre 1978 standard buses, see the appropriate service manual for inspection and maintenance procedures.

HINT: When using hub piloted rims, use anti-seize around the inner edge of the rim to prevent the rim from binding on the hub during installation or removal.

ADDITIONAL INFORMATION

1. Web Sites

www.accuridecorp.com
www.acdelco.com
www.bandag.com
www.binkelman.com
www.federalmogul.com
www.fleetowner.com
www.skf.com
www.stemco.com
www.timken.com

2. Fleet Owner Article – New Twist on Bearing Adjustment

The following are highlights of an article in the September 1991 copy of FLEET OWNER titled New Twist on Bearing Adjustment.

The trucking industry is confronted with two approaches to wheel-bearing adjustment. The prevailing procedure calls for a specified amount of axial end play to be left when mounting a hub. Running contrary to that is the theory that a controlled amount of preloading is acceptable, provided the axial load on the bearing is not excessive.

In the interest of providing a uniform standard for wheel-bearing adjustment, The Maintenance Council of ATA has asked its wheel-seal task force to draft a recommended practice that will address this issue, and thus help fleets get longer wheel-bearing life.

Until now, the more common practice has been to adjust wheel bearings so that the range of axial end play in wheel-end assemblies is very small, typically 0.001 to 0.005 inch for front axles and 0.001 to 0.010 inch for drive and trailer axles.

The alternative procedure, as recommended by Federal-Mogul, is to tighten the spindle nut against the bearing to achieve a 50lb.-ft. preload condition, thus preventing any axial end play and protecting the wheel seal.

Although bearing manufacturers, as well as the vehicle OEMs and axle makers, do not believe a small amount of preload is necessarily harmful to bearing life, they are very concerned about the consequences of too much preload -- a very real possibility since there is such a wide variance in wheel-bearing adjustments among fleets.

Mechanics are usually trained at the fleet level to adjust wheel bearings by backing off the spindle nut one-quarter to one-third turn before installing the adjustment lock washer and tightening the jam nut. This leaves a few thousandths of an inch of axial end play, providing enough free running clearance to allow a modest side-to-side movement of the wheel on the spindle. In fact, many fleets have guidelines that are too loose when it comes to adjusting wheel bearings.

There are five variables that affect preload -- friction of the spindle thread, friction of spindle-nut shoulder, torque wrench accuracy, accuracy of the mechanic, and the ability of the technician to maintain the preload setting when tightening the jam nut. If a fleet has a system to precisely control those variables, and can put a reasonable amount of preload into a bearing, it may be okay to slightly preload.

Manufacturers are concerned about the combination of too much reliance on the mechanic's judgment and too little shop control over wheel-bearing adjustment. A really tightly adjusted bearing can get so over-heated that it will run red hot and slice right through the spindle. There is a fine line -- just a few thousandths of an inch of clearance -- between an end-play adjustment that's too tight and one that's too loose.

The major problem with a loosely adjusted bearing is the pounding the seal takes as the wheel rotates, which may eventually lead to seal failure. Another reason for seal failure – and one that gets too little attention – is the difference in the expansion rates of a wheel and its spindle. As a truck warms up, the bearing's cone expands slightly, but the cup expands more. In a fully warmed vehicle, the differential produces a met increase in end play of from 0.001 to 0.002 inch. Therefore, the closer a wheel bearing can be adjusted – without going into preload – the more a fleet can be assured that its end play will stay below the 0.005 inch limit for front wheels and the 0.010 inch limit for drive and trailer wheels.

Federal-Mogul recommends that shop technicians set drive and trailer axle bearings into the hub housings by tightening wheel spindle nuts to 150 lb.-ft. then back off one-half turn and retighten with a torque wrench to 50 lb.-ft. Similarly, it advises fleets to initially torque the front-wheel spindle nuts to 100 lb.-ft. back off one-sixth turn, then final torque to 50 lb.-ft. before installing the lock washer.

Tightening jam nuts to 200 to 250 lb. will impose an additional compression load on the bearing and the added preload will slightly increase wheel drag, but it will not invite the wheel-bearing cup to spin in the hub, nor will it cause rear shoulder wear. What a fleet will gain is lengthened seal life, provided the hub cavity is kept clean of shavings and other foreign matter that can hurt the bearings.

Federal-Mogul feels that tighter adjustment will not harm bearings because the clamping forces on wheel bearings tend to diminish, and end play in wheel ends increases when a rig is operated.

Each time a wheel bearing has to be exposed for a brake job or other wheel-end work, carefully remove the bearing cone, clean the bearing, and steam clean the hub cavity to remove all tiny metal particles that can cause seal wear and oil leakage. Before a wheel-end is reassembled, eliminate all traces of moisture from the hub. Then, the bearing is greased prior to reinstallation. A new wheel seal is installed and the hub cavity is filled with fresh oil.

A drive-axle pinion bearing a front wheel-bearing are approximately the same size, and subject to the same types of loads. Yet in most fleets the pinion bearing, which is preloaded by design, outlasts the wheel bearing. The reason pinion bearings last longer, is that the axle housing is a cleaner environment than the hub cavity. If the hub cavity can be kept as clean as the axle environment, then both bearings should get equally long life.

Remember, consistency reduces the chance for mistakes in wheel-bearing adjustment.

For further information, please read the article in FLEET OWNER magazine article written by Stewart Siegel.

STEMCO® | BEARING ADJUSTMENT

STEMCO Endorses TMC's Recommended Wheel Bearing Adjustment Procedure

Proper wheel bearing adjustment is critical to the performance of wheel seals and other related wheel end products. For that reason, we are proud to be a part of TMC's Wheel End Task Force.
We are happy to bring these standards to you in the form of this technical guide. Working together, in this way, STEMCO helps keep your rigs rolling.

The following seven step bearing adjustment recommendation was developed by TMC's Wheel End Task Force. It represents the combined input of manufacturers of wheel end components.

STEP 1.

Bearing Lubrication:
Lubricate the wheel bearing with clean lubricant of the same type used in the axle sump or hub assembly.

STEP 2.

Initial Adjusting Nut Torque:
Tighten the adjusting nut to a torque of 200 ft-lbs, while rotating the wheel.

STEP 3.

Initial Back Off:
Back the adjusting nut off one full turn.

STEP 4.

Re-Torque Adjustment:
Re-Torque adjusting nut to 50 ft-lbs while rotating the wheel.

STEP 5.

Final Back Off:

AXLE TYPE	THREADS PER INCH	FINAL BACK OFF
Steer (Single Nut)	12	1/6 Turn*
	18	1/4 Turn*
Steer (Double Nut)	14	1/2 Turn
	18	1/2 Turn
Drive	12	1/4 Turn
	16	1/4 Turn
Trailer	12	1/4 Turn
	16	1/4 Turn

*Install cotter pin to lock axle nut in position.

STEP 6.

Jam Nut Torque:

AXLE TYPE	NUT SIZE	TORQUE SPECIFICATIONS
Steer (Double Nut)	Less Than 2$^5/_8$"	200-300 ft-lbs
	2$^5/_8$" And Over	300-400 ft-lbs
Drive	Dowel Type Washer	300-400 ft-lbs
	Tang Type Washer	200-275 ft-lbs
Trailer	Less Than 2$^5/_8$"	200-300 ft-lbs
	2$^5/_8$" And Over	300-400 ft-lbs

STEP 7.

Acceptable End Play:
The dial indicator should be attached to the hub or brake drum with its magnetic base. Adjust the dial indicator so that its plunger is against the end of the spindle with its line of action approximately parallel to the axis of the spindle.

Grasp the wheel or hub assembly at the 3 o'clock and 9 o'clock positions. Push and pull the wheel-end assembly in and out while *oscillating the wheel approximately 45 degrees*. Stop oscillating the hub so that the dial indicator tip is in the same position as it was before oscillation began. Read the bearing end-play as the total indicator movement.

NOTE: Acceptable end-play is .001"-.005."

For single nut self-locking systems, consult manufacturers' specifications.
STEMCO assumes no responsibility for bearing warranty.

STEMCO

BEARING ADJUSTMENT

Pro-Torq® Installation Procedure for Hubs with Manually Adjusted Wheel Bearings

STEP 1. Remove The Keeper From The Nut:

Use a screwdriver to carefully pry the keeper arm from the undercut groove on each side until the keeper is released.

STEP 2. Seat the Bearing:

With hub or hub/drum only:
Using a torque wrench:
1 **(A)** Tighten the nut to 200 ft-lbs.
Spin the wheel at least one full rotation.
(B) Tighten the nut to 200 ft-lbs.
Spin the wheel at least one full rotation.
(C) Tighten the nut to 200 ft-lbs.

With hub/drum/wheels:
Using a torque wrench:
1 Tighten the nut to 200 ft-lbs while the wheel is rotating.
2 Back the nut off until it is loose.

STEP 3. Adjust The Bearing:

With hub or hub/drum only:
Using a torque wrench:
1 **(A)** Tighten the nut to 100 ft-lbs.
Spin the wheel at least one full rotation.
(B) Tighten the nut to 100 ft-lbs.
Spin the wheel at least one full rotation.
(C) Tighten the nut to 100 ft-lbs.
2 Back the nut off one raised face mark (according to chart).

With hub/drum/wheels:
Using a torque wrench:
1 Tighten the nut to 100 ft-lbs while the wheel is rotating.
2 Back the nut off one raised face mark (according to chart).

FINAL BACKOFF

Part Numbers	Backoff
Trailer Axle Nut 447-4723, 447-4724, 449-4973	1/8 turn
Trailer Axle Nut 447-4743	1/4 turn
Steering Spindle Nut 448-4836, 448-4838, 448-4839, 448-4863, 448-4864, 448-4865	1/4 turn
Steering Spindle Nut 448-4837, 448-4840	1/3 turn
Drive Axle Nut 449-4904, 449-4973, 449-4974, 449-4975	1/8 turn

STEP 4. Install the Keeper:

Orange side facing out
1 Insert the keeper tab into the undercut groove of the nut and engage the keyway tang in the axle keyway. Insert keeper tab with the orange side facing out.
2 Engage the mating teeth.
3 Compress and insert the keeper arms, one at a time, into the undercut groove with a screwdriver.

For Steering Spindle Nut
448-4836, 448-4839, 448-4864, and 448-4865
448-4836, 448-4839, 448-4864, and 448-4865
1 Align the flat of the keeper with the milled flat on the spindle and insert the single keeper tab into the undercut groove of the nut. Insert keeper tab with the orange side facing out.
2 Engage the mating teeth.
3 Compress and insert the keeper arms, one at a time, into the undercut groove with a screwdriver.

NOTE: Recommended practice is to replace the keeper each time the Pro-Torq nut assembly is removed for maintenance purposes.

STEP 5. Inspect the Installation:

Failure to follow this instruction could cause the wheel to come off and cause bodily injury. Make sure that the keeper tab and keeper arms are fully seated into the undercut groove. Inspect keyway tang to insure it does not contact the bottom of the keyway. If contact exists, immediately notify your PRO-TORQ® representative.

This procedure will consistently produce a bearing setting of .001" to .003" end play.

STEP 6. Acceptable End Play:

The dial indicator should be attached to the hub or brake drum with its magnetic base. Adjust the dial indicator so that its plunger is against the end of the spindle with its line of action approximately parallel to the axis of the spindle. Grasp the wheel or hub assembly at the 3 o'clock and 9 o'clock positions. Push and pull the wheel-end assembly in and out *while oscillating the wheel approximately 45 degrees.* Stop oscillating the hub so that the dial indicator tip is in the same position as it was before oscillation began. Read the bearing end-play as the *total* indicator movement.

NOTE: Acceptable end-play is .001"- .005". *For single nut self-locking systems, consult manufacturers' specifications.*
STEMCO assumes no responsibility for bearing warranty.

STEMCO®
A Higher Standard of Performance.℠
an EnPro Industries company

PRO-TORQ®
ADVANCED AXLE SPINDLE NUTS

IMPORTANT

Pro-Torq® Installation Procedure for PreSet® or LMS® Hubs:
Pro-Torq® spindle nuts may be used with PreSet® or LMS® hub assemblies. When used with these systems, it is important to follow the hub manufacturers' product specific installation instructions. For PreSet® and LMS® hub assemblies, torque the Pro-Torq® spindle nut to a minimum of 250 ft. lbs. Engage the keeper. If the keeper can not be engaged, advance the spindle nut until it can be engaged. DO NOT BACK OFF THE SPINDLE NUT.

WARNING

Failure to follow this instruction could cause the wheel to come off and cause bodily injury.The PRO-TORQ® Spindle Nut is sold as an assembly with the keeper in place. DO NOT attempt to place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may deform the keeper and allow the nut to unthread during operation. DO NOT bend or manipulate keyway tang in any way. Doing so may cause the tang to break off in service. Failure to back off the nut will cause the bearings to run hot and be damaged.

TQM
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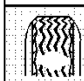
ISO/TS 16949

Tire Wear Diagnostic Chart

Wear Pattern		Cause	Action
	**Center Wear**	Over Inflation	Adjust pressure to particular load per tire catalog
	**Edge Wear**	Under Inflation	Adjust pressure to particular load per tire catalog
	**Side Wear**	Loss of camber or overloading	Make sure load doesn't exceed axle rating. Align at alignment shop
	**Toe Wear**	Incorrect toe-in	Align at alignment shop
	**Cupping**	Out-of-balance	Check bearing adjustment and balance tires
	**Flat Spots**	Wheel lockup & tire skidding	Avoid sudden stops when possible and adjust brakes

CAUTION

Tire wear should be checked frequently because once a wear pattern becomes firmly established in a tire it is difficult to stop, even if the underlying cause is corrected.

CLUTCHES

General Components .... Page #

CLUTCHES

1. Purpose

The clutch allows the driver to engage or disengage the engine torque from the manual transmission, allowing the driver to select a different gear range.

2. Inspection Procedure

Mechanical Linkage

Road test to detect any performance problems.
Check for proper free play adjustment.
Check for clutch slippage.
Stop vehicle and inspect for worn or broken parts.
Inspect the flywheel for wear within proper specifications, or if the ring gear is excessively worn.
Lubricate the linkage at all movable points.

NOTE: Refer to the appropriate manufacturer's service manual for proper adjustments.

Hydraulic Clutch

Check fluid level
Check master cylinder for leakage
Check slave cylinder for leakage
Check lines and fittings for leaking or rubbing and secure mounting

NOTE: For bleeding instructions, refer to manufacturer's recommended procedures.

HINT: Pull-type clutches adjust at the pressure plate.

ADDITIONAL INFORMATION

Web Sites

www.centerforce.com
www.barnettclutches.com
www.navistar.com
www.ramclutches.com
www.spicerparts.com

COOLING SYSTEM

General Components .... **Page #**

COOLING SYSTEM

1. Purpose

The function of the cooling system is to absorb the heat developed as a result of the combustion process, circulate the coolant to maintain efficient operating temperature, and protect system components. The cooling system must conform to Colorado minimum standards and FMVSS for the year of vehicle manufacture.

- **Coolant**
  The required coolant is a mixture of permanent base antifreeze with water, able to protect to -30 degrees Fahrenheit.

- **Radiator**
  The radiator is the main component for cooling system heat dissipation. The radiator shall be of sufficient capacity to cool the engine at all speeds in all gears.

- **Water Pump**
  The water pump circulates coolant through the water jackets and cylinder heads, where the coolant accumulates heat.

- **Thermostat**
  The flow of coolant is controlled by the thermostat, which restricts coolant flow through the radiator during engine warm up and then opens to prevent overheating.

- **Engine Fan**
  The fan forces air around the radiator tubes to transfer heat out of the coolant and decreases coolant temperature. The fan shall be heavy-duty reinforced type and may have a thermostatically actuated clutch.

- **Drive Belts**
  There are two basic types of drive belts: wedge-shaped and serpentine. Drive belts are used to drive the water pump and other engine components. Drive belts are to sit above the level of the pulleys.

- **Pressure Caps**
  The pressure cap is constructed with a spring-loaded valve that seats in the filler neck to prevent the escape of air or coolant while in the locked position. The pressure cap rating should never exceed manufacture specifications. Cooling system shall be equipped with a coolant recovery system.

- **Maintenance**
  Neglect of cooling system causes gradual damage, so the effects are often overlooked until major repairs are necessary. To maintain proper operation of the cooling system, install the correct replacement parts for the service or repair being preformed. The use of corrosion inhibitors or supplemental coolant additives may be necessary to maintain proper performance.

2. **Inspection Procedure**

- Check for leaks at radiator, heater cores, valves, water pump, hose and clamp connections, external leaks on engines.
- Check all drive belts for cracking, excessive wear, and proper tension.
- Check condition of all hoses.
- Check antifreeze condition, protection level, type of coolant, freeze point.
- Check fan, fan clutch, and fan shroud.
- Check block heater operation.
- Check shutter operation (if equipped).

Troubleshooting Table

Error! Bookmark not defined.Condition	**Possible cause**
Overheating	Radiator airflow restricted Loose or missing drive belts Defective thermostat Temperature gauge reading incorrect Radiator coolant flow restricted Damaged radiator hoses Faulty water pump Low engine oil level Defected or damaged fan clutch Excessive fan to shroud clearance Fan and/or fan shroud missing or damaged Defective radiator cap Low coolant level
Overcooling	Defective or missing thermostat Temperature gauge reading incorrect

	Defective or damaged fan clutch Defective radiator cap
Internal leakage	Head gasket leaking Cavitation erosion Defective air compressor Defective oil cooler Defective transmission cooler
External leakage	Loose or defective hose clamps Defective hoses Radiator core leaking Heater core leaking Defective radiator cap Cracked engine block or cylinder head

NOTE: Silicone hoses require a special hose clamp. Be sure you are using silicone type clamps for silicone hoses.

ADDITIONAL INFORMATION

Web Sites

www.arrowheadradiator.com
www.clearchoiceantifreeze.com
www.howstuffworks.com/cooling-system.htm
www.modine.com
www.narsa.org
www.prestone.com

DRIVE SHAFT COMPONENTS

General Components ....Page #

DRIVE SHAFT COMPONENTSError! Bookmark not defined.

1. Purpose

The drive shaft transfers engine power from the transmission to the rear wheels and should be serviced and inspected on a regular P.M. schedule.

2. Inspection Procedure

- **Drive Line**
  Inspect for shaft phasing on multiple driveline sections, loose or worn yoke and yoke retention bolt, splines, dents and missing drive shaft balance weights. Replace worn out parts.

- **Safety Loops**
  Inspect drive shaft hangers and make sure there is one for each section of the drive shaft and that they are securely mounted.

NOTE: The intent of the safety loop is to adequately support the driveline in the event of a failure.

- **U-Joints**
  Inspect for any movement or signs of caps turning. Replace if any signs of wear are found.

- **Carrier Bearings**
  Inspect for bearing and rubber packing and mounting bolts securely fastened. Replace if bearing play exists or if rubber packing is missing, deteriorated, or cracked.

3. Repair Procedure

The drive shaft needs to be repaired if there is distortion, it is out balance, or there are dents in the drive shaft. Remove and replace U-joints if necessary. Use the same equipment for removing and replacing the carrier bearings as you would for the U-joint. When repairing any component, be careful not to distort or damage the driveline.

NOTE: Use a press whenever possible. If not, use the best equipment available such as a vice and a suitable hammer. Caution must be taken not to strike the driveline tube otherwise damage to the driveline may occur.

ADDITIONAL INFORMATION

Web Sites

www.dana.com
www.driveshaftshop.com
www.drivetrain.com
www.spicerparts.com

ELECTRICAL

ELECTRICAL SYSTEM PREFACE

The State Specifications on the electrical system may have been revised in the current Colorado Minimum Standards. Some areas may have been edited and others completely deleted, but school bus technicians must remember that all areas and systems must be inspected and repaired if found defective. Any system or component on the vehicle may be upgraded to the current standard applicable at any time.

GENERAL ELECTRONICS

1. System Identification and Major Components

Instruments, gauges, and other chassis warning systems.

Cranking System

- Battery and cables
- Preheater system
- Starter and starter solenoids
- Starter interlock system

Charging System

- Alternator
- Regulator

Ignition System – Gasoline Engine

- Distributor
- Coil
- Spark plugs and wires
- Ignition switch

Ignition System – Diesel Engine

- Fuel shut-off solenoid
- Ignition switch

Lighting System

- Headlamps
- Signal, parking, backup, clearance, marker, stop arms, and interior lamps
- Electrical grounds
- Special application warning lights
- Multi-function controls and monitors

Electrical Accessories

- Radio and equipment
- Clocks

Mobility Aid Equipment (see also Section 18 – Special Needs)

- Power supply to the lift equipment
- Lift controls
- Lift motor

Optional equipment (see also Section 25 – Accessories)

- Strobe lights
- Surveillance equipment
- Stop arm strobe lights
- Starter interlock and vandal lock systems
- GPS

2. Inspection Procedure

Instruments, Gauges, and Other Chassis Warning Systems

- Check gauges for proper operation.
- Check gauges for proper visibility.

Cranking System

- Check the battery for output and condition.
- Check the battery cables for tightness and condition.
- Check the starter condition.
- Check the starter interlock for proper operation.

NOTE: See also Section 6 – Body, Frame, and Associated Equipment for additional information about the starter interlock.

Charging System

- Check the alternator for capacity, output, and overall condition.
- Check the alternator drive belts for proper adjustment and condition.

Ignition System

- Check the distributor, coil, spark plugs and wiring, and ignition switch, for proper operation and condition.
- Check the fuel shut-off solenoid and linkage for proper condition and adjustment.

Lighting System

- Check headlamps for cracks, clouding, and severe pits.
- Check headlamps for proper alignment.
- Check all signal, marker, turn, and brake lamps for proper color, and visibility.
- Check all lights for proper size and location.
- Check all lamp grounds for condition.
- Check the stop arm for visibility, ground wire condition, and proper adjustment upon engaging.
- Check the 8-way light system for proper operation.

NOTE: For additional information on 8-way light operation, see also Section 3 –

CDE Minimum Standards of this manual and page 12.14 on the 8-Way Light Systems.

Electrical Accessories

- Check any electrical accessory for proper operation.
- Check the starter interlock for proper operation.

Mobility Aid Equipment

- Check all connections, fuses, circuit breakers, and controls for condition and proper operation.

Optional Equipment

- Check all optional equipment for condition and proper operation. This will include, but is not limited to, strobe lights, stop arm strobes, and crossing arm.
- Check the operation and condition of surveillance equipment (if equipped).
- Check the operation and condition of GPS equipment (if equipped).

3. Diagnostic Tools

Unpowered Test Light

This tool consists of a 12-volt light with leads. The ends of the leads usually have alligator clamps, but various kinds of probes, terminal spades, and special connectors are used also.

The unpowered test light is used on an open circuit. One lead of the test light is grounded and the other lead is moved around the circuit to be open. Depending on the physical layout of the circuit, sometimes it will be easier to start at the power supply and other times it is easier to start at the circuit load or ground circuit.

Powered Test Light

This test light is a pencil-shaped unit with a self-contained battery, a 1.5-volt light bulb, a sharp probe, and a ground lead fitted with an alligator clip.

This test light is used mainly for testing components that are disconnected from the vehicle power supply. The powered test light is also useful for testing a suspected high resistance point in a circuit such as connectors and ground circuits that are corroded or loose.

Jumper Wire

The jumper wire is usually a long wire with alligator clamps. A safety version of the jumper has a fuse holder on it with a 10-amp fuse. This will prevent damaging the circuit if the jumper is connected in the wrong way.

The jumper is used to locate opens in a circuit. One end of the jumper is attached to a power source and then the other is attached to the load or the circuit, i.e. light or motor. If the load works, try "jumping" to circuit points that are progressively closer to the power supply. When the circuit load stops working, the open has been located.

The jumper is also used to test components in the circuit such as connectors, switches and suspected high resistance points.

Ammeter
The ammeter measures the amount of electrical current, amperes, moving through a conductor. The ammeter must be placed in series with the circuit being tested. Disconnect the circuit from the power source before connecting the ammeter. Be sure that the ammeter's positive terminal is connected to the positive (battery) side of the circuit and its negative terminal to the negative (ground) side of the circuit.

When using an ammeter or voltmeter, and the value being tested is unknown, always use the highest scale first and work downward to a mid-scale reading whenever possible. This will avoid damage to the instrument.

Voltmeter
The voltmeter gives the technician more information than the ammeter, ohmmeter, and test light combined. Its application for troubleshooting here is to measure the electrical pressure (voltage) drop in a resistance circuit.

To use a voltmeter for troubleshooting an electrical problem, connect it in parallel with the existing circuit being tested, otherwise the nature of the circuit would be changed and the reading would have no particular value or use. Connect the meter terminals according to polarity.

The dash-mounted voltmeter (in the vehicle) should also be observed for monitoring proper operation of the generator/alternator, battery, cranking motor, and the cranking circuit. In this application, battery voltage drop can be monitored while the engine is cranking. After the engine is running, generator/alternator output voltage can be monitored. This can be a valuable first step prior to diagnosing other electrical problems.

HINT: When using an ammeter or voltmeter, and the value being tested is unknown, always use the highest scale first and work downward to a mid-scale reading whenever possible. This will avoid damage to the instrument.

Ohmmeter
The ohmmeter is an instrument designed to indicate resistance in ohms. It is used to test the condition of a unit disconnected from the circuit.

Never use an ohmmeter in a powered circuit, or as a substitute for a voltmeter or ammeter as damage to the instrument will result.

NOTE: Ohmmeter Calibration (Analog Meter)
When the ohmmeter probes are connected together, a circuit is completed causing the meter needle to deflect. The needle should read ZERO ohms. If it does not, rotate the CAL or ADJ knob to zero the needle. When the probes are held apart, the needle moves to the maximum (infinite) resistance side of the scale. The meter is now ready to use.

DVOM (Digital Volt Ohmmeter)
Digitally checks volts, ohms, DC current, AC current, diodes, and miscellaneous other functions depending on manufacturer.

Battery Tester
The tester needed would be capable of load testing, reserve capacity, amps and volts.

ELECTRICAL BASICS

1. Battery Basics

General Description

The battery is the heart of the electrical system. It supplies current to the electrical system.

Batteries are rated by capacity (amp/hours), reserve capacity, and cold cranking amps. When replacing a battery, be sure to replace it with one of the same capacity rating, otherwise your electrical system may not function properly.

CAUTION: Protective equipment should be used at all times when working with batteries. A spark could cause fumes from the battery acid to ignite and/or cause the battery to explode.

Testing

The following tests should be done with both battery cables disconnected. A bad cable can cause erroneous readings.

- **Hydrometer/Refractometer Test**
  The hydrometer is used to measure the specific gravity (acid level) in each cell of the battery. These readings should be consistent, and if one cell reads low, the battery is bad. Do not add more acid to a battery; this will only cause the plates to be damaged. If a battery is fully charged, the acid level will read high. If the battery is dead, meaning the acid is all in the plates, the acid will read low.

- **Load Test**
  To load test the battery, you will need special equipment designed to do the job. The battery must be fully charged for this test. The voltage on a 12-volt battery should not drop below 9.6 volts. Follow test equipment guidelines for proper test procedures.

2. Starter Basics

General Description

The starter is a powerful electric motor. It may be a direct drive to the flywheel or a gear reduction type. The motor runs by the theory of magnetism, using opposing forces generated by the fields and the armature.

Current Flow

When you turn the ignition key to start you send current to the starter solenoid. This solenoid has two windings of wire: the “Pull-in” coil and the “Hold-in” coil. When the solenoid is first energized, both coils have current running through them. The solenoid contacts are closed, and at the same time the starter gear is forced in to mesh with the ring gear. Once the solenoid makes contact, current flows into the starter. First it goes through the fields, and turns them into electromagnets. After passing through the fields, it goes to the positive starter brushes and into the armature, which is the part that spins. The armature is made of coils of wire too, so when current flows through it, it also becomes a magnet. The current, which comes into the armature through the positive brushes, goes to ground through the negative brushes.

As soon as the solenoid makes contact, the pull-in coil is de-energized. This is because it grounds through the starter, through the solenoid contact. As soon as the solenoid is energized and the starter is hooked to the battery, the ground side or the pull-in coil is also hooked to the battery positive post. Therefore, both sides of the coil are hooked to positive, and there is no longer any negative. So no current flows. The hold-in coil is strong enough to keep the solenoid engaged until you release the key.

Now what we have is an electromagnet located inside another electromagnet. The two magnets work on each other and what happens is that the armature begins to spin. This is how we get the turning force, which we need to start the engine.

Once the key is released, the solenoid is disengaged, and the starter is no longer connected to the battery. The starter stops spinning, and the spring in the solenoid pushes the drive back into the starter housing.

Starter Tests

First, test for current draw. Disconnect the coil wire from the distributor and ground it, or disable the fuel shut off. Be sure the battery is fully charged before testing draw.

HINT: A low battery will read a high draw, and will lead you to the starter, when the problem is elsewhere.

Next, test the starter for voltage drop. Check for voltage drop across the contacts of the ignition switch, solenoid, battery connections, and starter windings. Check the appropriate service manual for detailed explanations of these voltage drop tests. These tests are very helpful in finding battery cables that are bad, but look good.

For instance, check for a voltage drop by placing the positive lead of your voltmeter on the positive battery post (not the cable end), and the negative lead on the positive post of the solenoid. A large drop (usually 1.0 volts or more) in voltage indicates a problem in the positive cable or connections.

NOTE: See the appropriate service manual for detailed explanations and specifications of the tests mentioned above.

3. Alternator Basics

General Description

The alternator works almost opposite of the starter, meaning that instead of using electricity to make a magnet, we use magnets to make electricity. The alternator is what supplies electric current to keep the battery charged up and to work the various electrical accessories in the car. It is composed of two parts: the electromagnet and the wire windings.

How It Works

The electromagnet is in the middle, and is turned by the engine (called the rotor). It is made of a coil of wire wrapped around two pieces of steel which are sandwiched together. When current is passed through this coil, a magnet is created.

The second part of the alternator is a set of stationary windings of wire called the stator. When the engine is running, the rotor is an energized magnet, and is turned inside the stator. By moving the electromagnet (rotor) past the stator, we create current in the stator. Diodes and resistors in the regulator then control the current. The regulator senses the needs of the battery and the electrical system, as well as converts alternating current to direct current.

Alternator Tests

Test the output of the alternator with an ammeter, and a voltmeter. For more information on the tests, check the appropriate service manual.

One field test that can be done is a magnetism test. Since the rotor becomes a magnet, if the rotor is working, the rear housing bearing will become magnetized. Check for magnetism at this bearing. If it exists, the alternator is probably charging. However, this test is not conclusive, and once the vehicle is back at your shop, further tests should be done.

Another helpful test is the Voltage Drop Test. See the chart in the Additional Information section for more information on this test.

NOTE: Remember, an alternator will only charge the battery if the cables and battery allow it to do so. If there is corrosion, or bad connections, the alternator will not do its job.

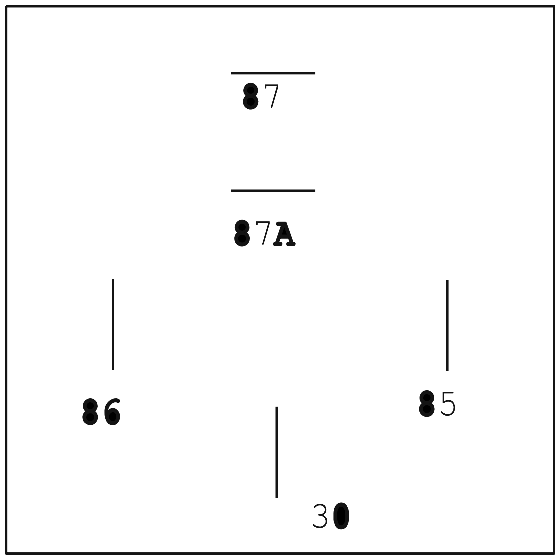
4. Wiring Code Chart

AWG gauge	Conductor Diameter Inches	Conductor Diameter mm	Ohms per 1000 ft.	Ohms per km	Maximum amps for chassis wiring	Maximum amps for power transmission	Maximum frequency for 100% skin depth for solid conductor copper	Breaking force Soft Annealed Cu 37000 PSI
OOOO	0.46	11.684	0.049	0.16072	380	302	125 Hz	6120 lbs
OOO	0.4096	10.40384	0.0618	0.202704	328	239	160 Hz	4860 lbs
OO	0.3648	9.26592	0.0779	0.255512	283	190	200 Hz	3860 lbs
0	0.3249	8.25246	0.0983	0.322424	245	150	250 Hz	3060 lbs
1	0.2893	7.34822	0.1239	0.406392	211	119	325 Hz	2430 lbs
2	0.2576	6.54304	0.1563	0.512664	181	94	410 Hz	1930 lbs
3	0.2294	5.82676	0.197	0.64616	158	75	500 Hz	1530 lbs
4	0.2043	5.18922	0.2485	0.81508	135	60	650 Hz	1210 lbs
5	0.1819	4.62026	0.3133	1.027624	118	47	810 Hz	960 lbs
6	0.162	4.1148	0.3951	1.295928	101	37	1100 Hz	760 lbs
7	0.1443	3.66522	0.4982	1.634096	89	30	1300 Hz	605 lbs
8	0.1285	3.2639	0.6282	2.060496	73	24	1650 Hz	480 lbs
9	0.1144	2.90576	0.7921	2.598088	64	19	2050 Hz	380 lbs
10	0.1019	2.58826	0.9989	3.276392	55	15	2600 Hz	314 lbs
11	0.0907	2.30378	1.26	4.1328	47	12	3200 Hz	249 lbs

12	0.0808	2.05232	1.588	5.20864	41	9.3	4150 Hz	197 lbs
13	0.072	1.8288	2.003	6.56984	35	7.4	5300 Hz	150 lbs
14	0.0641	1.62814	2.525	8.282	32	5.9	6700 Hz	119 lbs
15	0.0571	1.45034	3.184	10.4435 2	28	4.7	8250 Hz	94 lbs
16	0.0508	1.29032	4.016	13.1724 8	22	3.7	11 k Hz	75 lbs
17	0.0453	1.15062	5.064	16.6099 2	19	2.9	13 k Hz	59 lbs
18	0.0403	1.02362	6.385	20.9428	16	2.3	17 kHz	47 lbs
19	0.0359	0.91186	8.051	26.4072 8	14	1.8	21 kHz	37 lbs
20	0.032	0.8128	10.15	33.292	11	1.5	27 kHz	29 lbs
21	0.0285	0.7239	12.8	41.984	9	1.2	33 kHz	23 lbs
22	0.0254	0.64516	16.14	52.9392	7	0.92	42 kHz	18 lbs
23	0.0226	0.57404	20.36	66.7808	4.7	0.729	53 kHz	14.5 lbs
24	0.0201	0.51054	25.67	84.1976	3.5	0.577	68 kHz	11.5 lbs
25	0.0179	0.45466	32.37	106.173 6	2.7	0.457	85 kHz	9 lbs
26	0.0159	0.40386	40.81	133.856 8	2.2	0.361	107 kH	7.2 lbs
27	0.0142	0.36068	51.47	168.821 6	1.7	0.288	130 kHz	5.5 lbs
28	0.0126	0.32004	64.9	212.872	1.4	0.226	170 kHz	4.5 lbs
29	0.0113	0.28702	81.83	268.402 4	1.2	0.182	210 kHz	3.6 lbs
30	0.01	0.254	103.2	338.496	0.86	0.142	270 kHz	2.75 lbs
31	0.0089	0.22606	130.1	426.728	0.7	0.113	340 kHz	2.25 lbs
32	0.008	0.2032	164.1	538.248	0.53	0.091	430 kHz	1.8 lbs
Metric 2.0	0.00787	0.200	169.3 9	555.61	0.51	0.088	440 kHz	
33	0.0071	0.18034	206.9	678.632	0.43	0.072	540 kHz	1.3 lbs
Metric 1.8	0.00709	0.180	207.5	680.55	0.43	0.072	540 kHz	
34	0.0063	0.16002	260.9	855.752	0.33	0.056	690 kHz	1.1 lbs
Metric 1.6	0.0063	0.16002	260.9	855.752	0.33	0.056	690 kHz	

35	0.0056	0.14224	329	1079.12	0.27	0.044	870 kHz	0.92 lbs
Metric 1.4	.00551	.140	339	1114	0.26	0.043	900 kHz	
36	0.005	0.127	414.8	1360	0.21	0.035	1100 kHz	0.72 lbs
Metric 1.25	.00492	0.125	428.2	1404	0.20	0.034	1150 kHz	
37	0.0045	0.1143	523.1	1715	0.17	0.0289	1350 kHz	0.57 lbs
Metric 1.12	.00441	0.112	533.8	1750	0.163	0.0277	1400 kHz	
38	0.004	0.1016	659.6	2163	0.13	0.0228	1750 kHz	0.45 lbs
Metric 1	.00394	0.1000	670.2	2198	0.126	0.0225	1750 kHz	
39	0.0035	0.0889	831.8	2728	0.11	0.0175	2250 kHz	0.36 lbs
40	0.0031	0.07874	1049	3440	0.09	0.0137	2900 kHz	0.29 lbs

5. Standard 5 Pole Relay



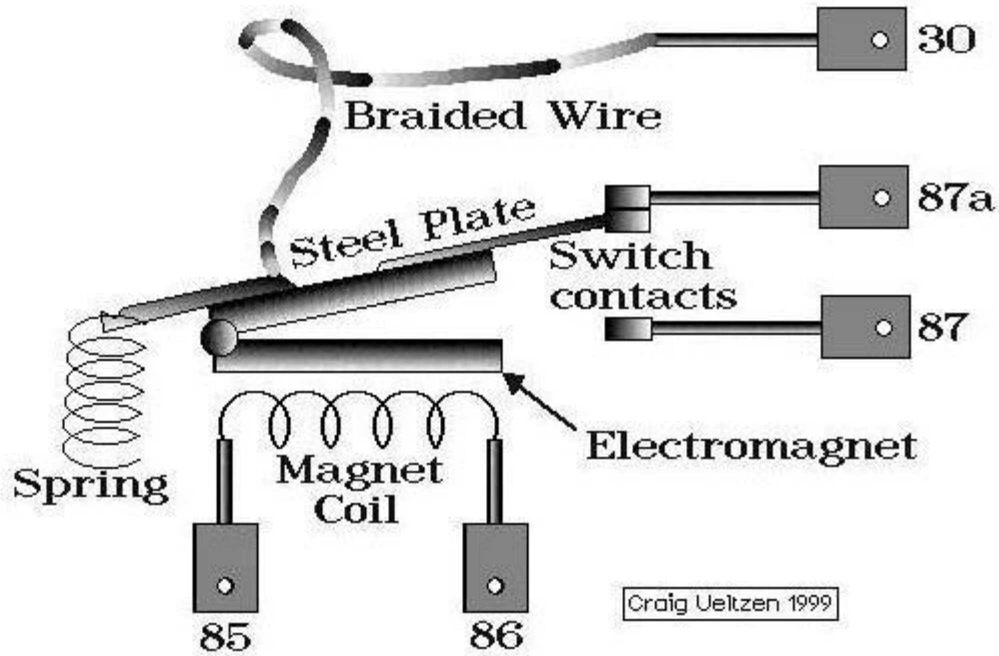
#85 Switched power (may be through the ignition switch, panel power switch, headlight switch, or any other switch).

#86 Ground (may be through a switch as a signal of some sort i.e. a door switch, or a door lock switch).

#30 Constant power (can be either switched with ignition or not).

#87 Power transfer from #30 (may be to a light, another switch, or any other circuit which needs a switched signal). Has current when the relay is normally off.

#87A Power transfer from #30 (may be to a light, another switch, or any other circuit which needs a switched signal). Has current when the relay is energized.



Relays are used to transfer high current. When power is applied across the 85 and 86 terminals, current flows through a coil of small wire. This builds up a magnetic field in the bar it's wrapped around, and the steel plate snaps to it. When the power is off, the spring pulls the plate back away from the magnet bar. The "click" is the plate slamming into the magnet as it turns on. It doesn't "click" when turned off, because the plate swings away from the magnet without hitting anything.

When the power is applied, the coil sets up a magnetic field in its windings. When the power is removed, the field collapses, and a reverse current of high voltage will kick back.

6. Multiplex System

Multiplexing is a method of using one communications path to carry two or more signals simultaneously.

Although, multiplexing has been common in the automotive industry for a number of years, it is still relatively new technology on school buses. Refer to the manufacturers' procedures and wiring diagrams for specific multiplex information. See also, the Additional Information Web Sites in this section.

8-WAY LIGHT SYSTEMS

1. Aeroflash

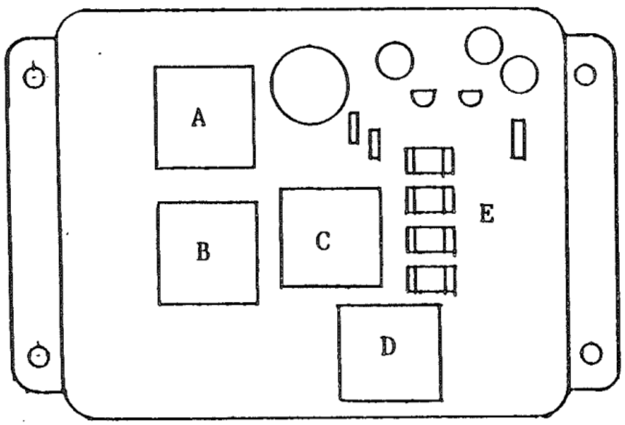
Aeroflash Model 165-0018 8-Way Light Flasher

The Aeroflash model 165-0018 eight way light flasher can be used to retrofit any bus with a “factory installed” eight way light system. Both sequential and non-sequential operation of the red lights can be achieved with this unit by merely moving a jumper wire on the bottom of the flasher. “Non-sequential” means the red lights come on every time the door is opened when the master switch is on. “Sequential” means the red lights only come on after the start switch has been actuated.

For basic installation and wiring information, refer to Fig. 1 and the following chart:

AEROFLASH TERMINAL NUMBER	DESCRIPTION
1	Door Switch
2 thru 4	Not used
5	Amber warning lamps - left.
6	Amber warning lamps - right.
7	Red warning lamps - left.
8	Red warning lamps - right.
9	Not used (see note).
10	Stop arm solenoid (if used).
11	Not used
12	Master switch (+12 volts).
13	Not used in most installations.
14	Start switch (momentary).
15	Not used
16	Ground

AEROFLASH MODEL 165-0018



BOTTOM VIEW
#1063197

Relay and Fuse Identification:

A. Latching relay
B. Selector relay
C. Amber flasher relay
D. Red flasher relay
E. 1AG - 20 AMP fuses

NOTE: 1. All four relays are identical and can be interchanged for trouble-shooting purposes.

2. Fuses "E" protect the lamp Outputs-terminals 5, 6, 7 and 8.

TROUBLE SHOOTING TIPS

1. Replace relay "A" if:
   a. System "dead".
   b. Amber lamps go out when "Starter Switch" is released.

NOTE: Also check "Master Switch" and "Start Switch".

2. Replace relay "B" if:
   a. Either amber or red flasher fails to operate when the other operates normally.
   b. System fails to change from amber to red when the door is opened.

NOTE: Also check "Door Switch".

3. Replace relay "C" if:
   a. Amber lamps fail to flash properly.

NOTE: Also check relay "B" and Fuses "E".

4. Replace relay "D" if:
   a. Red lamps fail to flash properly.

NOTE: Also check relay "B" and Fuses "E".

NOTE: If a "Fail Safe" switch is required to manually override the system and operate the red lights, use a double pole single throw switch.

To replace the Baader Brown model 6404-88-1920 or 6404-88-1125, refer to the following chart:

WIRE ON BAADER BROWN TERMINAL NUMBER	GOES TO AEROFLASH TERMINAL #	DESCRIPTION
1	8	Red lights - right
7	7	Red lights - left
6	6	Amber lights - right
12	5	Amber lights - left
8	1	Door switch
11	14	Start switch
9	12	Master switch (NOTE 1)
3	10	Stop arm solenoid, if used (NOTE 2)
5	--	(NOTE 3)
--	16	Add a ground wire to 16

NOTE 1: On some buses a master switch is not used and this wire goes directly to a body cut-off solenoid.

NOTE 2: On some buses a wire from a "Fail Safe" switch may be spliced into the stop arm solenoid wire at terminal 3 on the old flasher. Remove this wire, and use a double pole single throw switch to install a fail-safe switch.

NOTE 3: On some buses, a wire from the start switch may be connected to terminal 5 on the old flasher. Remove this wire and connect it to +12 volts or splice it into the wire going to terminal 12 on the Aeroflash flasher.

To replace the Collins "Octaflash" flasher, refer to the following chart:

COLLINS TERMINAL	AEROFLASH TERMINAL #	DESCRIPTION
Battery (+)	12	Master switch
Right rear red	8	Splice these wires
Right front red		together and connect to
8.		
Left rear red and	7	Splice these wires
Left front red		together and connect to
7.		

Right rear amber and	1	Splice these wires
Right front amber		together and connect to
6.		
Left rear amber and	5	Splice these wires
Left front amber		together and connect to
5.		
Ground	16	Ground
Start (amber)	14	Start switch (NOTE 4)
Door Sw. (red)	1	Door switch

NOTE 4: The Collins start switch goes to ground. The Aeroflash start switch goes to +12 volts. Remove the wire from ground and splice it into the “hot lead” at the master switch.

Relay Identification and Trouble Shooting Tips Model 165-0018

TROUBLE SHOOTING TIPS

1. Replace Relay “L” if:
   a. System “dead”
   b. Amber lamps go out when “Start Switch” is released.

NOTE: Also check “Master Switch” and “Start Switch.”

2. Replace Relay “S” if:
   a. Either amber or red flasher fails to operate when the other operates normally.
   b. System fails to change from amber to red when the door is opened.

NOTE: Also check “Door Switch.”

3. Replace Relay “A” if:
   a. Amber lamps fail to flash properly.

Note: Also check Relay “S” and Fuses “E.”

4. Replace Relay “R” if:
   a. Red lamps fail to flash properly.

Note: Also check Relay “S” and Fuses “F.”

IMPORTANT

All ground connections must be clean and tight.

RELAY AND FUSE IDENTIFICATION

L. Latching Relay
S. Selector Relay
A. Amber Flasher Relay
R. Red Flasher Relay
F. Lag - 20 AMP Fuses

NOTE:

1. All four relays are identical and can be interchanged for trouble shooting purposes.

2. Fuses “F” protect the lamp outputs- terminals 5,6,7, and 8.

3. Attach jumper wire to terminal “S” for “Sequential” operation. Red lights only operate after ambers have been activated.

4. Attach jumper wire to terminal “N” for “non-sequential” operation. Red lights operate every time door is opened.

2. ELS System

Normal Operation of Warning Light System

With entrance door closed, depress “MANUAL” button, amber lamps and pilot flash.

Open entrance door, amber lamps and pilot go off and read lamps and pilot flash and stop arm extends (if equipped).

Close entrance door, all lamps go off and Stop arm retracts (if equipped).

Open entrance door w/o depressing “MANUAL” button - No lamps flash.

With entrance door open, depress “MANUAL” button - red lamps and pilot flash and stop arm extends (if equipped).

NOTE: Manual start depends on door position.

Troubleshooting the ELS Model B-1 Flasher

The Model B-1 flasher is shipped from E.L.S. programmed for NON-SEQUENTIAL operation of the red lights. For SEQUENTIAL operation, merely remove and discard the jumper plug marked “N.S. jumper.” To do this, grasp the little black (or red) plastic plug with fingers or long-nosed pliers and pull out and away from the flasher. NON-SEQUENTIAL means the red lights come on every time the service door is opened (with the master switch on). SEQUENTIAL means the red lights only come on after the start switch has been actuated.

The heavy-duty replaceable relays are oriented from left to right in the following order:

Selector
Latching
Amber Flasher and
Red Flasher (**SLAR**).

“**SLAR**” may not be much of a word but if you remember it you will always remember the order of the relays.

Troubleshooting Tips

Replace relay “**S**” if:

- Either amber or red flasher fails to operate normally when the other operates normally.
- System fails to change from amber to red when the service door is opened.

Also check the Door Switch.

Replace relay “**L**” if:

- System dead.
- Amber lamps go out when “Start Switch" is released.

Also check Master Switch, Start Switch and the ground connection to the flasher.

Replace relay “**A**” if:

- Amber lamps fail to flash properly.

Also check for a blown fuse.

Replace relay “**R**” if:

- Red lamps fail to flash properly.

Also check for a blown fuse.

NOTE: A blown fuse indicates an overload or short circuit outside the flasher. The fuses in the B-1 can be used to localize this problem to the individual circuit involved (i.e. right or left, amber or red lamp circuit). Locate and repair the short before replacing a blown fuse.

Basic operation of the flasher can be checked quickly with only two connections and a 24-inch clip lead (24” wire with alligator clips on each end. Connect a “hot” lead to the terminal marked “MASTER SWITCH.” Connect the terminal marked “GROUND” to ground. Clip one end of the clip lead to the “hot” lead and momentarily touch the other end to the terminal marked “START SWITCH.”

You should hear the flasher energize and click at the normal flash rate.

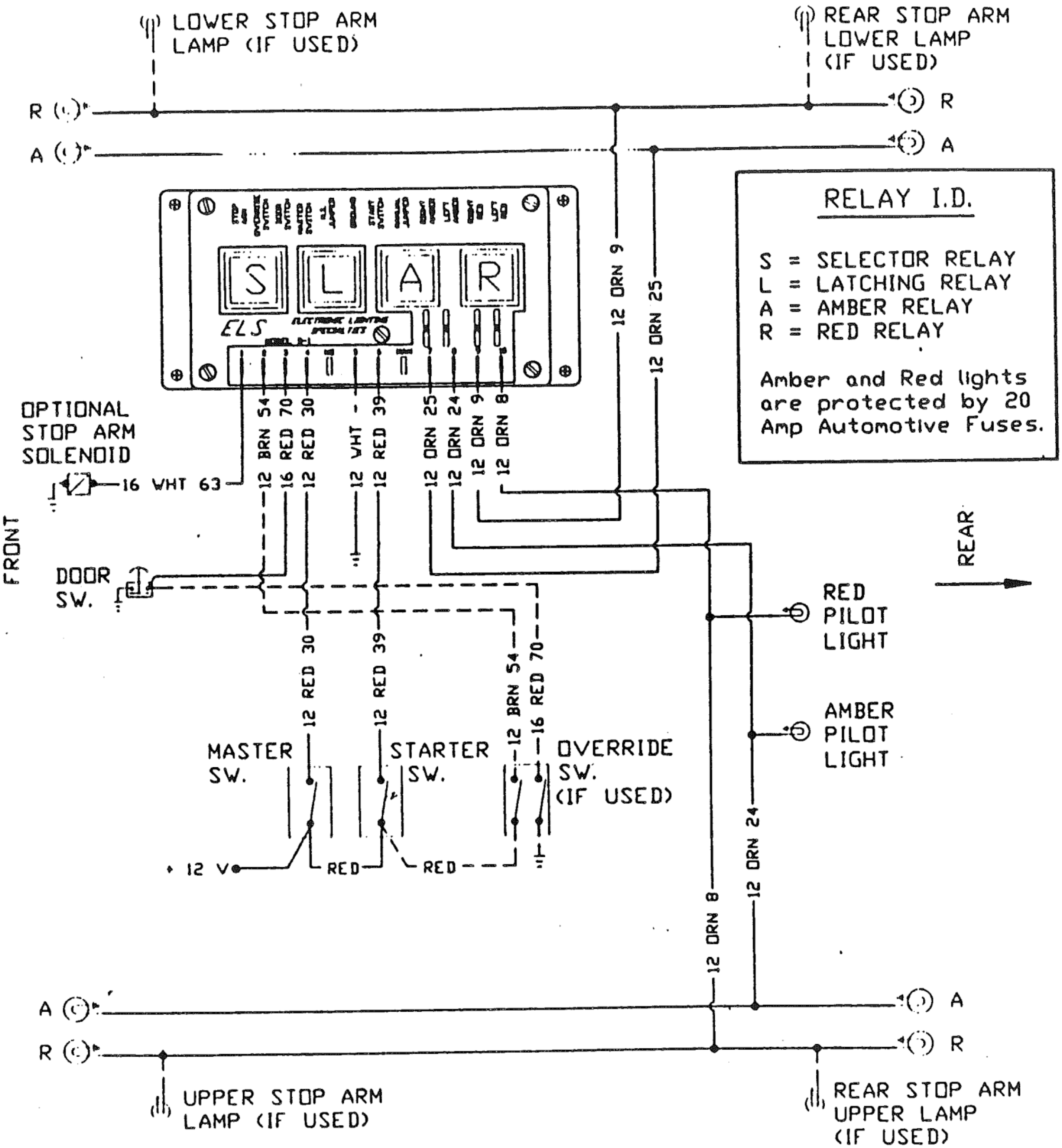
Disconnect the clip lead from the flasher (the flasher will continue to click) and connect one end of the clip lead to ground. Connect the other end of the clip lead to the terminal marked “DOOR SWITCH.” You should hear another distinct click as the flasher switches into the red mode. When you remove the clip lead, the flasher will de-energize and the clicking will stop.

GENERAL NOTES

- All wiring is 14 ga., UNLESS SPECIFIED OTHERWISE.
- W/L operation on diagram & production order may not coincide, if not, wire per production order.
- Flasher unit is RAC 760506, w/internal jumper connected to “sequential”.
- Warning light operation shown: Manual.
- Stepwell is wired into marker light circuit.
- Switch panel lights to be on same circuit as headlights.
- Refer to option in production data book for wiring of all other optional electrical equipment.
- All circuit breakers 20 amp. unless specified otherwise.

1155241 -- SWITCH, Manual
1126176 -- SWITCH, MOMENTARY, SPST, NC. CARDINAL 4033346
E D 1374149 -- FLASHER SYSTEM, 8 LAMP, RAC 760506
2006112 -- BREAKER, CIRCUIT, 20 AMP
2006799 -- LIGHT, PILOT, AMBER LENS, PL-19
2006807 -- LIGHT, PILOT, RED LENS, PL-19

1.


LOWER STOP ARM
LAMP (IF USED)
REAR STOP ARM
LOWER LAMP
(IF USED)
R
A
R
A
ELS
S
L
A
R
RELAY I.D.
S = SELECTOR RELAY
L = LATCHING RELAY
A = AMBER RELAY
R = RED RELAY
Amber and Red lights
are protected by 20
Amp Automotive Fuses.
12 ORN 9
12 ORN 25
OPTIONAL
STOP ARM
SOLENOID
16 WHT 63
12 BRN 54
16 RED 70
12 RED 30
12 WHT -
12 RED 39
12 ORN 25
12 ORN 24
12 ORN 9
12 ORN 8
FRONT
REAR
DOOR
SW.
RED
PILOT
LIGHT
AMBER
PILOT
LIGHT
12 RED 30
12 RED 39
12 BRN 54
16 RED 70
MASTER
SW.
STARTER
SW.
OVERRIDE
SW.
(IF USED)
+ 12 V
RED
RED
12 ORN 24
12 ORN 8
A
R
A
R
UPPER STOP ARM
LAMP (IF USED)
REAR STOP ARM
UPPER LAMP
(IF USED)

3. RAC System
Introduction

The RADIO ACCESSORY COMPANY 760506, 8 Way Light Warning System is a multifunction device designed to control the operations of the warning signals on a school bus.

The following details all the operations and functions of the unit, although all the following may not be applicable to a specific user's applications.

Features

Two-mode operation (Sequential and Non-Sequential).

Four SPDT palladium relays to control power switching.

Four 20 Amp blade type fuses to provide short circuit protection.

All relays and fuses are socketed for easy replacement.

Military specification timer design provides minimal parts count, high reliability, and good temperature and frequency stability.

Reliable operation down to 8.0 Volts.

Fiberglass G-10 circuit board material for added mechanical support.

Optional Override and Manual switch to bypass electronics of latch circuit in case of failure or special circumstances.

Easy accessibility to all external connections.

<u>Functional Description</u>

The RAC 760506, 8 Light Warning System comes packaged as a complete unit. Some external hardware is required to control its operations.

The unit has twelve, 0.250 male spade terminals, for external connections. These terminals are easily accessible from the top of the unit, and no disassembly is required. All the following references will be made to these numbers and/or labels.

Listing of terminal connectors:

1. DOOR SWITCH
5. AMBER LAMP
6. AMBER LAMP
7. RED LAMP
8. RED LAMP
9. OVERRIDE SWITCH
10. STOP ARM
12. POWER
13. (not used)
14. START SWITCH
16. GROUND
    MANUAL

The unit's main function is to provide sequencing between paired Amber Lamps or paired Red Lamps, so that either set of pairs will flash alternately. This means that for a single set of paired lamps there will be opposite conditions on the lamps. While one is "on" the other will be "off." This will occur at a rate of approximately 90 flashes per minute per lamp, (+/-30%). There is also the option of controlling a solenoid activated stop arm.

The set of paired lamps which are "flashing" are controlled by which input is activated, and which mode the unit is operating in.

Modes of Operation

Non-Sequential Mode

Placing the SEQ/NON-SEQ jumper on the terminal marked NON-SEQ sets Non-Sequential Mode operation. This is the standard configuration of the unit when shipped from the factory. (See MODE OPERATION drawing on pg. 2B)

Non-Sequential operation is so designated because in this mode either set of lamps (Amber or Red) may be activated at any time, and in any order (i.e. Amber first then Red, or Red first then Amber).

In this mode, the lamps may be activated by any one of the following four inputs:

Start Switch (14)
Door Switch (1)
Manual
Override Switch (9)

- **Start Switch (14)**

When activated, power is placed on the START SWITCH (14) terminal. This causes RLY1 to be energized, sending power to the timing circuit, starting the Amber Lamp flashing sequence. Once the start switch is de-activated the Amber Lamps will remain flashing until either the Door or Manual switches are activated.

- **Door Switch (1)**
  When activated, a ground is placed on the DOOR SWITCH (1) terminal. This causes RLY1 and RLY2 to energize, sending power to the timing circuit, causing the Red lamps to flash sequentially. At this time the STOP ARM (10) terminal will become a source of power so that a stop arm solenoid may be activated (if so desired) whenever the Door Switch is actuated. Once the Door Switch is de-activated the Red Lamps will cease flashing, and the STOP ARM terminal will lose power.

- **Manual Switch**
  When activated, a ground is placed on the MANUAL terminal. This causes RLY1 to be energized, sending power to the timing circuit, causing the Amber Lamps to flash sequentially. Once the Manual Switch is de-activated the Amber Lamps will cease flashing.

- **Override Switch (9)**
  When activated, power is placed on the Override Switch (9) terminal. This bypasses all the relay control logic and provides power directly to the timing circuit. This will cause the Amber Lamps to flash sequentially. Once the Override Switch is de-activated the Amber Lamps will cease flashing.

Summary
In the Non-Sequential mode, any one of three inputs (Override Switch (9), Start Switch (14) or Manual) when activated will cause the Amber Lamps to flash sequentially. Only the Start Switch (14) allows continuous operation, of the Amber Lamps, after it is de-activated.

The Door Switch (1) is the only input that will cause the Red Lamps to flash and the Stop Arm (10) to become a source of power. This will occur only while the Door Switch (1) is actuated.

Any of the above operations may occur in any sequence with the same results (only in the Non-Sequential mode).

Sequential Mode
Sequential mode operation is set by placing the SEQ/NON-SEQ jumper on the terminal marked SEQ (see Mode Operation drawing on pg. 2B).

Sequential mode operation is so designated because in this mode the Amber Lamps must be activated, and be flashing, before the Red Lamps are allowed to be operated by the Door Switch (1).

In the Sequential mode the four inputs are:

Start Switch (14)
Door Switch (1)
Manual
Override Switch (9)

Operate as follows:
Start Switch (14) - Same as in the Non-Sequential mode (see previous section).

Override Switch (9) - Same as in the Non-Sequential mode (see previous section).

Manual Switch - The Manual Switch does not operate in the Sequential mode.

Door Switch (1) - In the Non-Sequential mode the Door Switch's function is similar to its function in the Sequential Mode. The only difference is that the Start Switch (14) or the Override Switch (9) must be activating the Amber Lamps while the Door Switch is being activated. If this condition is not met then the Door Switch will have no effect on the circuits operation and the Red Lamps will not “flash” not will the Stop Arm (10) become active.

Relay Control Summary
RLY1: Power “on” relay. Provides power to the timing circuit and the lamps. (bypassed with the Override switch)

RLY2: Red/Amber lamp selector relay

RLY3: Red lamp flash relay

RLY4: Amber lamp flash relay

F1, F2: Red lamp fuse protection (20 Amp)

F3, F4: Amber lamp fuse protection (20 amps)

Connections and Applications
(Refer to 760506 Connection Drawing)
Connections and applications depend on a particular user's needs. The following explanation (and related drawing) is for the optimum connection scheme and may be varied as a user sees fit.

Start Switch (14)
Terminal is connected via SW1 to the terminal marked (13). SW1 is a normally open, momentary, push button switch. Terminal (13) is provided as a power terminal for the Start Switch and is not meant to have power connected directly to it. This is an optional connection. The same result may be obtained by connecting SW1 between the Start Switch (14) terminal and external power (+12 volts DC).

Manual
The manual terminal is connected via SW2 to chassis ground. SW2 is a normally open, two position switch (not applicable for Sequential Mode operation).

Door Switch (1)
Terminal is connected via SW3 to chassis ground. SW3 is a normally open, two position switch. For most applications this switch would be built into the door mechanism, so that whenever the door is opened SW3 would be actuated.

Override Switch (9)
Terminal is connected via SW4 to external power (+12 volts). SW4 is a normally open two-position switch.

Power (12)
Terminal is connected to a switched, external power source (+12 volts).

Ground (16)
Terminal is connected directly to chassis ground.

Stop Arm (10)
Terminal may be connected to an external stop arm solenoid, so that the stop arm will be activated whenever the Door Switch SW3 is activated. This is not a required connection.

Red Lamp (8)
Terminal is connected via the right front red lamp, and the right rear red lamp, to chassis ground.

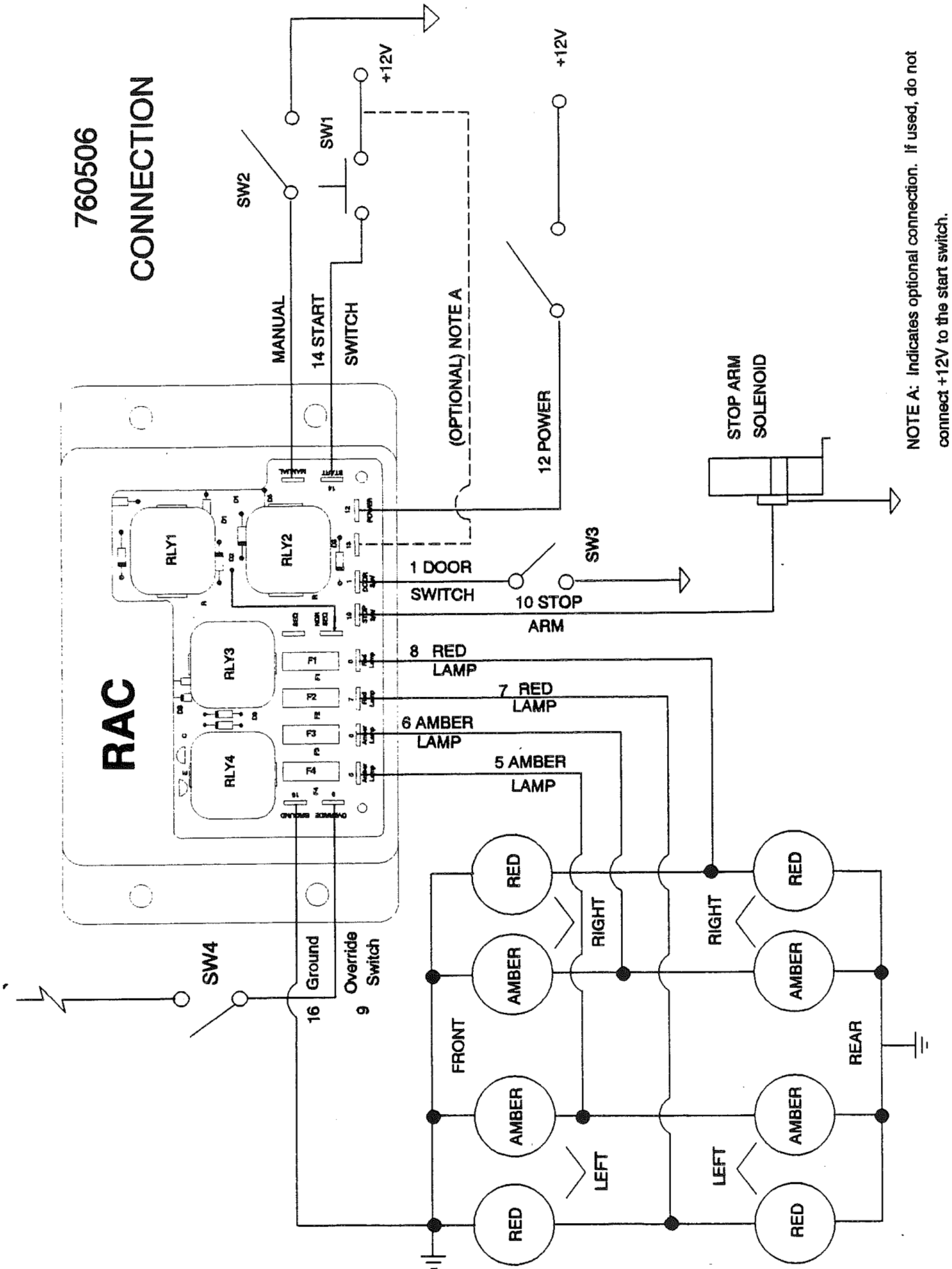
Red Lamp (7)
Terminal is connected via the left front red lamp, and the left rear red lamp,

to chassis ground.

Amber Lamp (6)
Terminal is connected via the right front amber lamp, and the right rear amber lamp to chassis ground.

Amber Lamp (5)
Terminal is connected via the left front amber lamp, and the left rear amber lamp to chassis ground.

NOTE: All connections can be made though the unit’s cover, so no disassembly is required.


760506
CONNECTION
SW2
SW1
+12V
+12V
MANUAL
14 START
SWITCH
(OPTIONAL) NOTE A
12 POWER
STOP ARM
SOLENOID
NOTE A: Indicates optional connection. If used, do not connect +12V to the start switch.
RAC
RLY1
RLY2
RLY3
RLY4
F1
F2
F3
F4
1 DOOR
SWITCH
SW3
10 STOP
ARM
8 RED
LAMP
7 RED
LAMP
6 AMBER
LAMP
5 AMBER
LAMP
SW4
Ground
16
Override
Switch
9
RED
AMBER
AMBER
RED
RIGHT
LEFT
FRONT
RED
AMBER
AMBER
RED
RIGHT
LEFT
REAR

8- Light Warning System Troubleshooting Guide

POSSIBLE CAUSE	SYMPTOM
Start Switch & Manual inoperative, Override is OK	RLY1
Stop Arm inoperative	RLY2
Red lamps inoperative, Amber lamps are OK	RLY3 F1, F2
Amber lamps inoperative, Red lamps are OK	RLY4 F3, F4
Amber and Red lamps inoperative	RLY1 Bad power and/or ground connection
Override Switch inoperative, Door Switch is OK	RLY4
Door Switch inoperative	RLY2 Jumper set in Seq. mode
Amber lamps flash continuously	RLY1
One Amber lamp inoperative	RLY4 F3, F4
One Red lamp inoperative	RLY3 F1, F2

NOTE: Replace individual components one at a time until the fault is found.

RAC 760506, 8 LIGHT WARNING SYSTEM, REPLACEMENT GUIDE

The RAC 760506, 8 Light Warning System, can be used to replace any factory installed 8 light warning system. The following gives replacement procedures for two of the more common units, the Aeroflash 165-0018 and the Baader-Brown 6404-88-1920.

AEROFLASH 165-0018:

The RAC 760506 will directly replace the Aeroflash 165-0018. The terminal numbering on the RAC unit is identical to that on the Aeroflash unit. The only modification required is new mounting holes for the smaller RAC unit.

When exchanging units, make connections one at a time from one unit to the other as follows:

Aeroflash terminal ----------------- to ----------------RAC terminal
9-Override 9 Override Switch
14-To Start Switch .... 14 Start Switch
1-To Door Switch .... 1 Door Switch
5-To Left Amber... 5 Amber lamp
6-To Right Amber .... 6 Amber lamp
7-To Left Red... 7 Red lamp
8-To Right Red... 8 Red lamp
10-To Stop Arm Solenoid .... 10 Stop Arm
16-To Ground .... 16 Ground
12-To Master Switch... 12 Power

NOTE: The SEQ/NON-SEQ jumper on the RAC 760506 must be placed on the terminal marked NON-SEQ if the Aeroflash unit's jumper is placed on the terminal marked "N". If the same jumper is on the Aeroflash terminal marked "S" then the RAC jumper must be placed on the terminal marked "SEQ".

BAADER-BROWN 6404-88-1920:

The RAC 760506 will replace the Baader-Brown 6404-88-1920 with only a few minor wiring changes.

Wiring connections are as follows:
Baader-Brown terminal ---------to--------- RAC terminal
3*.. 10 Stop Arm
8 .... 1 Door Switch
11** .... 14 Start Switch
1 .... 7 Red Lamp
7 .... 8 Red Lamp
6 .... 5 Amber Lamp
12 .... 6 Amber Lamp
9 .... 12 Power
***.. 16 Ground

3* Connect only the stop arm solenoid to the RAC terminal marked (10. Stop Arm). For applications where the Baader-Brown unit has a Failsafe Switch and a Red Pilot lamp connected to its terminal marked (3), proceed as follows:

> Using a double pole, single throw switch, connect the RAC terminal marked (9. Override Switch) through one pole to 12 Volts. Use the other pole to connect the RAC terminal marked (1. Door Switch) to chassis ground. This switch may now be used as a direct Red Switch. Connect the Red Pilot Lamp to the RAC terminal marked (8. Red Lamp).

11** Connect only the Initiate Switch to the RAC terminal marked (14. Start Switch). Connect the Amber Pilot Lamp to the RAC terminal marked (6. Amber Lamp).

***** Connect the RAC terminal marked (16. Ground) directly to chassis ground.

****** The RAC 760506 is equipped with a SEQ/NON-SEQ jumper. For direct replacement of the Baader-Brown unit, this jumper should be placed in the NON-SEQ position. This setting may vary depending on a particular state's requirements.

NOTE: If any problems are encountered, or additional information is needed, contact:

Radio Accessory Co.
Engineering Dept.
8939 F Street
Omaha, NE 68127
(402) 592-4270

4. Weldon 7000 System

0Z90-1094-00

Notice

To ensure proper and reliable function, this product must be installed according to the direction of this manual. The Weldon Model 7000 flasher conforms to applicable SAE guidelines for operation and durability. It is the responsibility of the installer to ensure that this component is integrated into the vehicle's warning lamp system according to Federal, State, and Local requirements.

Introduction

The Weldon Model 7000 flasher is designed specifically for the school bus warning lamp application. The 7000 has become the industry standard in 8-lamp flashers; offering the durability of solid-state switching and the precision of microprocessor control. The 7000 flasher allows the operation of eight 80W warning lamps, stop arm, and the stop arm lamps. The "start" button and passenger door switch interface directly to the flasher for sequential and non-sequential operation.

The flasher is designed to provide long-term, maintenance-free reliability. The flasher's electronics are fully encapsulated in a specially formulated epoxy to enhance durability and thermal performance. The epoxy fully isolates the electronic components allowing the assembly to withstand extreme levels of vibration and shock, and seals them from harmful fluids. The trademarked yellow enclosure is injection molded from a high-impact polymer and hot stamped to ensure the terminal labels will be legible for years.

The output channels of the flasher are over-current protected to prevent damage to the flasher or the wiring should a short occur or should inappropriate loading be applied.

Installation

1. Locate the Flasher in the Vehicle - The flasher should be mounted in the vehicle's electrical compartment or some location that provides convenient access to fused power, ground, and lamp wiring. The mounting area should be removed from corrosive environments such as salt/road spray, engine fluids, degreasing sprays, fuels, etc. Although the flasher is fully encapsulated, the wire terminals are exposed and susceptible to corrosion. As with any electronic device on the vehicle, the flasher should not be exposed to high temperature sources such as engine exhaust or electric/hot water heaters.
2. Secure the Flasher in the Vehicle - The flasher is to be securely mounted to a flat, rigid surface via the two mounting locations provided in the flasher case. **Under no circumstance should additional holes be drilled into the flasher. Any modifications to the flasher may damage it causing erratic and unsafe operation or failure and will void the warranty.**
3. Wire the Flasher – Harnessing for the warning lamps, stop arm, and other devices should be run per the circuit diagrams shown in Figures 2 or 3. Connect the harness to the flasher in order from Pin 11 to Pin 1 (Ground first). The terminals are to be wired per their individual requirements discussed in the next section. The wire harness connected to the flasher should be secured to prevent fracture of the wires or terminals from road shock and vibration. The harness should be supported with strapping secured to the vehicle. **Do not use the flasher's connections to support the weight of the harness**. Power to the flasher must be fused. The fuse should be as close to the battery side of the power circuit as possible. It is not necessary to fuse the lamp output leads from the flasher to the lamps, as the flasher will protect from shorts or over-current conditions on the outputs. The fuse must be sized appropriately such that the fuse trips before damage can occur to the wire harness. Keep in mind that the inrush current on a cold bulb filament can be 10X its normal operating current. The wiring gauge and fusing must be sized to protect the system and be large enough to prevent false tripping due to normally occurring inrush currents or voltage variations. **The flasher must be grounded**. The flasher will not be capable of reliable operation without a good ground on Pin 11. **The ground wire (Pin 11) must be connected first during installation.**

Specifications

Flasher is certified to SAE J1054 SEP94.

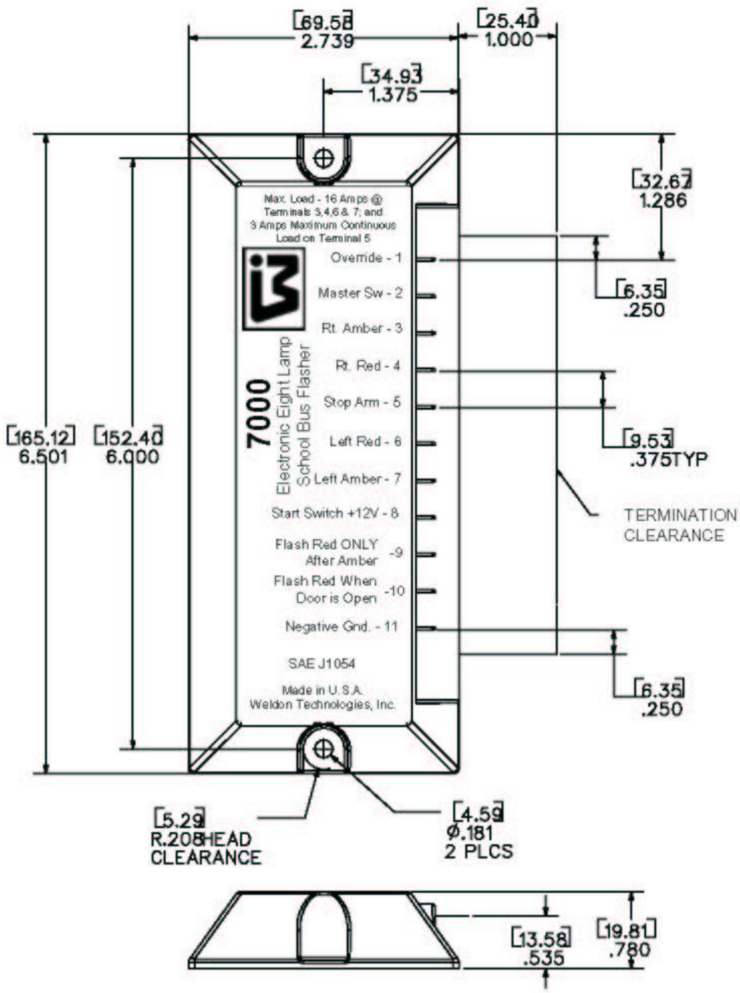


Figure 1 – Flasher Installation Drawing

Operating Voltage:	10 – 16VDC	Current Rating (Pins 3, 4,6 , 7):	16 Amps Continuous
Operating Temperature:	-40 to +55°C	Output Over-Current Trip Point:	40 ±10 Amps
Storage Temperature:	-40 to +85°C	+12V Input Sensitivity (Pin 8):	> +7V
Weight:	6.7oz [0.21kg]	Gnd Input Sensitivity (Pins 9,10):	< +0.5V

Electrical Hook-Up

The flasher connections must be made in 11 – 1 order. That is, start with the ground connection first, then work your way up to power. When removing the flasher, make sure the ground pin is removed last.

Master Override Switch (Pin 1)

The flasher can be wired with a master override switch that is used to force the flasher into red warning mode whenever the override switch is activated. This function is useful for activation of the red warning lamps and stop arm without having to push the start switch or open the passenger door. The override function will also provide a safe mode of operation should the door switch fail.

The master override switch is a double-pole, single-throw switch (a single switch that has two electrical circuits). One of the circuits is used to provide +12V power to the flasher (Pin 1). The other provides a ground to Pin 10 (Flash Reds Whenever Door is Open). The override switch effectively forces the flasher into non-sequential operation in a condition where the door is perceived as "open."

Master Switch (Pin 2)

The master switch provides warning lamp system power. This must be a high-current switch because it is providing all of the current through the flasher to the warning lamps and stop arm control. It is recommended that the power to the flasher be supplied through a high current automotive relay or solenoid that is activated by an operator-controlled switch. If several devices are powered by the master switch relay, a separate fuse must be installed for the flasher between the master switch relay and the flasher power input.

Right Amber Output (Pin 3)

The "Rt. Amber" output provides power to the amber warning lamps on the right front and rear of the vehicle. The output is activated when power and ground are applied to the flasher and a +12V momentary pulse is applied to the "Start Sw." input (Pin 8). When active, the output is flashed at 75 flashes per minute (FPM) with a 50% duty cycle. The "Rt. Amber" output alternates with the "Left Amber" output. The output is over-current protected and will shut down if the line is shorted or if too large an electrical load is applied. The output will not reset until flasher power is cycled.

Right Red Output (Pin 4)

The "Rt. Red" output provides power to the red warning lamps on the right front and rear of the vehicle and to one of the lamps on the stop arm(s). The output is activated when power and ground are applied to the flasher and the door is opened in sequential or non-sequential modes or the master override switch is enabled. When active, the output is flashed at 75 FPM with a 50% duty cycle. The "Rt. Red" output alternates with the "Left Red" output. The output is over-current protected and will shut down if the line is shorted or if too large an electrical load is applied. The output will not reset until flasher power is cycled.

Stop Arm Output (Pin 5)

The stop arm output (Pin 5) provides power to the stop arm and/or cross gate relay or valve causing it to extend when the red lamps are active. The stop arm output is dependent upon the red lamp outputs (internally the left and right red outputs are diode "or'd" together to create a steady output when the reds are active). Should the stop arm load be greater than the rated pin capacity there is a possibility that one or both of the red circuits will trip the current limit and be disabled. In the case of one red circuit being disabled, the arm will "bounce" in and out in harmony with the remaining red lamp circuit. Similarly, if one of the red circuits is overloaded, the arm will bounce.

The stop arm output is designed as a logic control pin. The stop arm control should be wired based on the following:

1. If the RMS current draw of connected loads does not exceed 3Amps, the stop arm devices may be powered directly off of flasher pin.
2. If the RMS current draw of connected loads exceeds 3Amps or is not known, power the devices through a relay as shown in Figure 2.
3. If using this flasher on a 4-way warning lamp system, the unit can be operated in sequential mode by controlling the stop arm through a relay - as shown in Figure 3.

Left Red Output (Pin 6)

The "Left Red" output provides power to the red warning lamps on the left front and rear of the vehicle and to one of the lamps on the stop arm(s). The output is activated when power and ground are applied to the flasher and the door is opened in sequential or non-sequential modes or the master override switch is enabled. When active, the output is flashed at 75 FPM with a 50% duty cycle. The "Rt. Red" output alternates with the "Left Red" output. The output is over-current protected and will shut down if the line is shorted or if too large an electrical load is applied. The output will not reset until flasher power is cycled.

Left Amber Output (Pin 7)

The "Left Amber" output provides power to the amber warning lamps on the left front and rear of the vehicle. The output is activated when power and ground are applied to the flasher and a +12V momentary pulse is applied to the "Start Sw." input (Pin 8). When active, the output is flashed at 75 FPM with a 50% duty cycle. The "Rt. Amber" output alternates with the "Left Amber" output. The output is over-current protected and will shut down if the line is shorted or if too large an electrical load is applied. The output will not reset until flasher power is cycled.

Start Switch Input (Pin 8)

The start switch is a positive voltage (+12V) momentary signal to the flasher that initiates the amber flash cycle. The duration of the momentary signal must be longer than 50ms or the flasher will reject the signal as electrical noise.

Sequential Flash Door Switch Input (Pin 9)

Sequential flash operation has the red cycle initiating only following an amber cycle. That is, the start button must be pressed before the reds will turn on. The passenger door switch sequential flash door switch input (Pin 9 – Flash Red ONLY After Amber) is connected to this input to operate the flasher in sequential mode. When the door is open, the input should be switched to ground. When the door is closed, the input switch must be open or floating.

Non-Sequential Flash Door Switch Input (Pin 10)

In this mode, the start button will initiate the ambers and opening the door will stop the ambers and start the reds - just like the sequential mode. However, non-sequential operation has the red cycle initiating any time the passenger door is opened. As with Pin 9, the door switch must complete a ground circuit to Pin 10 when the door is opened.

Flasher Ground (Pin 11)

The flasher has a logic ground connect at Pin 11. It is imperative that the flasher have a good ground as this will set the logic low level for referencing the input switches and for determining over-current conditions on the outputs. Without ground at Pin 11, the flasher's operation is not guaranteed and damage may be caused to the flasher or the vehicle wiring.

Eight-Lamp Sequential Installation with Master Override

A typical 8-lamp warning system installation is shown in Figure 2 below. With this setup, the flasher will alternately flash the amber lamps after the Start switch is depressed. The ambers will continue to flash until the passenger door or the master override switch is closed. Once a "door open" condition is detected, the ambers will shut down and the reds will begin to flash for as long as the "door open" condition exists. Once the door is "closed," the reds will finish cycling and the flasher will await the next operational condition.

For non-sequential operation, simply connect the door switch to Pin 10 and leave Pin 9 disconnected.

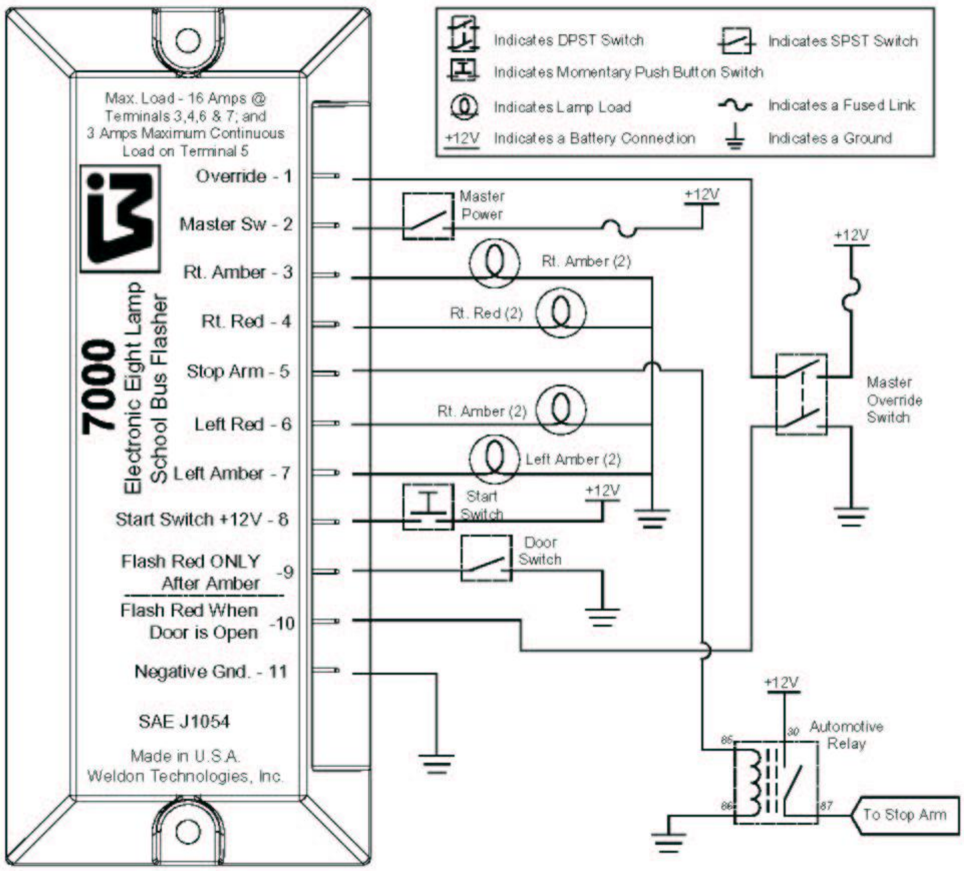


Figure 2 – Eight-Lamp Sequential Flasher Wiring Diagram with Master Override Switch

Four-Lamp Sequential Installation with Master Override

A typical 4-lamp warning system installation is shown in Figure 3 below. With this setup, the flasher will alternately flash the red lamps after the Start switch is depressed. When a "door open" condition is detected the stop arm will be activated and the reds will continue to flash. When the door is "closed" the reds will finish cycling and the stop arm will return to the side of the vehicle.

In this 4-lamp wiring, the master override switch only activates the red lamps. The passenger door must be opened to deploy the stop arm.

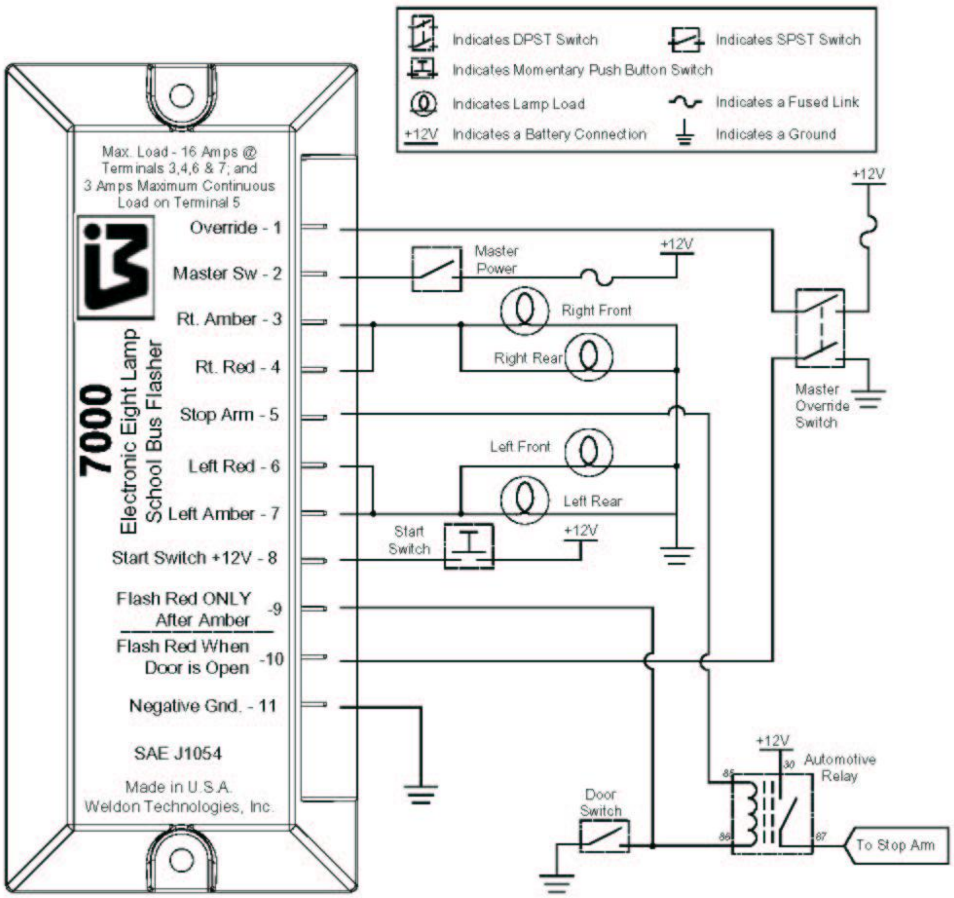


Figure 3 – Four-Lamp Sequential Flasher Wiring Diagram with Master Override Switch

Troubleshooting

Problem	Action
Flasher Does Not Function	Check that there is +12V to Pin 1 or 2 and that there is ground on Pin 11. It is best to use a test lamp. Once the flasher has power and ground, check that the lamps and stop arm are operational by individually removing the lamp output terminals and applying +12V to each lead wire. The lamps will illuminate and the stop arm will extend accordingly. If not, you will need to service the wiring or lamps. Once you have determined that the flasher has power and the lamps are operationa,l make sure the inputs are working correctly. First, check the operation of the red cycle by grounding a test lead to Pin 10. As long as the flasher is powered, the reds should immediately start flashing when ground is applied to Pin 10. If the ground is removed from Pin 10, the lamps will shut off. If the reds work correctly, confirm the Start Switch is correctly wired to test the ambers. First, disconnect the harness lead from Pin 8. Hook a test lamp up to the lead from the start switch. When the start switch is pressed it should provide +12V to the test lamp as long as the switch is pushed. Leaving the harness lead disconnected, use a jumper wire and apply +12V to Pin 8. This will start the amber lamps flashing. They will continue to flash until a ground is applied to Pins 9 or 10.
Ambers Start Flashing and Will Not Switch to Reds	This is likely due to a bad door switch. To test, start the ambers flashing and apply a grounded test wire directly to Pin 9. Grounding Pin 9 will make the flasher think the door is open, and the reds should start flashing if the ambers were running first. If the test lead works, then the door switch needs to be adjusted or replaced. Use a test lamp to confirm the door switch is grounding when the door is open.
The Master Override Switch is Not Working	First, make sure the switch is providing a ground circuit to Pin 10 of the flasher. If the master switch is off, the override switch will need to switch power to Pin 1 as well as ground to Pin 10. The override switch is typically a double-pole, single-throw, heavy-duty switch.
The Stop Arm "Bounces" In and Out When the Reds are Active	If the stop arm "bounces," it is because one of the red channels has shut down or failed. To test, disconnect the leads from Pins 4 & 6 and recycle the flasher power. Test operation with Pins 4 & 6 disconnected – the stop arm should operate correctly. Next, disconnect Pin 5 and reconnect Pins 4 & 6. The stop arm will return, and the red lamps will flash. If the red lamps on one side of the bus are not flashing, then that circuit has a short or an over-current condition (too large of a current load). Check for shorts or over-current with an amp meter. If both red sides are flashing properly, reconnect Pin 5. If either of the reds quits flashing, the load has exceeded the current limit on the flasher. The stop arm equipment must be run through a relay as shown in Figure 2. If both left and right reds continue to flash correctly but the arm "bounces," then the flasher has a bad diode and the flasher must be replaced.
The flasher "buzzes" when the ambers or red lamps first cycle	The flasher is not actually buzzing. On the first flash of each lamp cycle, the flasher runs a warm-up cycle that reduces the inrush current created by the cold bulb filaments. The warm-up cycle helps to extend bulb life and reduce system loading. The noise is likely an electrical switching noise that may be induced onto audio or electro/mechanical equipment on the bus. In most cases, the buzzing is never noticed, but it can be pronounced if a lamp monitor with reed-switches is used.

SPECIALTY MANUFACTURING CO.

TECHNICAL BULLETIN #2909E
SUBJECT: TROUBLSHOOTING 5-SERIES UNITS
EFFECTIVE DATE: 01/26/00

The 5-series stop / crossing arm contains two internal circuits; a motor circuit and a motor control circuit. The motor control circuit consists of two relays and three / two microswitches which are tied electronically to the 4 or 8-way flasher system of the school bus. The motor circuit is controlled by the motor control circuit, from which it is insulated. For this reason, the base of the unit must be properly grounded to the bus body.

For proper operation, the system voltage must be between 10v to 14 v. While it may seem complicated, the 5-series may be easily troubleshooted using a test light or DC voltmeter. Please refer to the appropriate wring diagram for the reference points listed. Note that components that are determined to be 'at fault' are not necessarily defective. The fault may be due to loose connections, dirty contacts, etc. as well as worn parts. The situations listed below are those that are most often encountered in the field. If further help is needed, contact the engineering department at Specialty Manufacturing.

A- Unit is switched ON, 4 or 8-way flasher system is ON and the door is open causing the lights at the top of the bus to switch from Amber to Red, but the unit will not open.

1. Pull the hinge fully open, remove the cover and then partially close the hinge. Check for voltage at (A). If this voltage is NOT within the guidelines, check for a steady voltage at the "Stop Arm Solenoid" terminal on the 4 or 8-way flasher system for a proper input signal. The flasher system or the wiring connections to the unit may be 'at fault'. If the voltage at these points checks out, proceed to step 2.

2. For three microswitch units, check the voltage at (B). If this voltage is NOT within the guidelines, microswitch MS2 is probably 'at fault'. If this voltage checks out or for two microswitch units, proceed to step 3. Reference note at D-1.

3. Disconnect the white wire at (C) and check the voltage on the bared relay R1 terminal at (C). If this voltage is NOT within the guidelines, relay R1 is probably 'at fault'. If this voltage checks out, reconnect the white wire (feeling the relay "click") and proceed to step 4. If the relay doesn't "click", the white wire may not be properly grounded.

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4. Check the voltage at D on microswitch MS1. If this voltage is NOT within the guidelines, microswitch MS1 is probably 'at fault'. If this voltage point checks out, proceed to step 5. Reference the note at D-1.

5. Disconnect the double white wire at E and check the voltage on the bared relay R2 terminal. If this voltage is NOT within the guidelines, relay R2 is probably 'at fault'. If this voltage checks out, reconnect the double white wires (feeling the relay "click) and proceed to step 6. If the relay doesn't "click", the white wire may not be properly grounded.

6. Check the voltage at F on relay R2. If this voltage is NOT within the guidelines, then relay R2 internal contacts are probably 'at fault'. If this voltage checks out, proceed to step 7.

7. Disconnect the black wire at G on relay R1 and check the voltage on the black wire. If this voltage is NOT within the guidelines, the Motor is probably 'at fault'. If this voltage checks out, touch connect the black lead to ground momentarily to verify the motor runs and then reconnect the black lead to the relay R1 and proceed to step 8. If the motor runs with the black lead touched to ground, the problem is either the relay R1 contacts or the orange wire connections.

8. Disconnect the orange wire at H on relay R1 and check the voltage on the bared terminal of the relay. If this voltage is NOT within the guidelines, the contacts of R1 are 'at fault'. If this voltage checks out, then the orange wire connections or the base to chassis grounding is 'at fault'.

B- Unit is switched ON, opens to 95+ degrees or excessively past 90 degrees.

1. This is most often due to microswitch MS1 'at fault'. Reference the note at D-1.

C- Unit is switched ON, opens to ~90 degrees, but will not nearly return if pushed way past the 90 degree position.

1. This is most often due to microswitch MS2 'at fault'. Reference the note at D-1.

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D- Unit operates properly, but continues to run after closing.

1. This is most often due to microswitch MS3 'at fault'. NOTE- During installation of new microswitches, they must be pushed away from the cam as far as possible before tightening the nuts to clamp the cover plate holding them in position.

E- Unit is switched ON, opens properly, but will not close after being switched OFF (door closed).

1. Pull the hinge fully open, remove the cover and then partially close the hinge. Check the voltage at I. If this voltage is not within the guidelines, microswitch MS3 is probably 'at fault'. If this voltage checks out, proceed to step 2. Reference the note at D-1.

2. Check the voltage at G. If this voltage is not within the guidelines, relay R1 is 'at fault'. If this voltage checks out, proceed to step 3.

3. Disconnect the red wire at F and check the voltage at the red wire. If this voltage is NOT within the guidelines, the Motor is probably 'at fault'. If this voltage checks out, reconnect the red wire and proceed to step 4.

4. With the unit in the full open position and switched OFF (door closed), disconnect the double black/green or blue/green wires at A. If the unit closes, the unit is NOT 'at fault'. The problem lies within the 4 or 8-way flasher, which is not signaling the unit to close. Contact the flasher manufacturer for assistance in troubleshooting.

F- Unit is switched ON, opens properly, but moves back and forth about 3 to 4 inches on the blade tip at the full OPEN position, commonly called "oscillation". (For stop arms only)

1. This is most often caused by wear on the microswitch pawls or in the camshaft. There is NO adjustment and none should be attempted. This problem may be corrected by replacing the microswitch plate assembly (p/n 5177) or the camshaft (p/n 5031). Much earlier units using the snap ring camshaft (p/n 5025) should order the camshaft replacement kit (p/n 5169).

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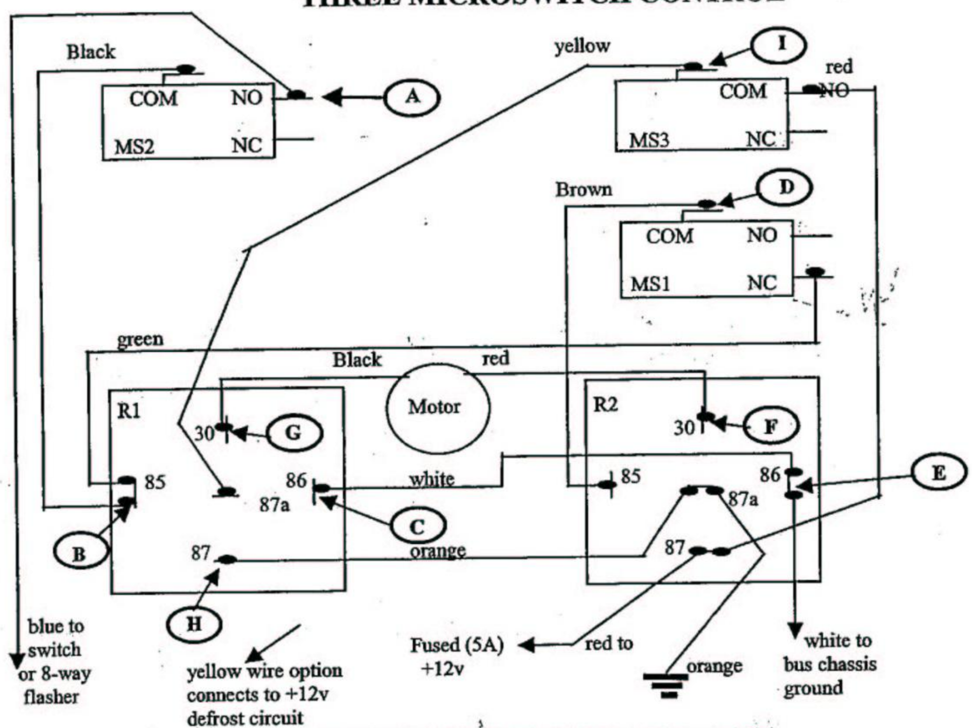
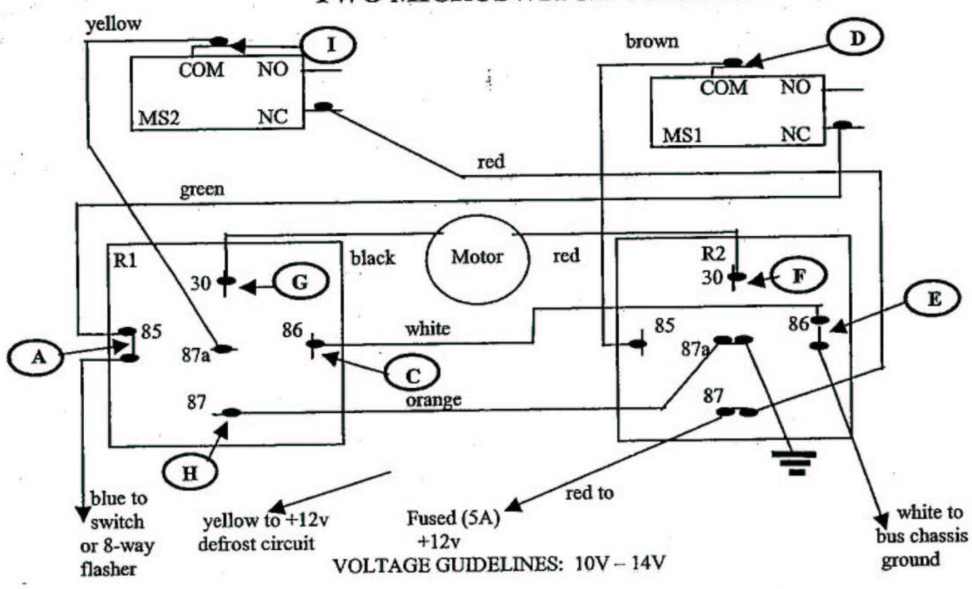
THREE MICROSWITCH CONTROL



TWO MICROSWITCH CONTROL



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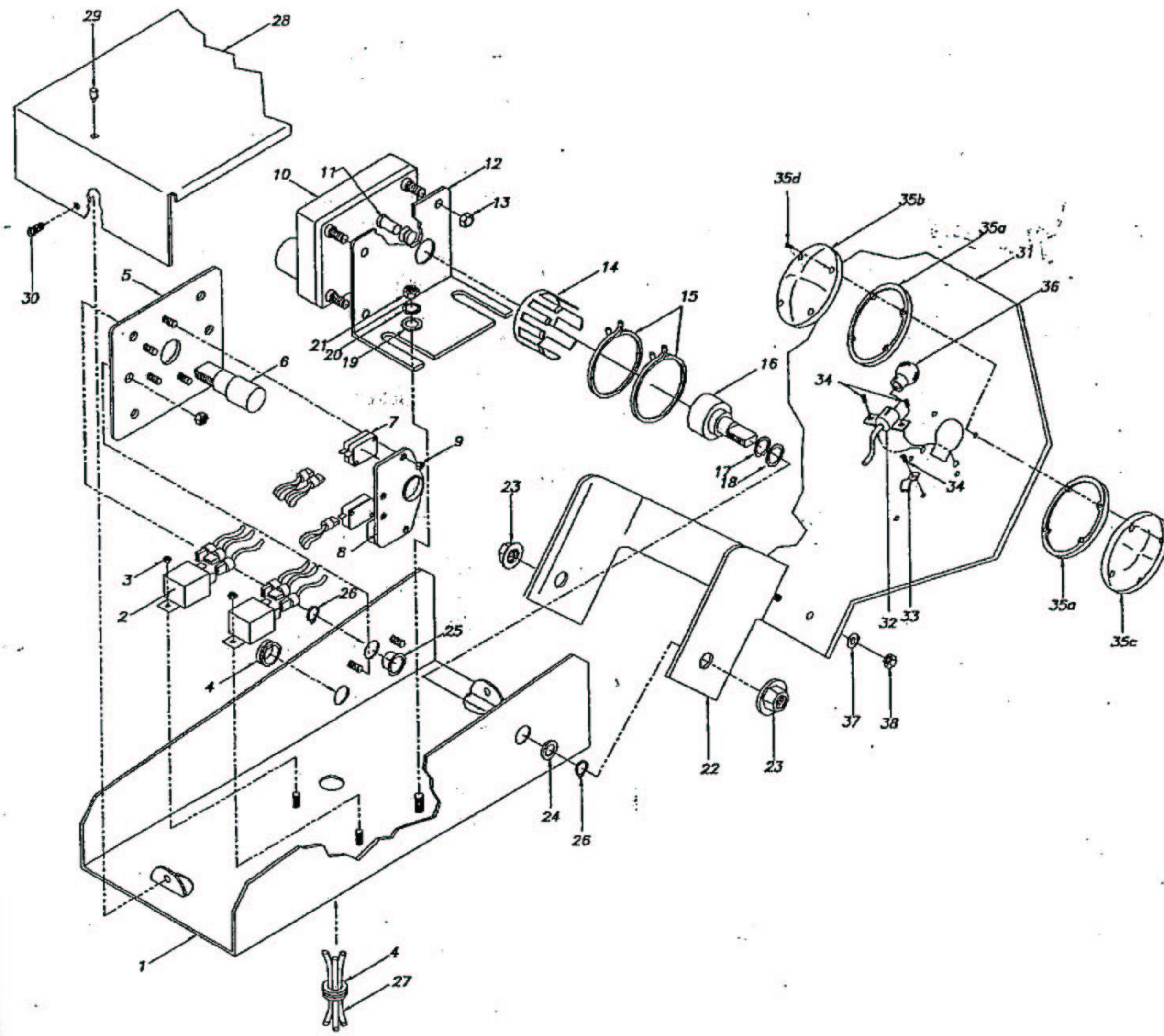
STOP ARMS
5 SERIES ELECTRIC



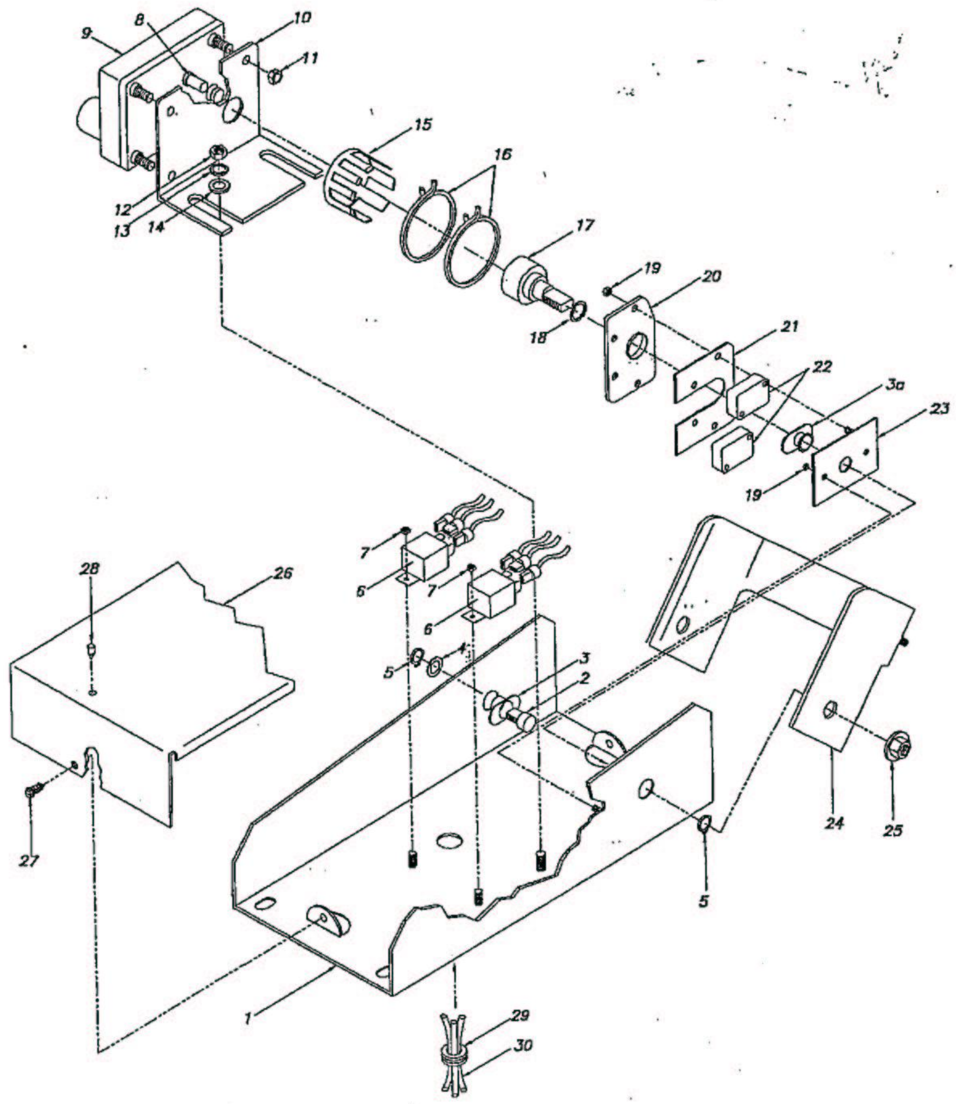
Stop Arms
5-Series Electric

ITEM NO.	SMC P/N	QTY.	DESCRIPTION
	005110		5-Series Stop Arm Base Assembly
1	005101	1	Base, Painted with Studs
2	003010	2	Relay
3	005832	4	Insert Hex Nut, Nylon 8-32
4	003027	2	Grommet
5	005006	1	Microswitch Mounting Plate
6	005031	1	Cam - Threaded
7	005007	3	Microswitch
8	005016	1	Cam Positioner Plate
9	005440	4	#4-40 Nylon Hex Locknut
10	005014	1	Motor
11	005065	1	V-Seal
12	005005	1	Motor Bracket
13	004048	4	Hex Nut
14	005003	1	Clutch, Plastic
15	005030	2	Roto Clip
16	005002	1	Slip Clutch, Aluminum
17	005032	1	O-Ring
18	005176	1	Bushing, Nylon
19	000147	2	Washer, Flat ¼"
20	000148	2	Lockwasher
21	000143	6	Insert Locknut 00
22	005168	1	Hinge Bracket
23	005122	2	Washer HD Whiz Nut
24	005164	1	Washer, SS, 1" O.D.
25	005166	1	Bushing, Nylon
26	005165	2	Snap Ring
27	005012	1	Wiring Harness
28	005125	1	Cover
29	000177	1	Rubber Bumper
30	000137S	2	#10 x ½" SMS Serrated
31		1	Blade Choice (contact distributor)
32	005189	2	Socket & Pigtail
33	000198	4	Tube Clamp – Molded
34	000192	8	Screw, Self-Tapping
35	000194K	2	Lens Kit, Red (inc. following parts)
35a	000193SAE	4	Lens Gasket
35b	000194	2	Lens, Red Solid
35c	000194-C	2	Lens, Red Cut-Out
35d	000185ST-F	8	Screw, Hex Head
36	001156DC	2	Bulb, Double-Contact
37	000104	4	Flat Washer, Nylon
38	000142	4	Locknut, Nylon

Replacement Parts Not Shown

005008	1	Clutch
005029	1	Clutch and Motor Assembly
005039	1	Microswitch Arm and Harness
005126	1	Adapter, Windguard
007000	1	Windguard

Safety Guard Crossing Control Arms
5 - Series Electric



Crossing Control Arms
5-Series Electric

ITEM NO.	SMC P/N	QTY.	DESCRIPTION
1	058101	1	Base, Painted with Studs
2	005057	1	Hinge Pin, Inverted
3	005176	1	Bushing, Nylon with Tab
3a	005166	1	Bushing, Nylon, no Tab
4	005164	1	Washer, SS, 1" O.D.
5	005165	2	Snap Ring
6	003010	2	Relay
7	005832	4	Insert Hex Nut, Nylon 8-32
8	005065	1	V-Seal
9	005014	1	Motor
10	005005	1	Motor Bracket
11	004048	4	Hex Nut
12	000143	2	Insert Locknut
13	000148	2	Lock Washer
14	000147	2	Washer, Flat, ¼"
15	005003	1	Clutch, Plastic
16	005030	2	Roto Clip
17	005014	1	Clutch Driver/Cam, Threaded
18	005032	1	O-Ring
19	005440	4	#4-40 Hex Nut, SS
20	005058	1	Plate, Flat - Inverted
21	005038	1	Heater
22	005007	2	Microswitch
23	005016	1	Plate, Switch Mounting/Inv
24	005168	1	Hinge, Threaded with Studs
25	005122	2	½-20 Hex Washer Hd Whiz Nut
26	058125	1	Cover, 5-Series X/A
27	000137S	2	10 x ½ Hex Washer Hd Screw
28	000177	1	Rubber Bumper
29	003027	1	Grommet
30	005019	1	Harness, Base Quick-Disc Wiring

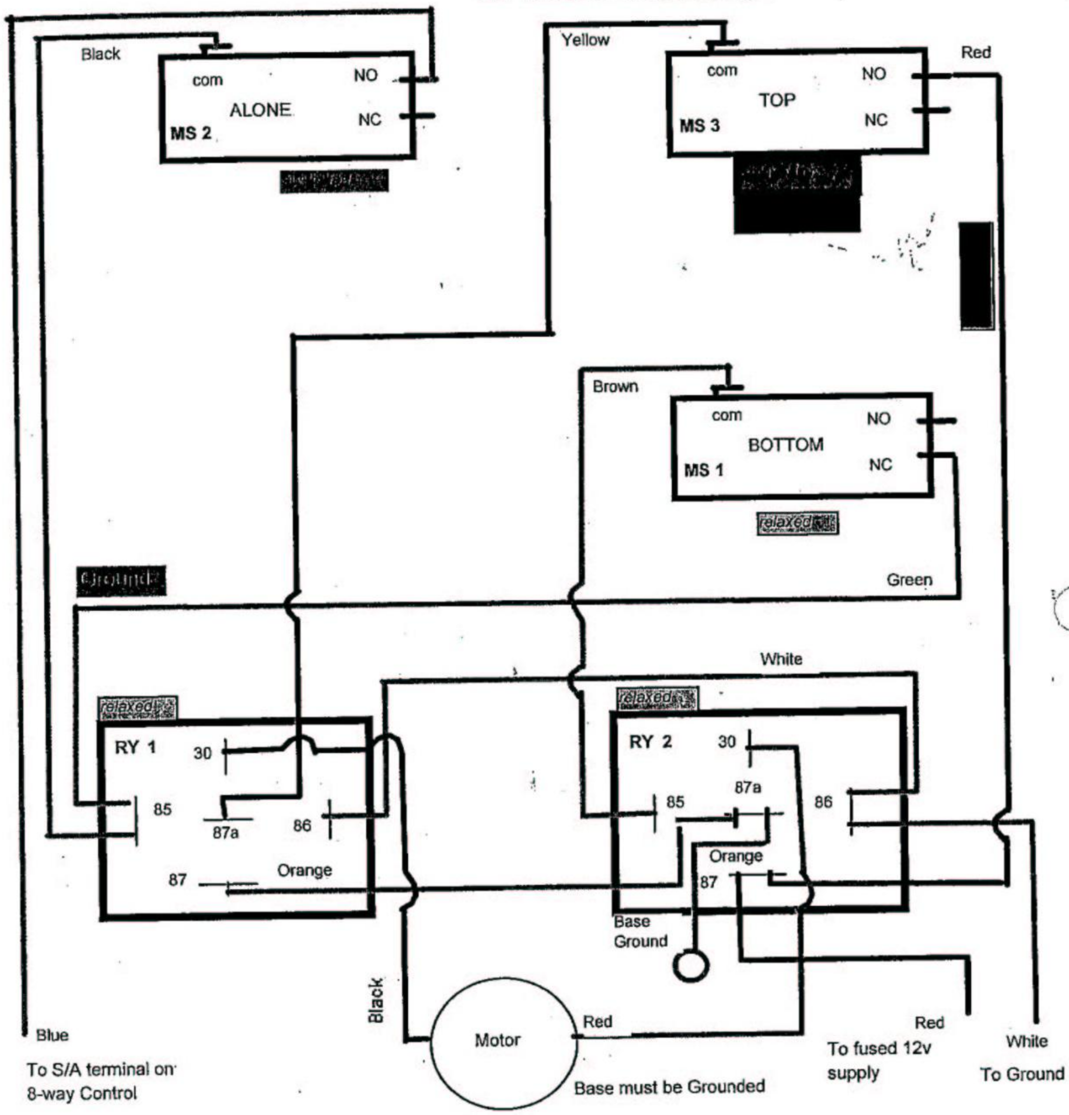
Replacement Parts Not Shown

SMC P/N	QTY.	DESCRIPTION
000104	4	Washer ¼" Nylon Flat
000142	4	Nylon Locknut
005042	1	Wire Harness Replacement (Complete)
005062	1	Clutch Assembly
005063	1	Clutch and Motor Assembly

Specialty Mfg. 5-Series S/A

THREE MICROSWITCH Configuration Page 1

S/A with Door closed, arm @0*



MS3 senses the proper closed position per the cam to be ærelaxedÆ and thus both motor leads are at ground voltage. When the arm is not at the proper closed position, MS3 becomes æswitchedÆ and applies the 12v to the Black motor lead and the motor runs to bring the arm into the 0* position!

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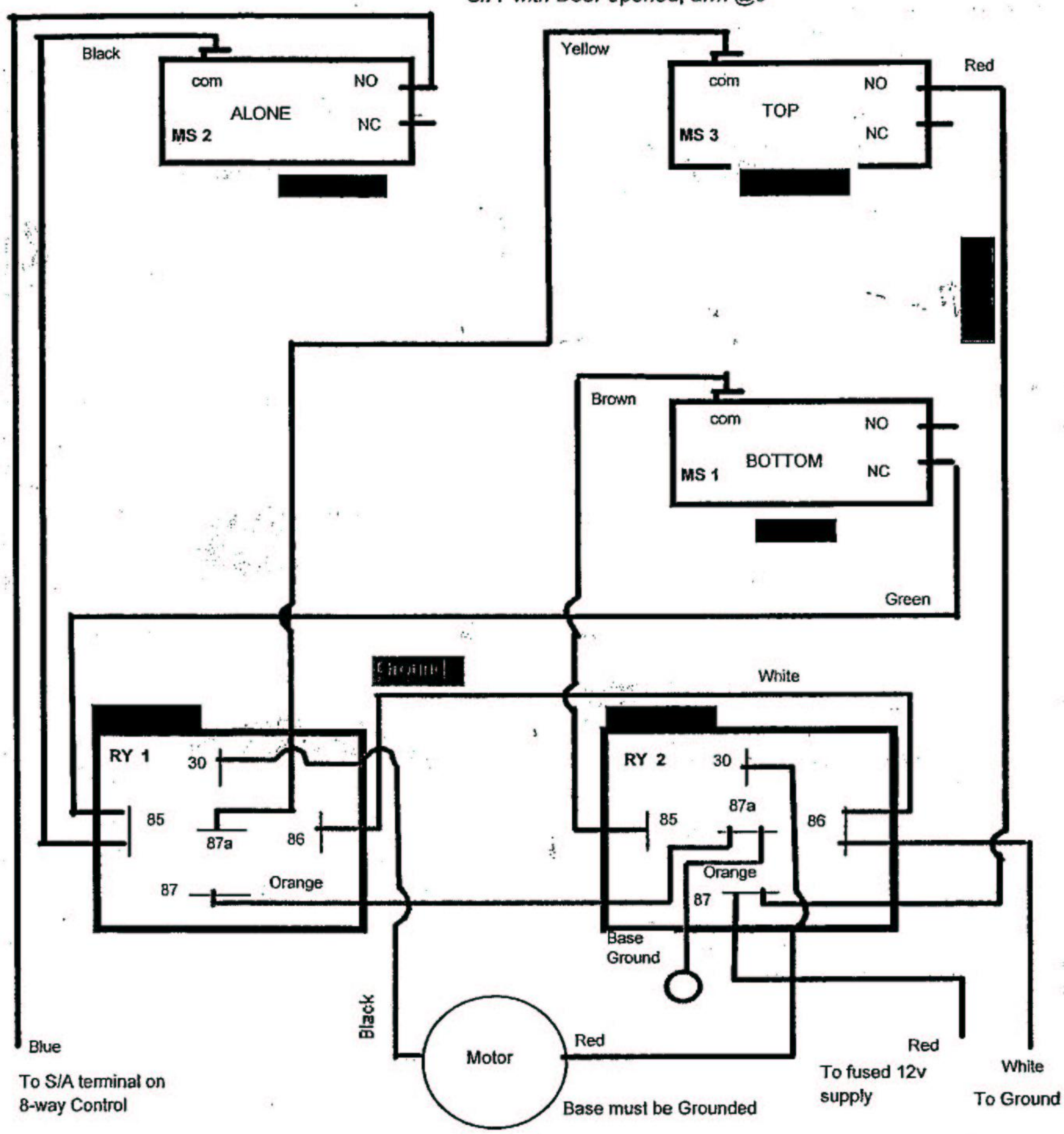
THREE MICROSWITCH Configuration

Page 2

S/A with Door opened, arm @0*



When the door is opened, the Blue wire from the 8-way Control becomes a <u>steady</u> 12v signal. This signal energizes both relays which reverses the voltage polarity on the motor leads resulting in the motor running to æopenÆ the arm to the 90* position as determined by MS1 and the cam!

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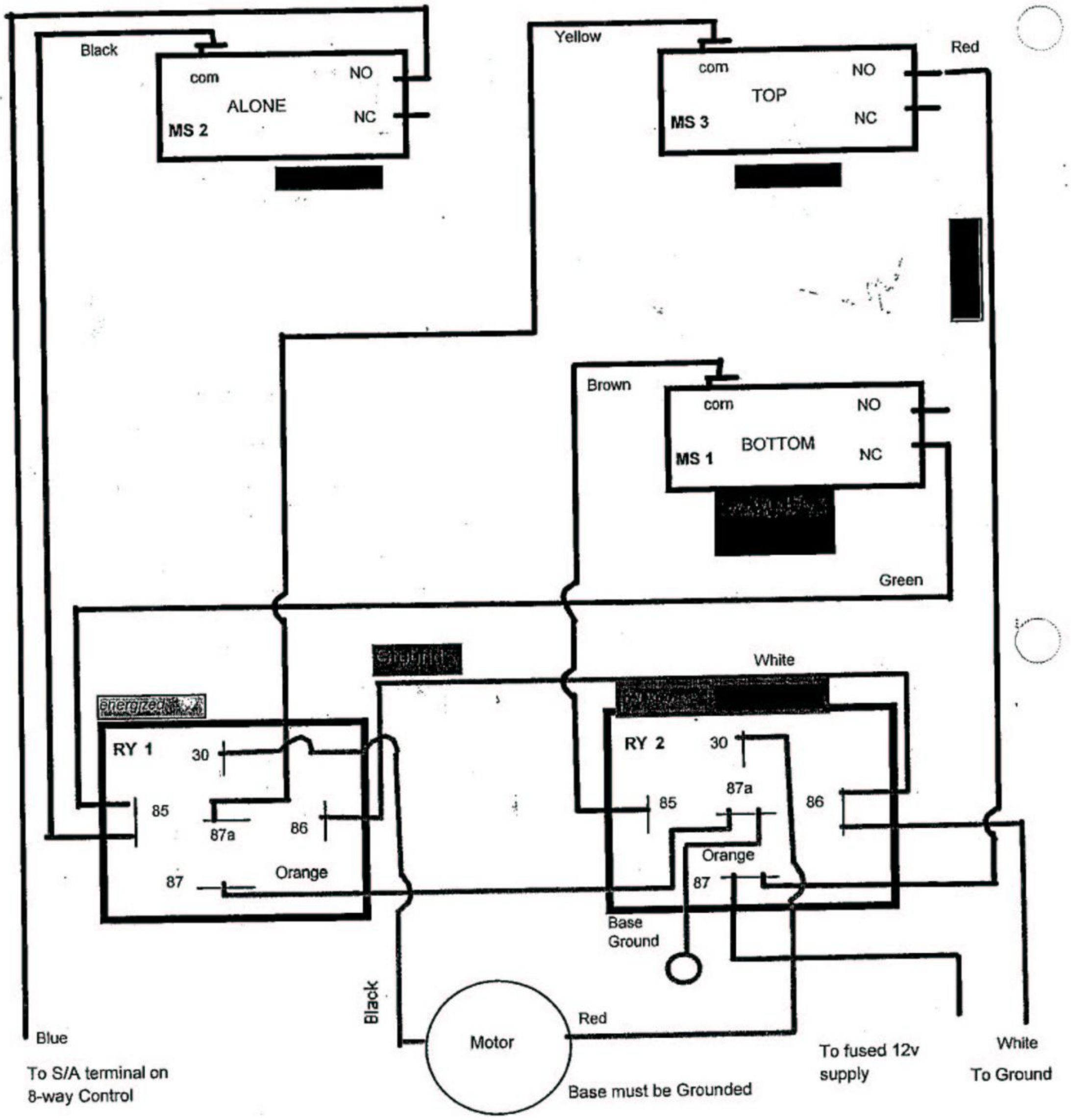
THREE MICROSWITCH Configuration

Page 3

S/A with Door opened, arm @ 90*



MS1 senses the proper opened arm position at 90* to become æswitchedÆ. This relaxes RY2 to remove the 12v power from the Red motor lead and the arm stops!

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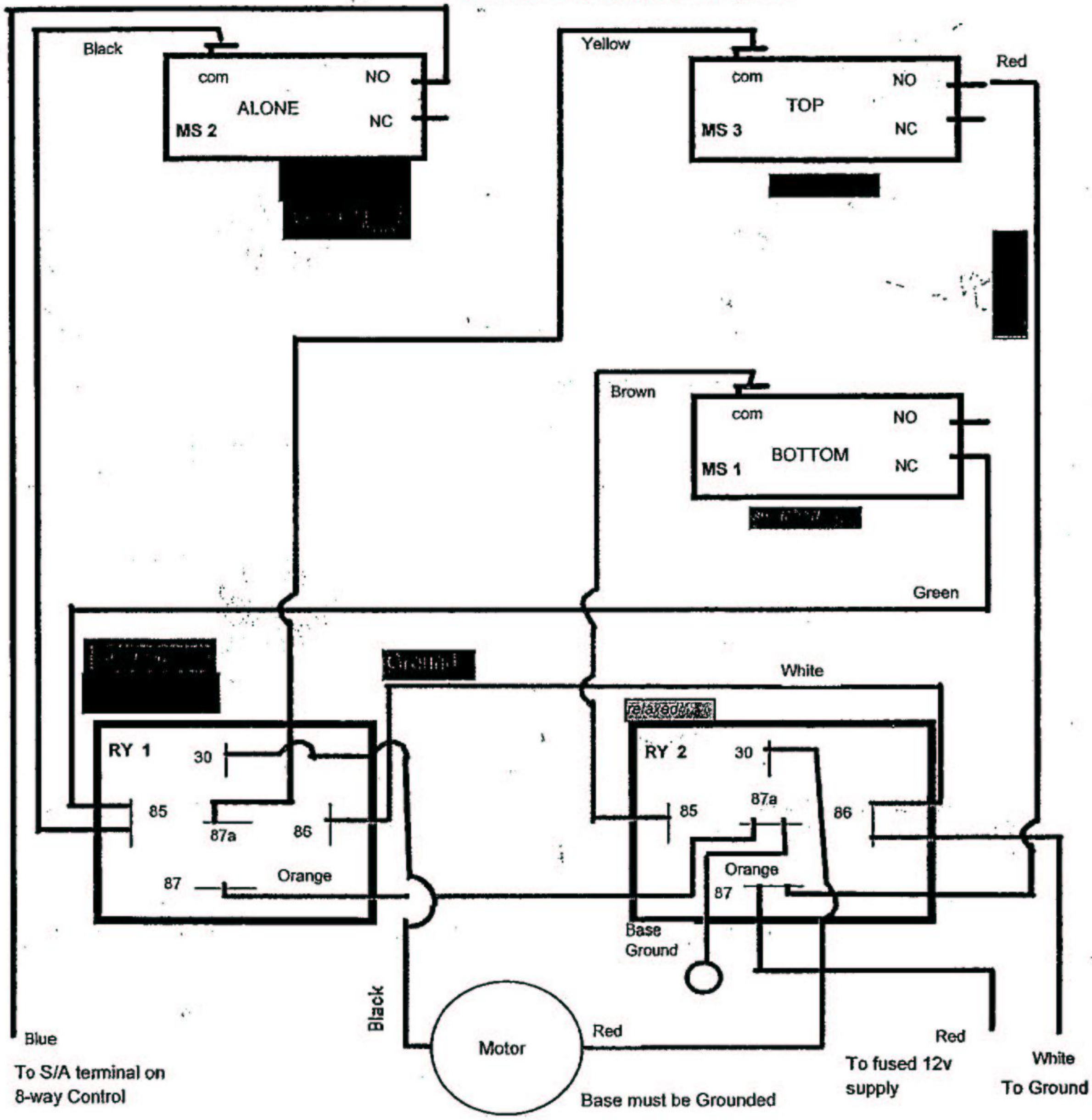
THREE MICROSWITCH Configuration

Page 4

S/A with Door opened, arm @> 90*



When the wind or coasting takes the arm past ~95*, MS2 senses this and becomes ærelaxedÆ. This relaxes the relay RY1 which then applies 12v power to the Black motor lead to move the arm back to the 90* position! Worn microswitch pawls or loose parts can introduce an arm waving situation at the 90* position!

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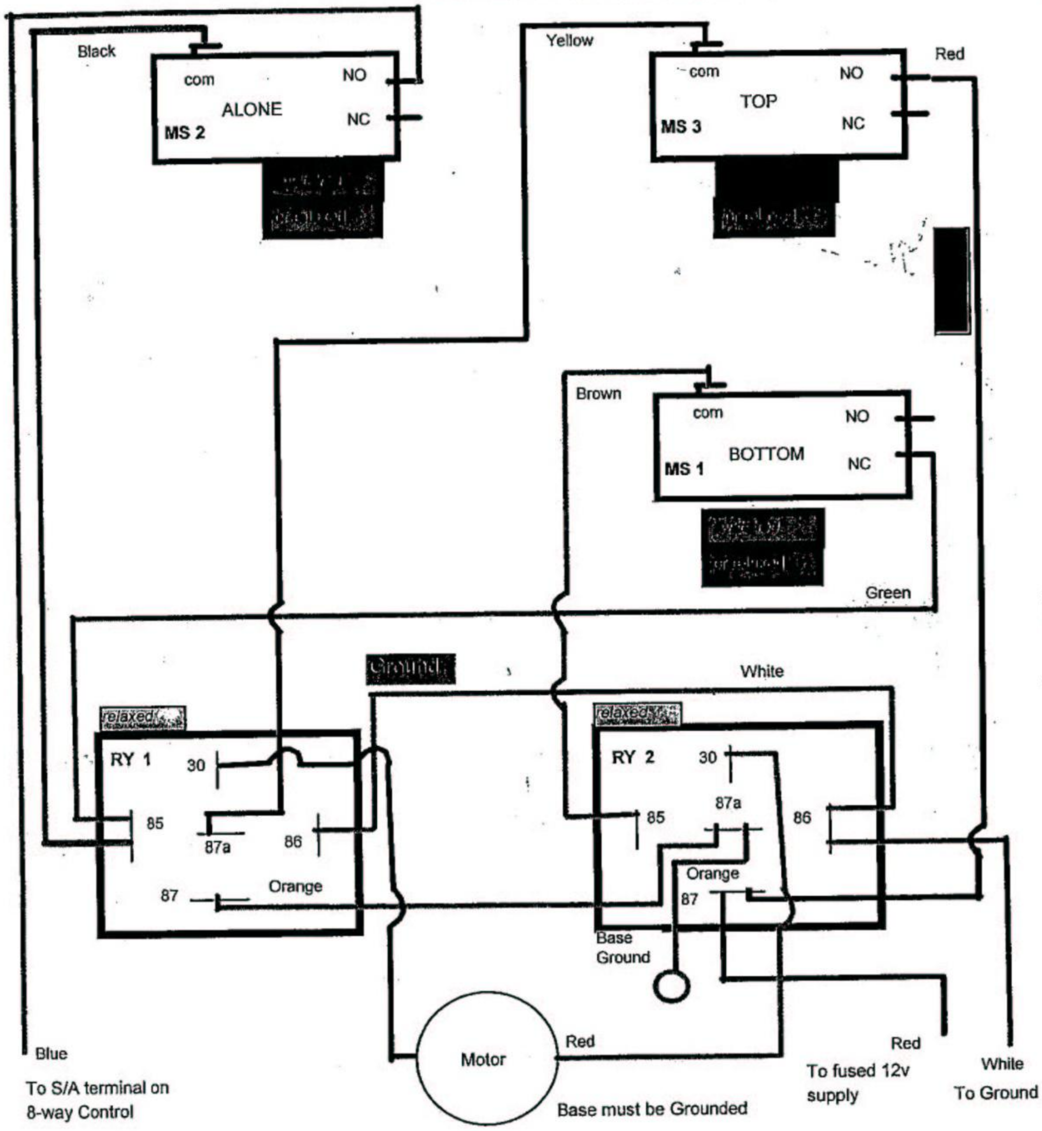
THREE MICROSWITCH Configuration

Page 5

S/A with Door closed, arm @ 90*– 0*



When the door is closed, the steady 12v signal disappears from the 8-way Control and the Blue wire. All relays become relaxed and MS3 becomes the controlling item to power the Black motor lead to move the arm into the 0* position and the whole cycle can start over!

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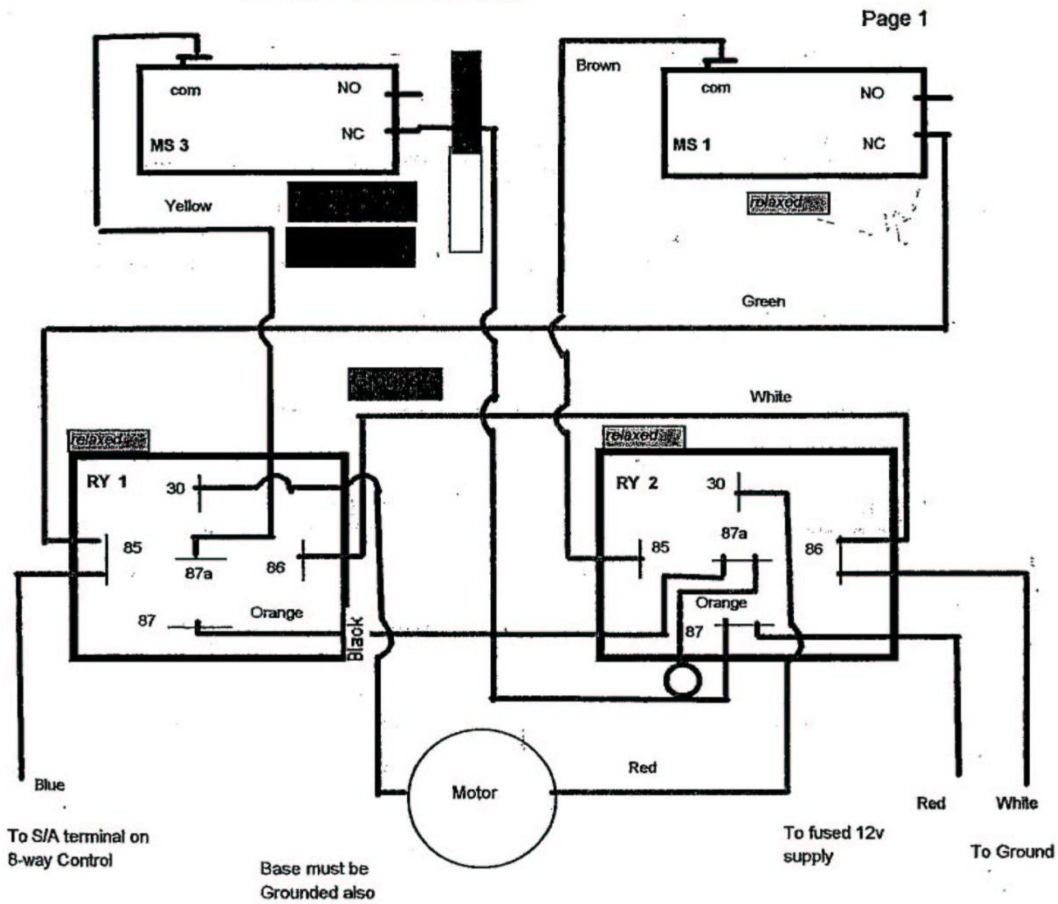
Specialty Mfg. 5- Series X/G
TWO MICROSWITCH Configuration

X/G with Door closed, gate @0*



MS3 senses the proper closed position of the cam to be æswitchedÆ and thus both motor leads are at ground voltage. When the gate is not at the proper closed position, MS3 becomes ærelaxedÆ and applies the 12v to the Black motor lead and the motor runs to bring the gate into the 0* position!

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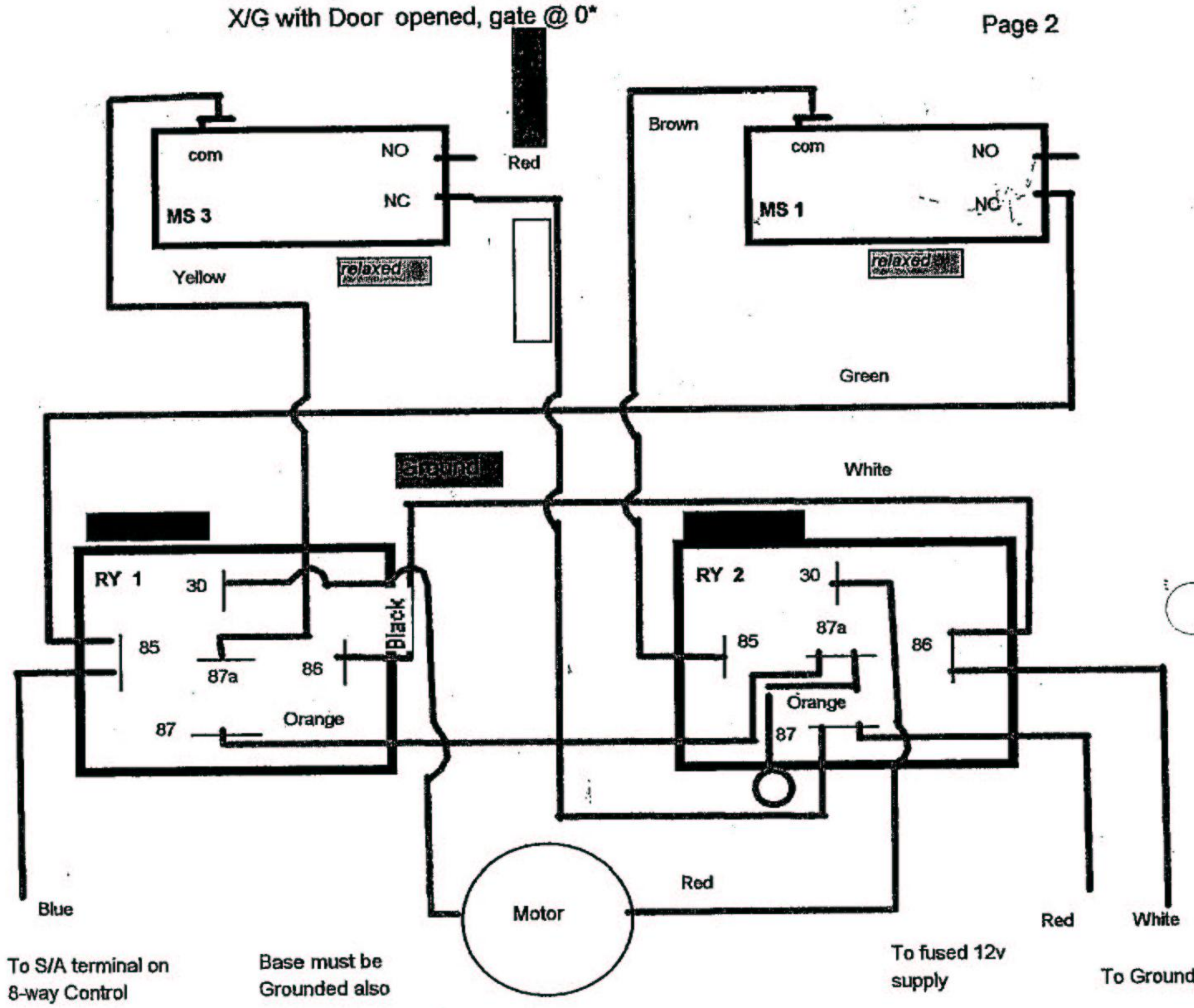
TWO MICROSWITCH Configuration

X/G with Door opened, gate @ 0*

Page 2



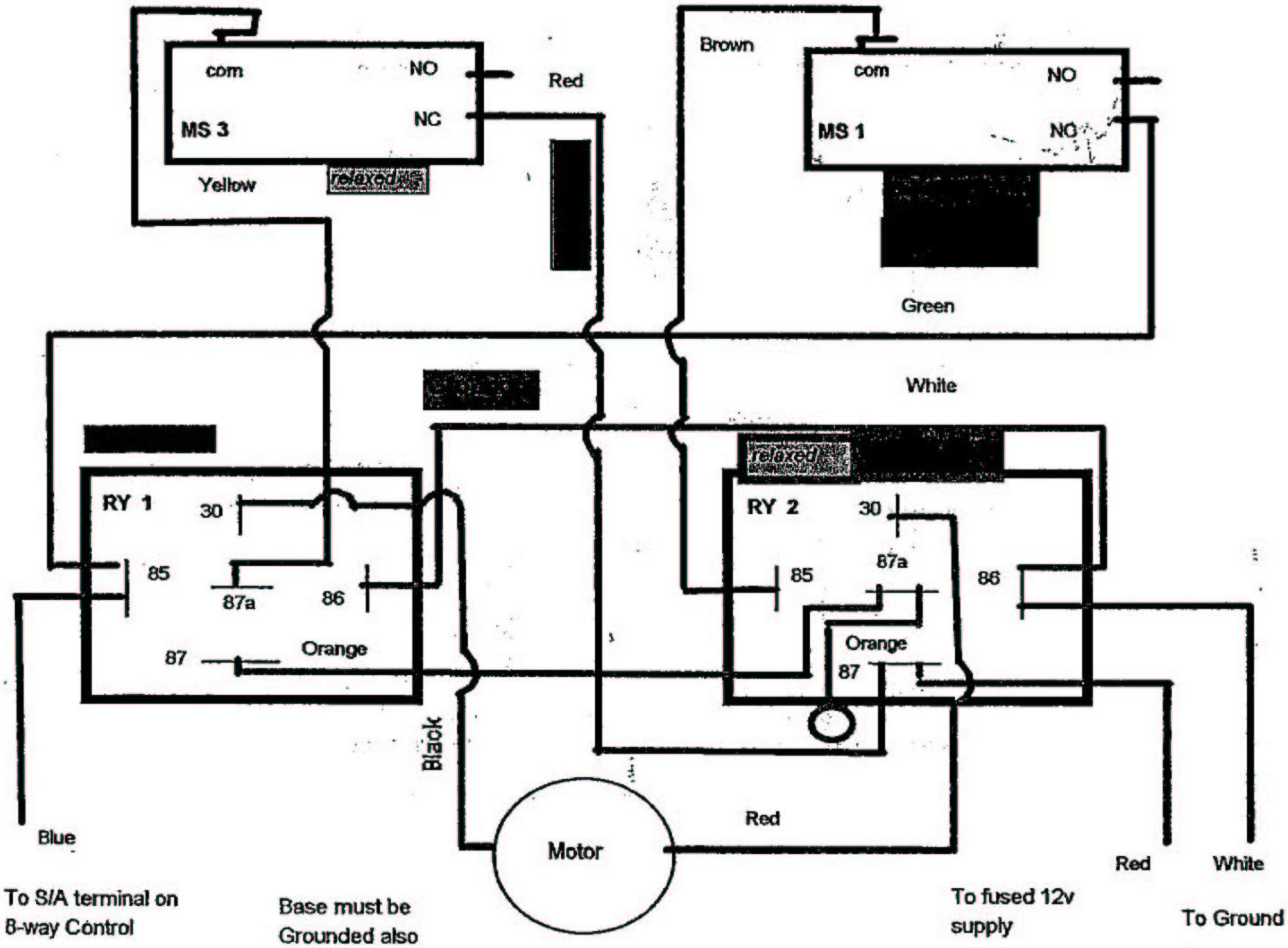
When the door is opened, the Blue wire from the 8-way Control becomes a <u>steady</u> 12v signal. This signal energizes both relays which reverses the voltage polarity on the motor leads resulting in the motor running to æopenÆ the gate to the 90* position as determined by MS1 and the cam!

ECR 2-14-98

TWO MICROSWITCH Configuration

X/G with Door opened, gate @90*

Page 3



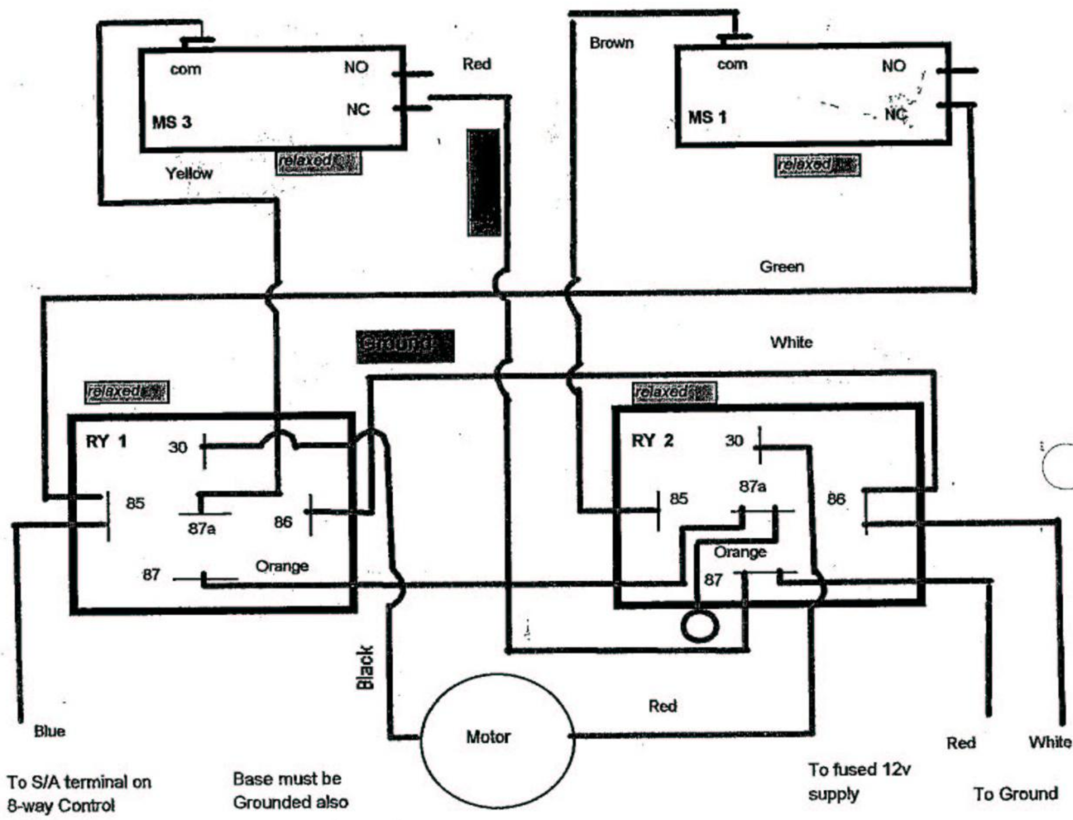
MS1 senses the proper opened position to be æswitchedÆ and thus both motor leads are at ground voltage. When the gate is not at the proper open position, MS1 becomes ærelaxedÆ and applies the 12v to the RY2 to energize and connect the Red motor lead to the 12v supply. Thus the motor runs to bring the gate into the 90* position as determined by MS1!

ECR 2-14-98

TWO MICROSWITCH Configuration

X/G with Door closed, gate @<90*

Page 4



When the door is closed, the steady 12v signal disappears from the 8-way Control. All microswitches and relays become relaxed to apply 12v to the Black motor lead and ground to the Red motor lead. The motor runs to move the gate into the closed position as determined by MS3 and the whole cycle can start over!

ECR 2-14-98

SPECIALTY
MANUFACTURING CO.

TECHNICAL BULLETIN #A002
SUBJECT: TROUBLSHOOTING 6-SERIES UNITS
EFFECTIVE DATE: 02/10/00

The 6-series stop / crossing arm contains two internal circuits; a motor circuit and a motor control circuit. The motor control circuit is a solid-state hall-effect, encapsulated module that senses the position of the arm and energizes the motor according to the control signal from the 4 or 8 light flasher system. When the 4 or 8 light flasher system is ON and the door is opened, the 'Stop Arm Solenoid' terminal on the flasher system provides a steady 11 – 14 volt signal to the solid-state control module via the Blue Wire. The control module provides the proper voltage and polarity for the motor to move the hinge and attached arm to the OPEN position. When this signal is 0 volts (door closed and lights off), the control module provides the proper voltage and polarity to return the hinge and attached arm to the closed position. The vane attached to the drive shaft is shaped to sense the position of the hinge in relation to the status of the control signal and to start or stop the motor action accordingly. The 6-series unit is internally grounded through the white, eliminating the possibility of faulty external chassis grounds.

While it may seem complicated, the 6-series may be easily troubleshooted using a test light or DC voltmeter. Please refer to the appropriate wiring diagram for the reference points listed. Note that components that are determined to be 'at fault' are not necessarily defective. The fault may be due to loose connections. The situations listed below are those that may be encountered in the field. If further help is needed, contact the engineering department at Specialty Manufacturing.

A- Unit is switched ON, 4 or 8-light flasher system is ON and the door is open causing the lights at the top of the bus to switch from Amber to Red, but the unit will not open.

1. Pull the hinge fully open, remove the cover and then partially close the hinge. Check for voltage at (A) . If this voltage is NOT within the guidelines, check for a steady voltage (11-14 v) at the "Stop Arm Solenoid" terminal on the 4 or 8 light flasher system. If this voltage is not within the guidelines, the flasher system is 'at fault'. If the voltage at these two points is within the guidelines, proceed to step 2.

2. Check the voltage at (B) . If this voltage is NOT within the guidelines, the power source on the bus is 'at fault'. Verify the associated fuse or circuit breaker is okay. If this voltage is within the guidelines, proceed to step 3.

3. Check for a chassis ground at (E) . If no ground is found, check the connection of the white wire inside the bus. If this chassis ground connection is okay, proceed to step 4.

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4. Remove the Black and Red motor wires and check the voltage across the terminals at C and D . If this voltage is NOT within the guidelines (0 v and +11/14 v to OPEN) or (+11/14 v and 0 v to CLOSE), the module is probably 'at fault'. If this voltage checks out, the Motor is probably 'at fault'. The Motor can be verified faulty by touching the Black and Red wire terminals across a known GOOD 12 volt voltage supply such as a battery or the live bussbar and ground. If the Motor runs during this touch check, the terminals crimped onto these wires may be 'at fault' or one of these wires may be shorted to the motor casing and gearbox.

B- Unit is switched ON, opens to 95+ degrees or excessively past 90 degrees.

1. This is most often due to the vane being out of position on the clutch shaft. The small hole of the vane should ~line up with the left top edge of the module body. For proper operation, the vane is nested onto two shaft flats angled to each other and held in place with a nut and lockwasher and may be corrected if it is loose or has slipped out of position.

C- Unit is switched ON, opens to ~90 degrees and closes when switched OFF, but will not return to the OPEN position if pushed way past the 90 degree position.

1. This is most often due to the module being 'at fault'.

D- Unit operates properly, but continues to run after closing.

1. This is most often due to the vane being out of position on the clutch shaft. The small hole of the vane should ~line up with the left edge of the module body at the 90 degree position and the top right edge of the vane lobe should ~line up with the left top edge of the module at the closed position. For proper operation, the vane is nested onto two shaft flats angled to each other and held in place with a nut and lockwasher and may be corrected if it is loose or has slipped out of position.

E- Unit is switched ON, opens properly, but will not close after being switched OFF (door closed).

1. Pull the hinge fully open, remove the cover and then partially close the hinge. Check for voltage at A to ~0 volts. If this voltage is NOT within the guidelines , check the voltage at the "Stop Arm Solenoid" terminal on the 4 or 8 light flasher system for a proper input signal of ~0 volts. The flasher system or the wiring connections to the unit may be 'at fault'. If the voltage at these points checks out, proceed to step 2.

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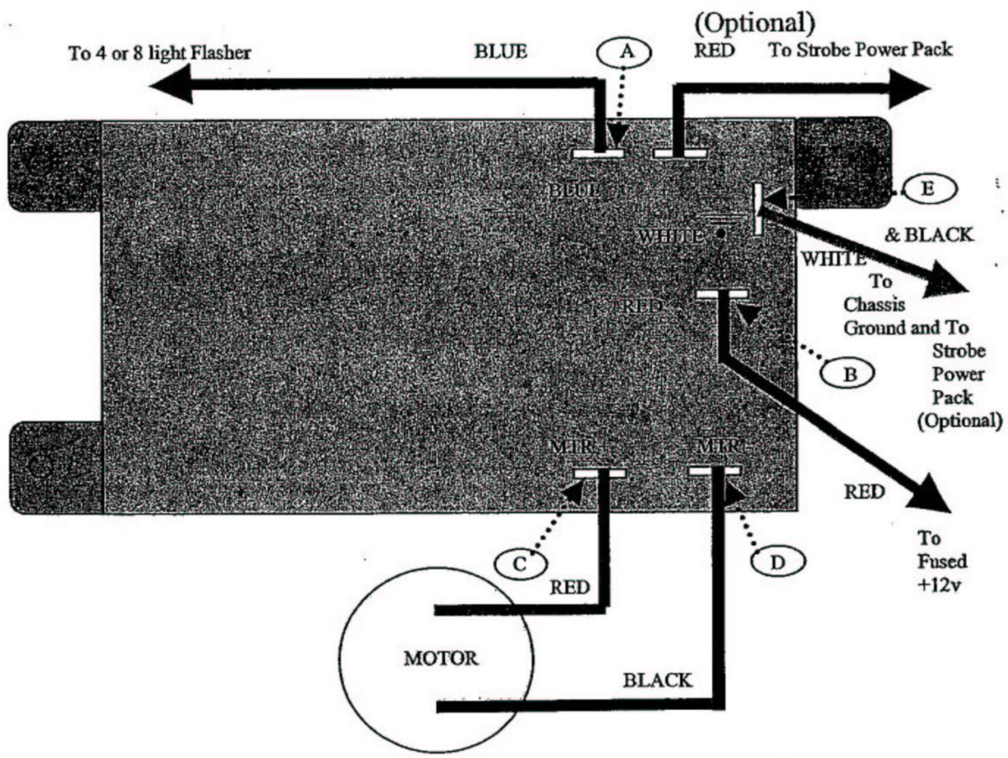
2. Remove the Black and Red motor wires and check the voltage across the terminals at C and D . If this voltage is NOT within the guidelines (0 v and +11/14 v to OPEN) or (+11/14 v and 0 v to CLOSE, the module is probably 'at fault'. If this voltage checks out, the Motor is probably 'at fault'. The Motor can be verified faulty by touching the Black and Red wire terminals across a known GOOD 12 volt voltage supply such as a battery or the live bussbar and ground. If the Motor runs during this touch check, the terminals crimped onto these wires may be 'at fault' or one of these wires may be shorted to the motor casing and gearbox.

F- Unit is switched ON, opens properly, but moves back and forth about 3 to 4 inches on the blade tip, commonly called "oscillation".

1. This is most often caused by the signal voltage from the 4 or 8 light flasher NOT being steady. Contact the manufacturer of the flasher unit for assistance.



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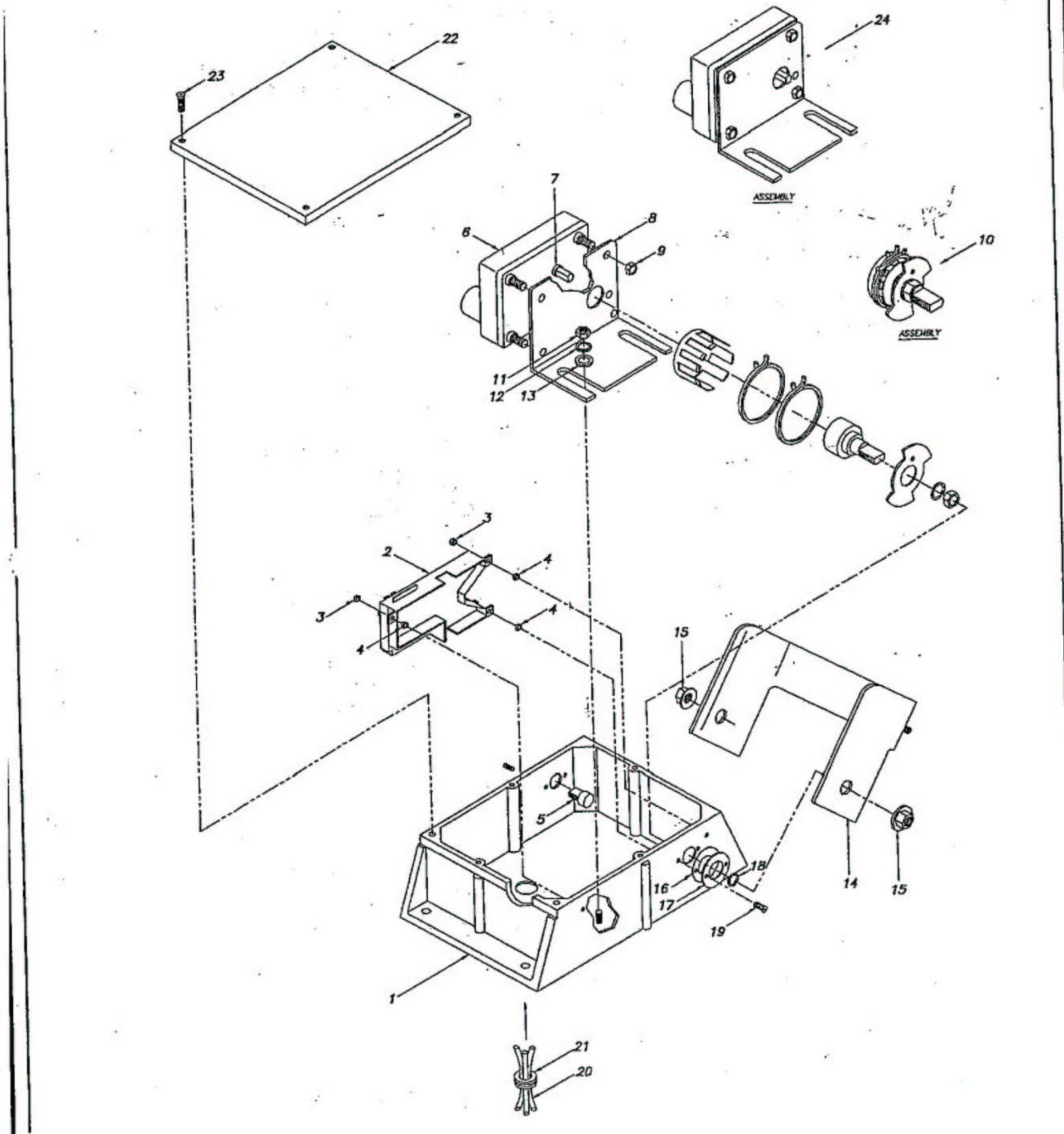
Crossing Control Arms
6 - Series Solid-State Electric



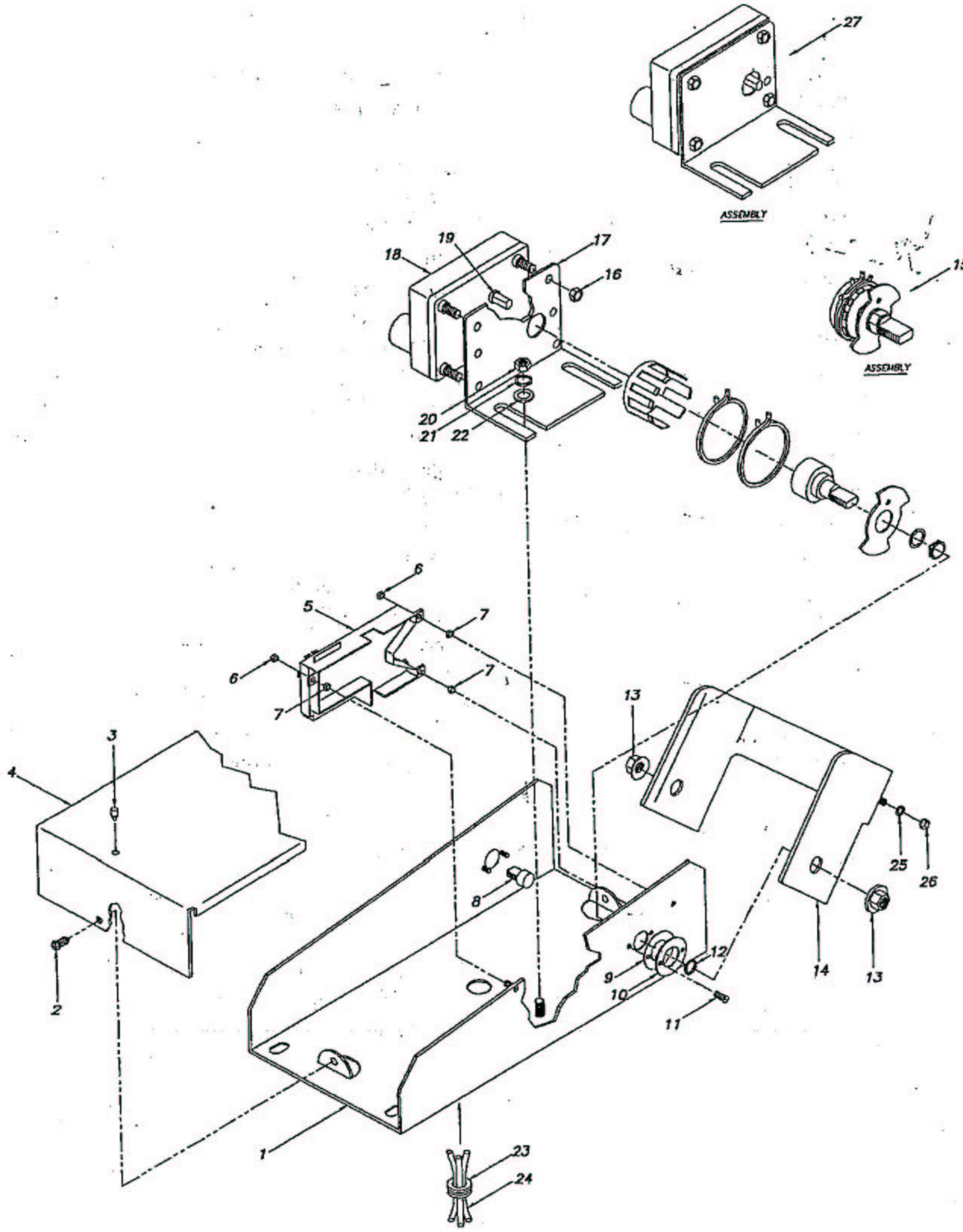
Crossing Control Arms
6-Series Electric

ITEM NO.	SMC P/N	QTY.	DESCRIPTION
1	068101	1	Base, Cast Aluminum, Painted with Studs
2	006120	1	Control Module
3	005832	7	Nut 8-32
4	000153	3	Spacer Nut, SS
5	005057	1	Hinge Pin
6	005014	1	Electric Motor
7	005065	1	V-seal
8	005005	1	Motor Bracket
9	004048	4	Nut 10-32, Nylon Lock
10	005065	1	Clutch/Vane Assembly
11	000143	2	Nut, ¼-20 Hex SS
12	000148	2	Washer, ¼" Split SS
13	004047	2	Washer ¼"
14	005168	1	Hinge Bracket
15	005122	2	Nut ½-20, Whiz
16	006144	1	Gasket
17	006123	2	Bushing
18	006041	2	Seal, Bushing-Shaft
19	006137	4	Screw, 8-32 x 5/8" FH Octal
20	006119	1	Harness
21	003027	1	Grommet
22	068125	1	Cover
23	006138	4	Screw, 10-32 x 3/8" Pan Slotted
24	005066	1	Motor Bracket Assembly

Replacement Parts Not Shown

SMC P/N	QTY.	DESCRIPTION
000104	4	Washer ¼" Nylon Flat
000142	4	Nylon Locknut
005042	1	Wire Harness Replacement (Complete)
005062	1	Clutch Assembly
005063	1	Clutch and Motor Assembly

Stop Arms
6 - Series Solid-State Electric



Stop Arms
6-Series Solid State Electric

ITEM NO.	SMC P/N	QTY.	DESCRIPTION
1	006101	1	Base, Painted with Studs
2	00137S	4	#10 x ½" Screw, HxHd Self Tap
3	000177	5	Rubber Bumper
4	005125	1	Painted Cover
5	006120	1	Control Module, Solid State, Encap.
6	005832	7	8-32 Nylock Nut SS
7	000153	3	Spacer Nut, SS
8	005057	1	Hinge Pin, Hardcoated AL
9	006144	1	Gasket
10	006123	2	Bushing
11	006136	4	8-32 x ½" Screw, FtHd Octal
12	006041	2	Seal, Bushing-Shaft
13	005122	2	½-20 Whiz Nut
14	005168	1	Painted Hinge w/Studs
15	006133	1	Clutch Vane Arm
16	004048	4	10-32 Nylock Nut SS
17	005005	1	Motor Bracket
18	005014	1	Motor
19	005065	1	V-seal
20	000143	2	¼-20 Nut SS
21	000148	2	¼" Split Washer SS
22	000147	2	¼" Washer SS
23	003027	2	Grommet (1 not shown)
24	006117	1	Harness
25	000104	4	¼" Nylon Washer
26	000142	4	¼" Nylock Nut
27	005066	1	Motor Bracket Assembly

Replacement Parts Not Shown

001001	1	Strobe Power Pack for 6x6x series
001004	1	Strobe Power Cable for 6x6x series
003013	1	Flasher for 6x2x series
005045	1	Plastic Blade Tab
005126	1	Bracket Adapter
006116	1	Terminal Doubler for 6x6x series
006144	1	Bushing Gasket
007000	1	Windguard
	1	Blade Assm: Select from Catalog

ALTERNATOR SYSTEMS

Prestolite/Leece Neville Systems

Technical Services

Troubleshooting Leece-Neville Alternators

A Step-By-Step Approach To Electrical Systems Problems

Finding problems in your vehicles electrical system doesn't need to be a difficult process. By following the logical process of investigation described in the service bulletin, you can track down and fix most of the commonly encountered electrical problems and particularly those related to the electrical system.

Step 1. Check the Battery Condition

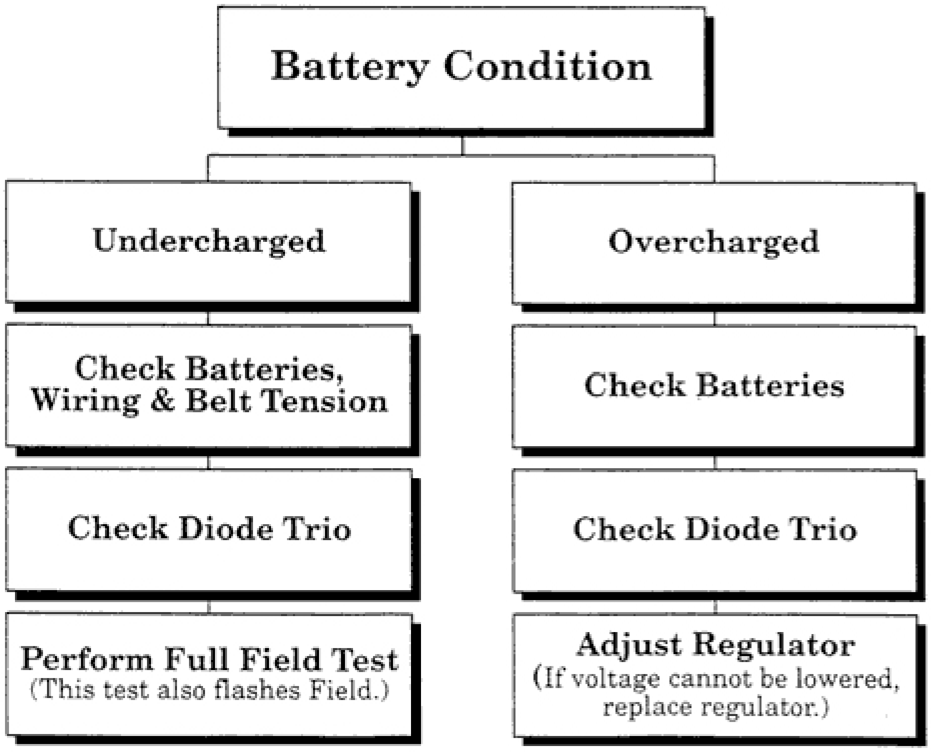
A. Before beginning the battery test, make sure that the batteries are 95% - 100% charged. Use a battery charger, if necessary.

B. Shut off all electrical accessories in the vehicle and run the engine at approximately 1000 - 1200 RPM.

C. Connect a DC voltmeter to the battery terminals and measure the voltage. Compare the values to those specified by the battery manufacturer. If the voltage is above the manufacturers specification, an OVERCHARGE condition exists. If the measured voltage is below the manufacturers specification, an UNDERCHARGE condition exists.

Step 2. Overcharge and Undercharge Tests

Battery overcharge and undercharge conditions each require a specific set of procedures to be performed. The following diagram shows the order in which the procedures are performed. A more detailed description of these procedures follows.



For OVERCHARGE Condition

Overcharge batteries (output over 14.2 volts for most 12-volt systems, or over 28.4 volts for 24-volt systems) can be caused by a defective battery (usually indicated by excessive gassing), a defective diode trio, or a defective or improperly adjusted voltage regulator.

After testing the batteries for shorts, perform the "Diode Trio Test" procedure in this bulletin, followed by "Voltage Regulator Adjustment" procedure, if necessary.

For UNDERCHARGE Condition

To avoid unnecessary work, always check for loose belts, a defective battery, and damaged or corroded wires and connections first. If the battery, belts, and wiring are in good working condition, perform the "Diode Trio Test" procedure. If the diode trio is in good shape, perform the "Full Field Test."

Diode Trio Test (on units equipped with a diode trio)

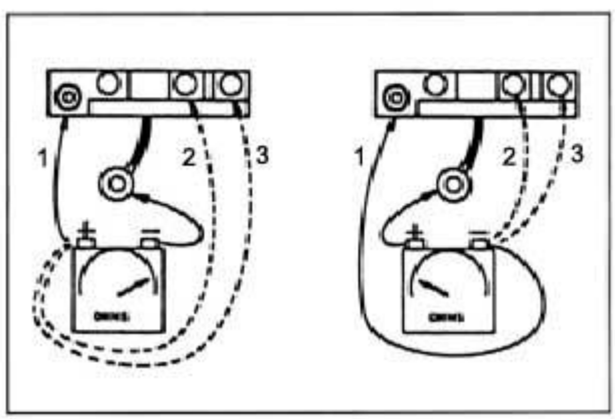
1. Remove the diode trio from the alternator.

2. Connect the negative (-) ohmmeter test lead to the diode trio lead terminal as indicated in the diagram. Connect the positive (+) test lead to each of the three copper contact pads, one at a time. Observe the resistance at each contact pad and write down the resistance for each contact for later reference.

3. Reverse the leads so the positive (+) test lead is connected to the diode trio lead terminal and the negative (-) test lead connects to the contact pads. Again observe the resistance at each of the contact pads and record the results for each contact.

NOTE: The diode trio is OK when a LOW resistance reading is observed in one direction and a HIGH resistance is observed in the other direction. Occasionally the diode trio malfunctions under operating conditions only.

4. If the diode trio is malfunctioning, replace it. Otherwise, reinstall the diode trio on the alternator.



Full Field Test

1. Run engine at approximately 1000 RPM with all electrical accessories "OFF". Measure the output voltage across the alternator terminals and write it down for later reference.

NOTE: Use a digital voltmeter with .01-volt reading capabilities or any good voltmeter.

2. Attach a short jumper to a 2" piece of stiff wire (a paper clip is suitable).

3. Connect the other end of the jumper to the negative (-) alternator output terminal and insert the wire in the FULL FIELD ACCESS HOLE (see photo). Hold the wire firmly against the brush terminal inside the housing. (Also flashes Field.)

4. With the jumper in place, connect a voltmeter across the alternator terminals and run the engine at approximately 1000 RPM. Compare this voltage reading with the voltage reading obtained in Step 1.

5. With the jumper still hooked up and the wire in the FULL FIELD ACCESS HOLE, connect an AC voltmeter across terminals 1&2, 1&3, and 2&3, and note the voltages. If all of the voltages are approximately the same, they are considered "balanced."

6. Remove the jumper and wire from the alternator. If the voltage in Step 4 is higher than the voltage in Step 1, and the voltages measured in Step 5 are balanced, the stator and alternator are OK and you should proceed to the "Voltage Regulator Adjustment" procedure

If the voltage in Step 4 is higher than the voltage in Step 1, and the voltages measured in Step 5 are not balanced, the alternator stator or rectifier(s) defective. Repair or replace alternator.

If the voltage in Step 4 is lower or equal to the voltage in Step 1, and the voltages measured in Step 5 are balanced, the alternator is defective. Replace alternator.

If the voltage in Step 4 is lower or equal to the voltage in Step1, and the voltages measured in Step 5 are not balanced, alternator stator or rectifier(s) are defective. Replace the alternator.

Voltage Regulator Adjustment

Leece-Neville alternators are equipped with one of two regulators. The Fully Adjustable Regulator has a flat cover plate. The Three Step Regulator has a finned, curved cover plate. Use the following test procedure that is appropriate for you regulator type.

Fully Adjustable Regulator

NOTE: Battery must be at least 95% charged prior to this procedure. Also make sure wire connections and belt tension are OK.

1. Shut off all electrical accessories and run the engine at approximately 1000 RPM.

2. Connect a voltmeter to the alternator outputs.

3. Remove the plastic screw from the regulator (see photo) and insert a small screwdriver in the hole. Engage the screwdriver blade in the slotted adjustment screw inside the regulator.

CAUTION: The adjustment potentiometer screw has high and low stops. DO NOT exert excessive pressure on the screwdriver or you may damage the regulator.

4. Turn the screwdriver clockwise to raise the voltage, counterclockwise to lower the voltage. Set the voltage between 14.0 and 14.2 volts (28.0 to 28.4 volts for 24-volt

units).

CAUTION: DO NOT force the screwdriver past the set stops at either end of the adjustment range to avoid regulator damage.

5. Remove the screwdriver and voltmeter and install the plastic screw in the adjustment screw access hole.

Three-Step Adjustable Regulator

---

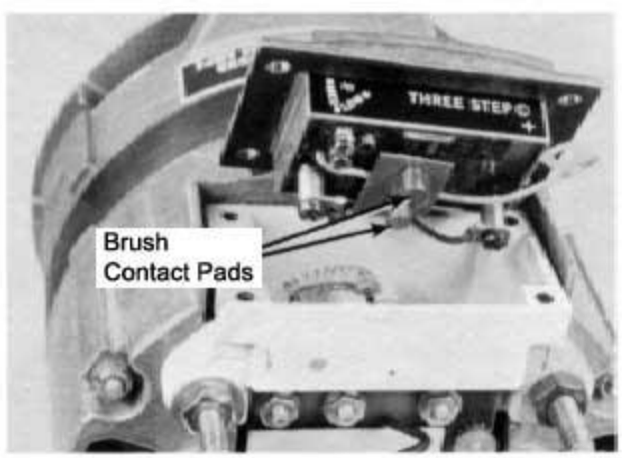
1. Stop the engine and disconnect the battery ground cable.

2. Remove the #10-32 nuts and lockwasher from the regulator terminal and disconnect the diode trio lead (if alternator is equipped with a diode trio).

3. Remove the four screws from the regulator cover. Lift the regulator out of the housing and move it out of the way as far as the leads will permit. Inspect the two regulator brush contact pads (see photo). If dirt or corrosion is noted, clean the pads with #600 or finer sandpaper.

NOTE: In some cases, dirty or corroded contact pads can cause a low charge condition and voltage adjustment may not be necessary.

4. Inspect and reinstall the brushes.



5. To adjust the voltage, remove and reinstall the adjustment strap in one of three positions: between terminals A and B (low), between terminals A and C (medium), or between terminals B and C (high). Each change in the strap will result in an increase

or decrease in the alternator output voltage of approximately .4 volts.

Installation Instructions
Voltage Regulator 102200

These instructions cover the removal and installation of the 102200 voltage regulator, which is used on the 12 volt "JC" alternators.

The 102200 regulator has an "AC/DC" circuit built in which will allow it to be used on 12 volt "JB" and "JC" style alternators equipped with or without a diode trio. For alternators without a diode trio install a jumper wire from the regulator terminal on the alternator to one of the "AC" terminals (this will excite the alternator), the use of an ignition wire is no longer necessary. On alternators with a diode trio the regulator may be installed in the normal fashion.

Regulator Removal

1. Disconnect battery ground cable.

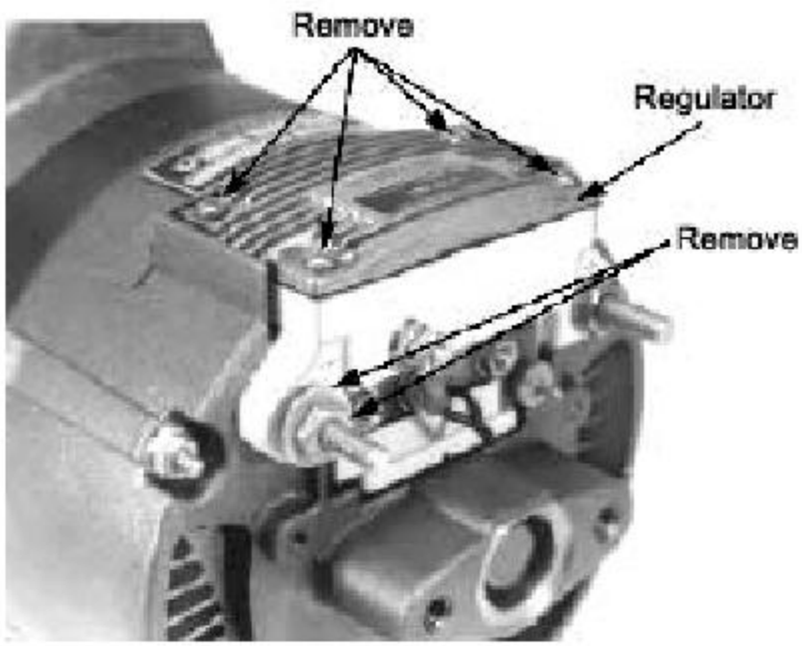


Figure 1

2. Remove four screws from regulator cover. Remove the two #10 nuts from the terminal located on the regulator holder to disconnect the diode trio lead (if alternator is equipped with a diode trio), or the jumper wire connected to the A/C tap. Tilt regulator up and remove the 10-32 square head screw to disconnect regulator blue lead (also white with blue tracer) (Figure 1).

3. Remove the brushes and visually inspect them. If brushes appear burned, cracked, or damaged, then brushes must be replaced. Inspect the springs and the shunt lead within

the
spring for damage. Replace brushes if necessary. Check brush length. If brush is less than
half its original length (or about 3/8"), then replace brush.
4. Inspect the Red, Black, and White leads which were disconnected from the regulator. If insulation is damaged so bare wire is noticed, then alternator should be disassembled and the leads replaced.

Regulator Installation

1. Clean each of the two brushes with a spray electrical contact cleaner of the type that does not contain silicone. Silicone attacks brushes and will cause short brush life. Clean brush contact caps with #600 grade (or finer) sand paper.
2. Insert a brush in each of the two brush openings. Compress the springs and retain with
a pin inserted through the access hole in the regulator holder. A suitable pin can be made
of a 1/16" drill or brazing wire (Figure 2).

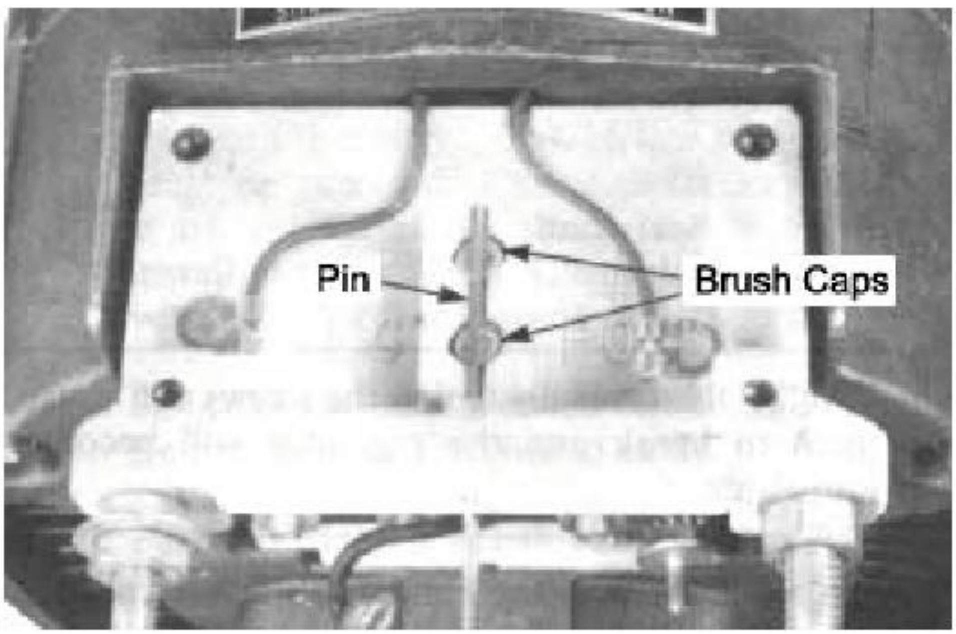


Figure 2

If the original brushes are being reused, then the wear pattern of each brush must be matched with the radius of the slip rings (Figure 3).

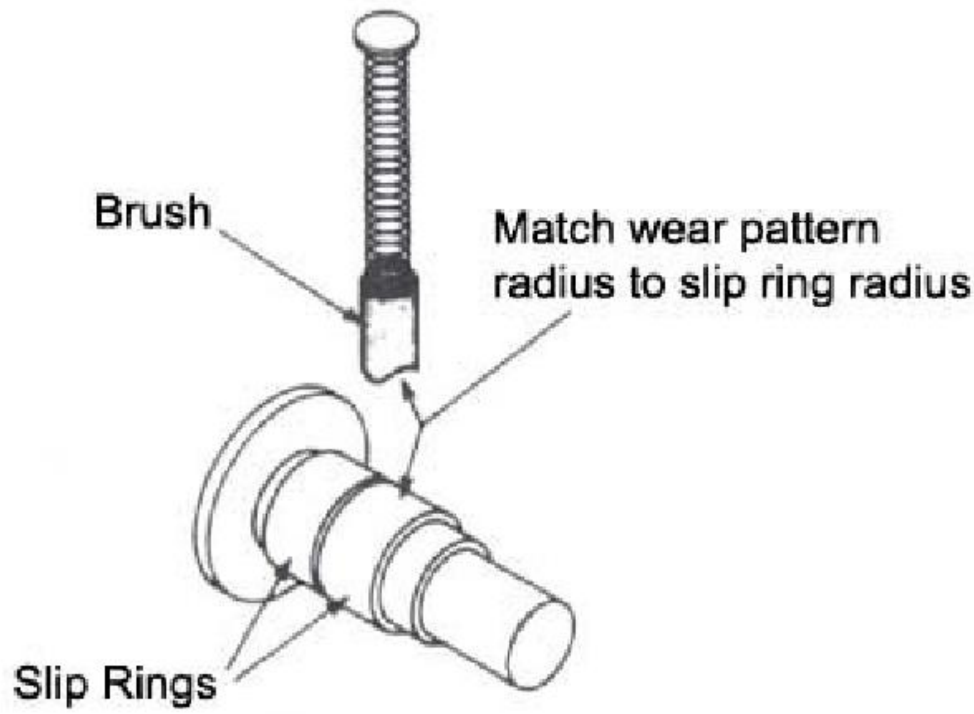


Figure 3

3. Insure that regulator gasket is in good condition and in position around the regulator circuit board. Align regulator with the holder so when installed the words "Leece-Neville" on the cover face away from the alternator.

Regulator Voltage Adjustment

NOTE: Before any adjustments are made insure that the batteries, terminal, wiring, and alternator drive belt(s) are in good working condition, and are properly tightened. Batteries must be at least 95-100% charged.

1. "Flash" field as follows:

With the engine off, connect a short jumper to the alternator NEGATIVE output terminal and to a piece of stiff wire or 1/16" drill. Insert the drill in the "full field access hole" as far as it will go for 1-2 seconds. This will restore the residual magnetism in the rotor (Figure 4).

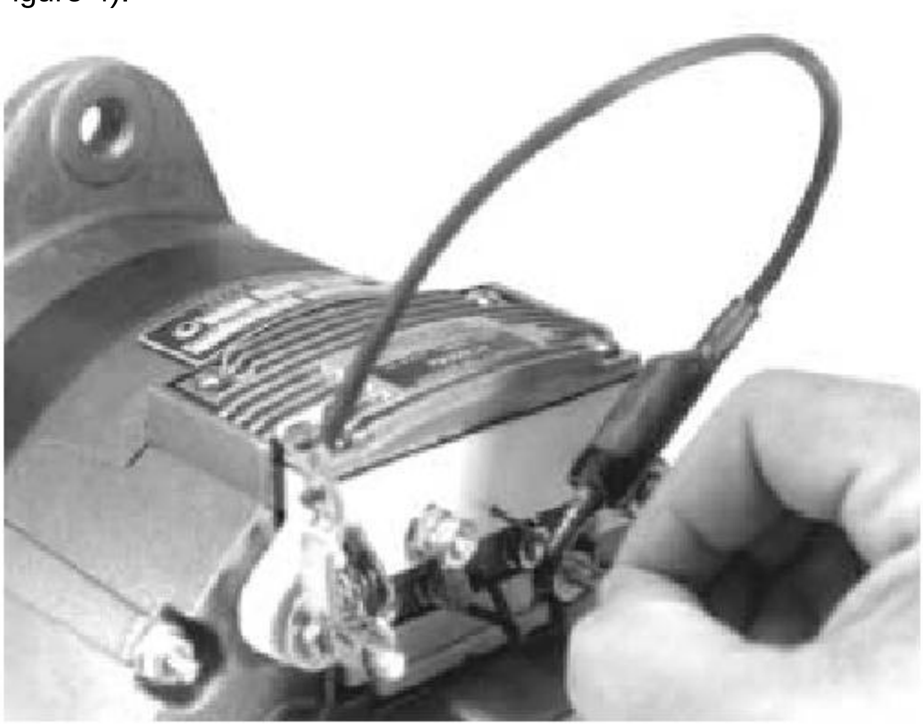


Figure 4

2. Run engine at 1000-1200 rpm with an accurate voltmeter connected across the battery terminals and make a note of the voltmeter reading. Compare to vehicle manufacturer's voltage setting specification. If voltage is outside values specified, the continue with instructions listed below for adjusting regulator.

Regulator Adjustment

1. Stop engine and disconnect battery ground cable.
2. Remove #10-32 nuts and lockwasher from regulator terminal and disconnect diode trio
lead (if alternator is equipped with a diode trio), or the jumper wire connected to the A/C tap.
3. Remove the four screws from the regulator cover. Lift regulator out of housing and move it out of the way as far as the leads will permit. Inspect the two regulator brush contact pads. If dirt or corrosion is noticed then clean pads with #600 sand paper (or finer) (Figure 5).

NOTE: In some cases dirty or corroded pads can cause a low charge condition, and voltage adjustment may not be necessary.

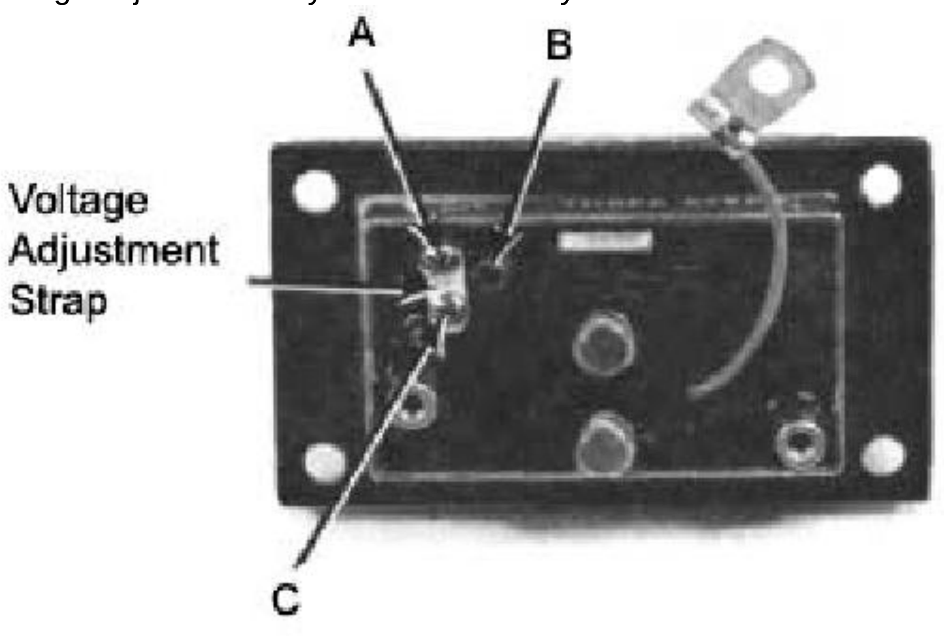


Figure 5

4. Inspect and reinstall brushes as described in "Regulator Removal" and "Regulator Installation" sections in this instruction sheet.
5. To adjust voltage remove and reinstall voltage adjustment strap in any of the three positions available: A & B (High), A & C (Medium), or C & B (Low).

Each change in position of adjustment strap will result in an INCREASE or DECREASE in voltage of approximately .4 volts.

Example:

a) Voltage at battery with engine at 1000-1200 rpm 13.6 Volts

b) Vehicle manufacturer spec. for voltage setting 14.0+ .1 Volt

c) Voltage adjustment strap position A & C

Necessary Adjustment: Voltage adjustment strap should be changed to "C & B" position to increase voltage by (approximately) .4 volts to 14.0 volts.

Regulator Static Test Values

For static (bench) test purposes the regulators are factory set at the following: Low 13.60
+ .15, Med 14.00 + .10, High 14.40 + .15. These values should not be confused with voltages above which are taken at the battery and will vary due to voltage drops.

CAUTION: *Recommended torque for the #4 cross head screws used for securing voltage adjustment strap is 4-5 in. lbs. Overtightening these screws may cause them to break and the regulator would become unusable*.

6. Complete regulator installation as described in "Regulator Installation" section.

7. Reinstall battery ground cable and repeat Steps 1 and 2 in "Regulator Voltage Adjustment" section to insure proper voltage.

8. Place regulator in holder. Apply a small amount of downward pressure on the regulator and REMOVE PIN from access hole to release brush springs. Hold down regulator and secure it with four #8-32 x 7/16" long screws (Figure 6).

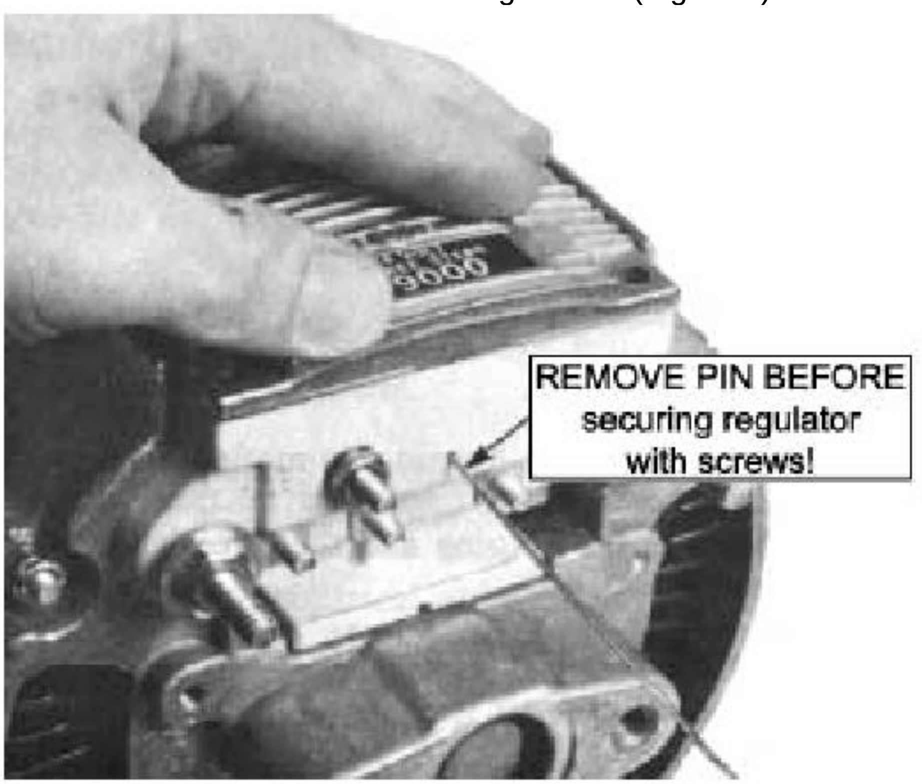
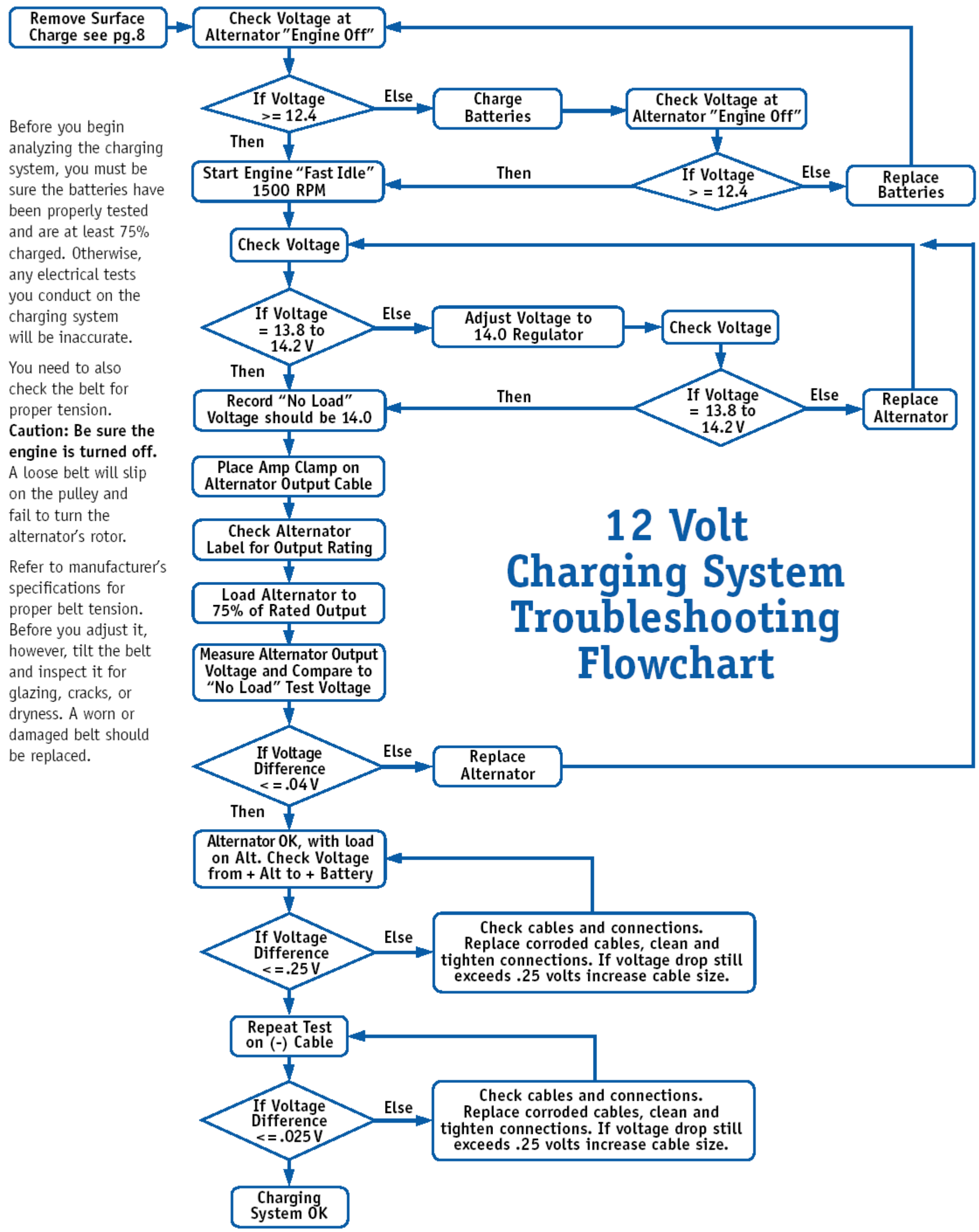


Figure 6 **CAUT**

ION: *The pin used to retain the brushes during regulator assembly MUST BE REMOVED BEFORE the regulator is secured to avoid regulator damage. WARRANTY IS VOID ON ANY REGULATOR RETURNED WITH "PIN" DAMAGE!*

9. Reconnect ground cable to battery.



ADDITIONAL INFORMATION

1. Web Sites

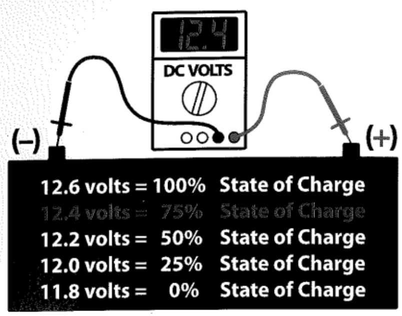
www.acdelco.com
www.centralstatesbus.com
www.delphi.com
www.exide.com
www.littlefuse.com
www.hgmakelim.com
www.interstatebatteries.com
www.penntexusa.com
www.prestolite.com
www.thomasbus.com

2. Voltage Drop Test

H.G. Makelim Co.

Alternator & Starter Voltage Drop Tests

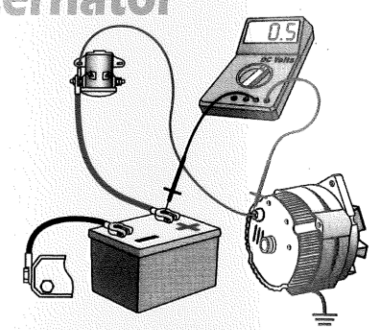
USING DVOM TO TEST A BATTERY'S STATE OF CHARGE



IN ORDER FOR ALTERNATOR & STARTER TO FUNCTION:

Battery must be at 12.4 volts minimum
All connections must be metal to metal, clean and tight

Alternator



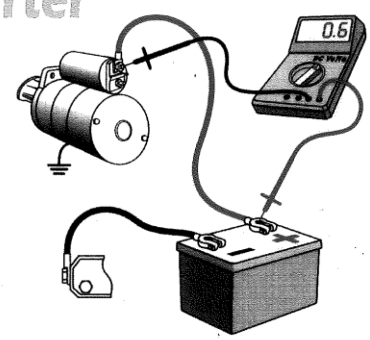
ALTERNATOR VOLTAGE DROP TEST (+) SIDE
- Battery must be fully charged: 12.6 volts
  - Voltmeter (+) lead to alternator B+ bolt
  - Voltmeter(–) lead to battery (+) post
  - With engine running at high RPM, all loads on, record_______V/Drop

NOTE: Should not exceed 0.5 V/Drop

ALTERNATOR VOLTAGE DROP TEST (–) SIDE
- Voltmeter (+) lead to battery (–) post
- Voltmeter (–) lead to alternator case
- With engine running at high RPM, all loads on, record_______V/Drop

NOTE: Should not exceed 0.3 V/Drop

Starter



STARTER VOLTAGE DROP TEST (+) SIDE
- Battery must be fully charged: 12.6 volts
- Disable fuel or ignition
  - Voltmeter (+) lead to battery (+)
  - Voltmeter(–) lead to starter B+ stud
  - While cranking, record_______V/Drop

NOTE: Should not exceed 0.6 V/Drop

STARTER VOLTAGE DROP TEST (–) SIDE
- Voltmeter (+) lead to starter case
- Voltmeter(–) lead to battery (–)
- While cranking, record_______V/Drop

NOTE: Should not exceed 0.3 V/Drop

ENGINE SYSTEMS

DIESEL ENGINES

1. Purpose

All type A, B, C, and D buses equipped with a diesel engine must conform to CDE and FMVSS standards for the year of vehicle manufactured. Re-powers must meet or exceed the same standards.

Diesel engines provide low RPM-high torque power with fuel efficiency. The vehicle must be geared to allow engine RPM to be maintained within the manufactures specification at all times.

Diesel engines must meet the Colorado Department of Health opacity requirements for the area they travel within.

NOTE: A diesel-powered vehicle traveling to an area where the opacity standards are more rigid than the Colorado Department of Health standards, must meet the stricter standards of that area.

Engine heaters may be installed in the block or coolant lines, or a thermostatically controlled engine lubricant oil pan heater may be permanently installed.

2. Inspection Procedure

- Check thoroughly for oil leaks.
- Check thoroughly for fuel leaks.
- Inspect fuel lines for wear, cracking, kinking, etc.
- Check air cleaner for restriction. Replace the filter or repair the restriction if it is more than 8 inches of water or it the manufacturer's maximum restriction specification occurs.
- Check for excessive smoking. All diesel engines must meet Colorado Department of Health standards set for the areas in which it travels (See above note).
- Check that the engine RPM's remain within the manufacturer's specifications at both maximum (high idle, if equipped) and idle speeds.
- Inspect motor mounts for cracks and broken, or missing, bolts. Check that rubber insulators have not deteriated and are not missing.
- Check that auxiliary components are securely mounted to the engine (ie: alternators, air compressor, starter, etc.).
- Cooling system inspection (See Section 10 on the Cooling System).
- Fuel system inspection (See Section 15 on the Fuel System).
- Exhaust system inspection (See Section 14 on the Exhaust

System).

- Inspect drive belts for proper adjustment, and replace if worn or cracked.

DIESEL ENGINE TROUBLESHOOTING

1. **Engine Fails to Start**

- Fuel tank empty
- Plugged filter or fuel lines
- Defective transfer pump or injection pump
- Air in fuel lines
- Low cranking speed
- Glow plugs not functional
- Defective engine kill solenoid, wiring, or cable
- Check oil level (International)

NOTE: Do not use starting fluid on engines equipped with glow plugs or intake heaters!

2. **Engine Starts Hard**

- Cranking speed too low
- Improper fuel
- Water in fuel
- Improper injection timing
- Poor compression
- Glow plugs or glow system are not functional
- Engine block heater malfunctioning

3. **Low Power Output, No Smoke**

- Accelerator linkage travel restricted or out of adjustment
- Governor high idle adjustment incorrect (governor gap on 8.2 Detroit engines)
- Low fuel pressure
- Low fuel supply pressure
- Improper maximum fuel setting
- Air cleaner restriction
- Improper injection timing
- Exhaust system restriction
- Improper rack setting
- Fuel shut-down system adjustment

4. **Engine Smokes, Lacks Power**

- Air cleaner restricted
- Low compression in one cylinder
- Injection pump out of time

- Leaking injector nozzles
- Fresh air hose to cleaner not loose, disconnected or torn
- Injector spray pattern bad or clogged

5. White Smoke

- Cold temperature outside
- Long idle periods
- Poor fuel quality
- Air in fuel system
- Valve adjustment not correct
- Misfiring cylinder

6. Blue Smoke

- Indicates engine is burning oil
- Oil levels too high
- Valve guides / seals worn or defective
- Rings worn or defective
- Worn cylinder walls
- Worn or blown seals in the turbo or supercharger
- Wear or damage to pistons

7. Black or Gray Smoke/Engine Runs Smooth

- Indicates engine may be running rich
- Engine under load
- Air cleaner restricted
- Improper valve adjustment
- Fuel injection timing is incorrect
- Poor fuel quality
- Exhaust restriction

GAS ENGINES

1. Purpose

All type A, B, C, and D buses equipped with a gasoline engine must conform to CDE and FMVSS standards for the year of vehicle manufactured. Re-powers must meet or exceed the same standards.

Gasoline engines provide torque power through internal combustion. Vehicles must be geared to allow engine RPM's to be maintained within manufacturers specifications at all times.

Engine heaters maybe installed in the block or coolant line, or a thermostatically controlled engine lubricant oil pan heater may be permanently installed.

Gasoline powered vehicles must meet Colorado Department of Health Emission requirements for the areas they travel within.

NOTE: A gasoline powered vehicle traveling to an area where the Air Care Colorado emissions testing program is enforced does not have to comply with the program rules for an occasional trip. However, there are two exceptions - visible smoke and traveling within the nine-county Air Care Colorado program area (basically Denver, Boulder and the northern Front Range) more than 90 times per year.

2. Inspection Procedure

- Check thoroughly for oil leaks.
- Check thoroughly for fuel leaks.
- Inspect fuel lines for wear, cracking, kinking, etc.
- Check air cleaner for restriction. Replace the filter or repair the restriction if it exceeds the manufacturers maximum restriction specification.
- Check for excessive smoking. All vehicles operating within the nine-county Air Care Colorado program area must meet the Colorado Department of Health standards for the area in which they travel (see also above note).
- Check emissions controls. All vehicles must be equipped with the factory installed emission controls and they must all be operational.
- Inspect motor mounts for cracks and broken, or missing, bolts. Check that rubber insulators have not deteriorated and are not missing.
- Check that auxiliary components are securely mounted to the engine (i.e.: alternators, air compressor, starter, etc.).
- Cooling system inspection (See Section 10 on the Cooling

System).

- Fuel system inspection (See Section 15 on the Fuel System).
- Exhaust system inspection (See Section 14 on the Exhaust System).
- Inspect drive belts for proper adjustment, and replace if worn or cracked.
- Perform all tune-up procedures in accordance with the manufacturer's procedure.

GAS ENGINE TROUBLESHOOTING

1. **Engine Fails To Start**

   - Fuel tank empty
   - Plugged filter or fuel lines
   - Defective carburetor (if equipped)
   - Defective fuel pump
   - Primary or secondary ignition

2. **Engine Hard Starting**

   - Cranking speed too slow
   - Incorrect ignition timing
   - Poor compression
   - Carburetor needs adjustment (if equipped)
   - Low fuel pressure

3. **White Smoke**

   - Cold temperatures outside
   - Valve adjustment
   - Blown head gasket
   - Defective vacuum modulator

4. **Blue Smoke**

   - Oil levels too high in engine
   - Worn valve guides or seals
   - Worn rings

5. **Electrical Ignition System – Engine Fails To Start**

   - Module defective
   - Insufficient voltage
   - Faulty wiring harness
   - Computer components defective (if equipped)
   - Pick up coil broken or defective (if equipped)
   - Rotor shorted or defective
   - Spark plugs or wires faulty

ADDITIONAL INFORMATION

Web Sites

www.aircarecolorado.com
www.cat.com/maintenance-and-support
www.cummins.com
www.deere.com
www.detroitdiesel.com
www.donaldson.com
www.hortonww.com
www.internationaltrucks.com
www.pacbrake.com
www.thomasbus.com

NOTE:

CAT - Register for your account at www.cat.com/on-highway-transportation
If you have problems contact your local CAT rep.

EXHAUST SYSTEM

General Components .... Page #

EXHAUST SYSTEM

1. Purpose

All type A, B, C, and D school buses must have an exhaust system capable of directing the discharge of harmful combustion fumes to the atmosphere and must conform to Colorado Minimum Standards, 301-25, for the year of vehicle manufacture.

Exhaust pipe, muffler, and tail pipe shall be outside the passenger portion of the bus body and attached to the chassis.

2. Inspection Procedure

- **Hangers**
  Exhaust system may use hangers, which permit required movement due to expansion and contraction caused by heat of the exhaust and relative motion between the engine and chassis of the bus.

- **Muffler**
  Muffler shall be heavy-duty truck type of aluminized or stainless steel, or ceramic coated to offer maximum resistance to corrosion or oxidation. Exhaust backpressure shall not exceed the engine manufacturer's maximum requirement for that make/model.

- **Emissions Control Systems**

  DOC - Diesel Oxidation Catalyst
  Must offer maximum resistance to corrosion or oxidation. Exhaust backpressure shall not exceed the engine manufacturer's maximum requirement for that make/model and must meet standards for vehicle year if installed by manufacturer. DOC replacement is not required if properly maintained unless there is a component failure.

  DPF - Diesel Particulate Filter
  Computer controlled device that has a series of warning lamps to indicate defective equipment. See manufacturer service manual for specific details and must meet standards for vehicle year if installed by manufacturer.

WARNING: REMOVAL OF EMISSIONS CONTROLLED SYSTEMS IS PROHIBITED IF FACTORY INSTALLED.

- **Tail pipe**
  Tail pipe shall be constructed of seamless or electrically welded tubing of 16 gauge steel or equivalent, and shall extend at least five inches beyond chassis frame with sufficient length to reach the bumper or to the left side of bus, but not to extend beyond the rearmost part of the bumper.

  Where frame is extended to rear bumper, 5-inch extension is not required. Type A school buses may have exhaust pipe route to right or left behind rear axle. Diameter of tail pipe shall not be reduced after it leaves the muffler. The rear end of the tail pipe must be located at least 20 inches to the right or left of the centerline of the chassis. Baffle style tail pipe can be used with DPF application.

NOTE: Exhaust temps can reach up to 1200 degrees Fahrenheit while in the regeneration cycle.

- **Shields**
  Exhaust system shall be insulated from fuel tank and fuel tank connections by a securely attached metal shield at any point where it is 12 inches or less from the fuel tank or fuel connections.

3. Repair Procedure

No part of the exhaust system may be temporarily repaired with wrap or patches. No part of the exhaust system shall leak or discharge at any point forward of or directly below the driver/passenger compartments.

The exhaust system must be securely fastened to the vehicle.

ADDITIONAL INFORMATION

Web Sites

www.aircarecolorado.com
www.airflo.com
www.catalyticexhaust.com
www.cumminsfiltration.com
www.dieselnet.comwww.donaldson.com
www.enginecontrolsystems.com
www.freightlinertrucks.com
www.internationaltrucks.com
www.mandrelbending-tubefabrication.com
www.nelsonexhaust.com

FUEL SYSTEM

FUEL SYSTEM

1. Purpose

The typical fuel system consists of a storage tank, transfer pump, lines and filter(s), and a way to meter exact amounts of fuel. The fuel system must conform to Colorado Minimum Standards and FMVSS for the year of vehicle manufacture.

- **Fuel tank**
  Fuel tank shall be filled and vented entirely outside the passenger compartment. Type B, C, and D buses shall have a drain plug of at least 1/4 inch in diameter and shall be located in the lowest level of the tank.

  No fuel supply line shall be mounted below the fuel tank. Fuel tank shall be securely mounted and have an approved cage (where required).

- **Fuel filters**
  Fuel filters are used to keep the fuel as clean as possible at all times.

- **Transfer pump**
  The transfer pump moves fuel from the storage tank to the rest of the system at low pressure. Depending on manufacturer's preference, several types of pumps can be used and may be part of the injection pump or it can be a separate unit.

- **Injection pump/injectors**
  The injector pump and/or injectors must perform the following tasks:
  - Measure (meter) exact amounts of fuel.
  - Time the instant of fuel injection.
  - Control the rate of fuel mixture.
  - Break up (atomize) fuel into tiny particles.
  - Distribute the metered/atomized fuel to the engine’s individual combustion chambers.

- **Lines**
  Fuel lines may be metal or an approved flexible hose. Every fuel line must be long enough and flexible enough to accommodate normal movements of the parts to which it is attached without incurring any damage. Lines must be secured against kinking or other causes of mechanical damage.

2. Inspection Procedure

Check for fuel leaks.
Check fuel tank mounting/cage/shields.
Check fuel lines for proper routing and condition.
Check filler cap seal and retaining chain if applicable.

ADDITIONAL INFORMATION

Web Sites

www.dieselnet.com
www.internationaltrucks.com

PARTS CONTROL SYSTEMS

General Components **Page #**

INVENTORY SYSTEMS

1. Purpose

The purpose of this section is to share ideas and introduce concepts that will aid in managing inventory, rather than simply keeping track of it. Any inventory control system that one uses will provide answers to these questions:

What do we have on hand?
How much have we used and where?
How much did it cost?

An inventory management system, however, incorporates all of the control data to answer questions like:

What do we need?
What haven't we used?
How can we save?"

2. Inventory Carrying Costs

One widely cited estimate of inventory carrying costs is approximately 25 percent per year of the total value. So if an inventory's total value is $10,000.00, it costs an additional $2,500.00 per year to **hold** it on a shelf. The components used to arrive at this figure are as follows:

Insurance	0.75
Storage facilities	0.25
Taxes	0.50
Transportation	2.00
Handling costs	5.00
Depreciation	2.50
Interest	6.00
Obsolescence	8.00
TOTAL	25.00%

NOTE: Components may vary, such as taxes (most school districts are tax exempt) and interest. Despite these variables, the carrying costs are substantial.

3. Computerized Systems

Regardless of the size of the fleet, maintenance requires parts inventory, and a system to manage it. A computerized system is advisable if:

The inventory is in more than one location.
The fleet is large enough to make parts tracking and cost analysis difficult.
When the cost of the system justifies the efficiency it will create.

4. Inventory Parameters

Parts inventory parameters are the same in computerized or manual systems.

- **Part Number**
  Any number that defines that part, such as a manufacturer's number or your own system number.

- **Part Description**
  Brief definition and application (i.e.: air compressor leak kit, recapped tire).

- **Location**
  Where the part is (i.e.: basement, shed, row 5 bin 2).

- **Cost**
  Should reflect current cost and if possible, indicate a price history.

- **Vendor**
  Preferred source. Vendors will often work with you to stock items that you order from them. They also need to be made aware of state bid prices and fleet discounts, to negotiate the best price. Always use reputable vendors.

- **Usage History**
  Should indicate how often the part is used and on what types of vehicles. Usage history and cost are necessary to determine cost per mile analysis.

5. Inventory Factors

One of the difficult things to determine in parts inventory is what to stock, and how many. The review cycle, the time between order dates, can be managed so that the order frequencies are based on ordering the minimum size required to get the best terms. Suggested factors for determining what parts to stock and stock amounts are:

- **Cost**
  Need to balance the necessity of the item against the cost. If you choose not to stock an item for cost reasons have an available

source for when you need it.

- **Critical**
  Safety aspect of the part. Although, an air compressor governor may be changed infrequently, a vehicle can't safely be driven without it, so it is usually stocked.

- **Lead Time**
  The amount of time the part takes to get in once it has been ordered.

- **Frequency of Use**
  Stock used in preventative maintenance checks, service intervals, and other established needs.

- **Review Cycle**
  Parts needed more than twice during its determined review cycle, should be stocked. Different parts may have different review cycles.

- **Shelf Life**
  Certain parts (tires, hoses, batteries, belts, DEF) have a shelf life. Be aware of your expiration times and frequency of use. You may need to adjust your maximum inventory levels.

6. Parts Stocking Suggestions

- Parts that are available from nearby sources need not be stocked.

- Add or reduce inventory levels at the time of vehicle additions or disposal.

- Have rebuilt components in stock to reduce downtime.

- Establish a good rapport with your vendors. They can be very helpful.

- The higher the cost of an item the shorter the review time and the smaller the order.

- Minimize number of suppliers.

- Decentralization keeps the buyer closer to the inventory resulting in shorter review cycles and lead times.

TIRE TRACKING

1. Purpose

Tire tracking can be a very useful tool to a school district as we are all aware of the rising costs of tires. It is important to remember that sizes of fleets may differ substantially and the use of tire tracking and its value may vary from district to district. There are many different kinds of tires and many variables to consider when tracking tires such as:

Types of Roads	Weather
Types of Terrain	Type of Bus
Drivers' Tendencies	Wheel Position
Types of Tires	

Tire tracking can be done either manually or by computer if your software is set up to do so. Choose a method that works best for your district to see how tires are wearing and what they are costing. The cost of tires can be tracked by either cost per 32nd of tire tread or cost per mile.

NOTE: At the end of this section is a sample form used by various school districts that may be beneficial.

2. Manual/Computer Tire Tracking

In most cases, the reason for tracking tires manually is lack of access to a computer program to do so. Although manual tire tracking is slower, it is still important to determine the best performance of the tire.

Tire tracking by computer can be very beneficial for several reasons:

- Speed.
- Access to records.
- Computer generated printout of cost and usage that computes cost automatically instead of manually.
- Accuracy.

3. Cost Per Mile (CPM)

The cost per mile is determined by dividing the price of the tire (minus any retread value) by the total mileage.

Example:	New tire price……	$246.93
	Minus residual casing value……	-35.00
	Equals cost of tire……	$211.93
	Divided by total miles……	20988

Equals CPM…………………………………….....$0.01/mile

4. **Cost Per 32nd**
   The cost per 32nd is determined by dividing the price of the tire (minus any retread value) by the 32nd's of tread use.

   Example:

   New tire price……………………………………..$246.93
   Minus residual casing value…………………….. –35.00
   Equals cost of tire……………………………….$211.93
   Divided by 32nds of tread used
   (24 new, 6 replaced)………………………………18
   Equals cost per 32nd ……………………...……$11.77/32nd

NOTE: Cost per 32nd is most useful when comparing the performance of specific brands or types of tires.

COST NEGOTIATIONS

1. Negotiations

Positive supplier relationships through courtesy and impartiality are part of good negotiating. District purchasing agents demonstrate loyalty and enhance their proficiency by maintaining current technical knowledge and high standards of ethics. Here are some negotiating points for success:

- Be flexible.
- If necessary, compromise.
- Don't leave any details until later.
- Don't negotiate on the phone, if you can do it in person.
- Time pressure could cause you to lose.
- Always maintain the power to walk away.
- Always document your agreements.

2. State Bids

There is also the option of using the state bid awards to purchase parts. This is done by the State of Colorado, Division of Purchasing and some of the items are throughout the state. You can receive copies of these awards by calling the State Purchasing Division at (303) 866-6464. Currently there are bids available for the following:

- Batteries
- Tires (statewide)
- Vehicles
- Parts
- Fluids

The parts bid is with many vendors and lines, and there is a copy of the vendors currently participating. The bid itself is simple to understand and is usually good for one year. The parts bid in the metro area has more than one vendor, giving you an option on the brand and price you want to use. These are just price agreements and other suppliers may be checked to make sure it's the best deal for your district.

GENERAL

1. Vehicle Cost Per Mile Formula

Costs per year divided by the annual mileage. Vital fluids, fuel, preventative maintenance and repairs should be computed separately for clearer comparisons and trouble-shooting. It is easy to see how these analyses can help to set and achieve fleet goals. Spot failure in parts or design and success in requesting assistance from manufacturers.

Example: A school bus (a 48 passenger wheel chair bus) traveled 11564.0 miles in a year. This vehicle cost $1191.70 during preventative maintenance and services and an additional $1309.69 in repairs during the school year. Total cost (parts and labor) was $2501.39 (2501.39 divided by 11564 = .216) so this vehicle cost $0.22 per mile for maintenance. This same vehicle averaged 6 miles per gallon of fuel. The average price for fuel for that year was $0.65/gallon. So the fuel cost was $0.11 per mile. This vehicle cost $0.33 per mile in fuel and maintenance. Vital fluids for this vehicle (oil, antifreeze and additives) cost $57.60 or approximately 2.25 % of the total annual costs.

2. Warranties

Part warranties will often pay for themselves. For example, there is a new alternator on the market that fits most buses. It has a two-year warranty, with limited mileage, including removal and installation.

- **Tracking Warranties**
  There are different ways to track warranties, manually or electronically. Manual/computer spreadsheets (even magnetic wallboards for quick reference) can be updated and used. Some software programs have the capability to track warranties. Another idea is to attach a tag to the item or write warranty information on the item itself.

3. Failure Analysis

Occasionally a particular part will fail on a series of vehicles. Regardless of design flaws, inadequate parts, or any other reason, vehicle manufacturer warranties are implied. Sometimes another part or design flaw will make a part continually fail. For example, a block heater hose needed to be re-routed. Failure analysis requires documentation of the vehicles involved and work performed. Communication and cooperation among technicians, other districts and manufacturers are necessary.

4. Liabilities

Whenever you are purchasing parts or equipment, safety and liability must be considered first. You must also consider purchasing parts that are either OEM or aftermarket, taking into consideration the quality of the part, price, availability and warranties. When deciding on new or rebuilt parts replacement, make sure to first check on existing warranties.

5. Communication

When you are having trouble with a specific part, share you discoveries. School districts get better pricing for buying collectively and should be explored more often. Published state bids should be requested to indicate what a good price is. There are no benefits to keeping this information to yourself. If you are contemplating a change (like investing in a computer inventory system, alternative fuels, etc.) check with suppliers and other school districts. Ask questions, compare notes. Remember, the power of information is in sharing!

Visit the Colorado State Pupil Transportation Association web site at www.cspta.org to submit obsolete parts lists or any other communication you might deem important. The Colorado Department of Education supplies a list of certified vehicle manufacturers annually. Their web site can be found on the Additional Information page of this section.

There is ASE parts specialist certification available to counter people. There is testing on light duty and medium/heavy parts. Test times and locations can be found online at www.ASE.com.

ADDITIONAL INFORMATION

1. Web Sites

www.acdelco.com
www.carquest.com
www.cde.state.co.us
www.chalks.com
www.directbus.com
www.jasperengines.com
www.maesco.com
www.napaonline.com
www.necentral.net

2. Tire Tracking Form

TIRE INSTALL/REPLACE FORM

Bus Number: ____________________

Number of Tires: _________________ ___New ___Used ___Recap

Part Number:
____

Size: ___________________________ Brand: ________________________________

LF Serial #:______________________ RF Serial #: ___________________________

LRO Serial #:____________________ LRI Serial #: _________________________

RRI: Serial #:____________________ RRO Serial #: __________________________

LF Tread Depth: _________________ RF Tread Depth: _______________________

LRO Tread Depth: _______________ LRI Tread Depth: ______________________

RRI Tread Depth: ________________ RRO Tread Depth: _____________________

LF Tire Pressure: ________________ RF Tire Pressure: ______________________

LRO Tire Pressure: _______________ LRI Tire Pressure: _____________________

RRI Tire Pressure: _______________ RRO Tire Pressure: _____________________

Mechanic: ______________________ Hours:_________________________________

ELECTRICAL RETARDERS

RETARDERS

1. Purpose

Retarders may be used for descending grades, in city traffic, approaching stoplights, and in general, wherever vehicle slowing is required. This leaves the normal service brake system cooler for emergency stops and prolonging brake life. There are different types of retarders available; hydraulic, electric, and engine.

2. Electric Retarder

The electric retarder is a self-contained unit that fits in the driveline. It consists of a number of simple yet powerful electromagnets fixed to the retarder frame. When switched on, the electromagnets exert a very strong drag force on the two-iron disc (rotors) attached to the drive shaft of the vehicle. There is no actual contact so there is no wear.

The electric retarder operates on the eddy current principle. It is even simpler than an electric motor. Electric retarders use a number of powerful electromagnets to create a very strong force for reducing the vehicle motion.

The electromagnets are progressively switched on by a multi-position control mounted on the steering column, dashboard or connected with the brake pedal. The type that operates in conjunction with the brake pedal is automatic and functions when the operator begins to engage the brake pedal. The driver actuates the hand control manually. A monitor light comes on when the retarder is operated. A master switch turns the system on and off.

The electric retarder is available in different sizes and capacities.

The retarder system is composed of a control switch, a relay box, and retarder.

- **Control Switch**
  The control switch activates a relay for each stage of the retarder. This switch is not user serviceable and must be replaced as a unit.

- **Relay Box**
  The relay box switches power directly from the battery to the retarder. The user serviceable items in the relay box are the fuses, contacts, coils, power protective diode assembly, and indicator light protective diode assembly.

- **Retarder**

The retarder slows the driveline through the use of opposing magnetic fields. Repairs to the retarder consist of replacement of the bearings, seals, coils, and internal wiring repairs.

3. Maintenance

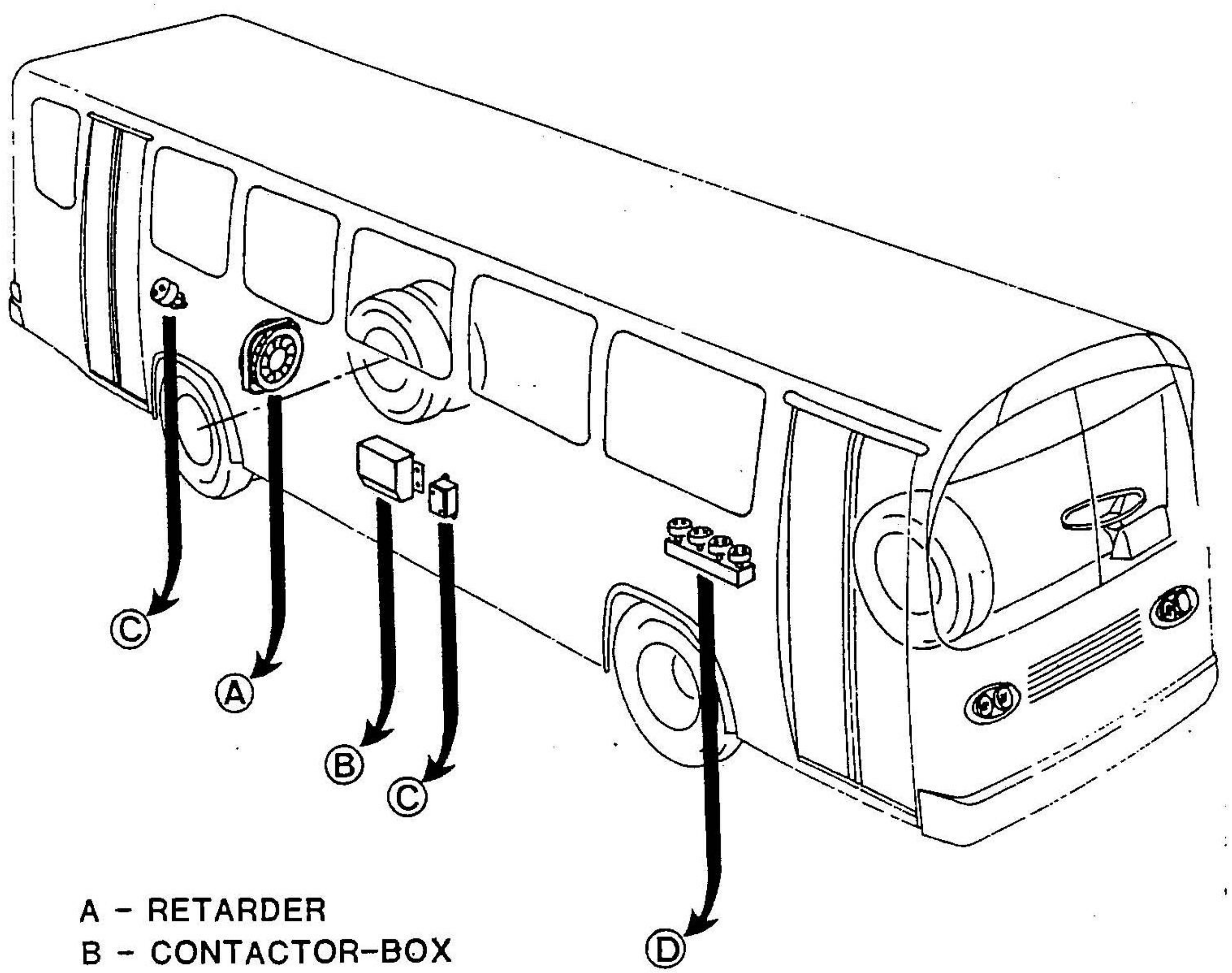
Maintenance of the retarder system consists of greasing the retarder, washing the retarder, and routine checking of the retarder system components.

4. Inspection Procedure

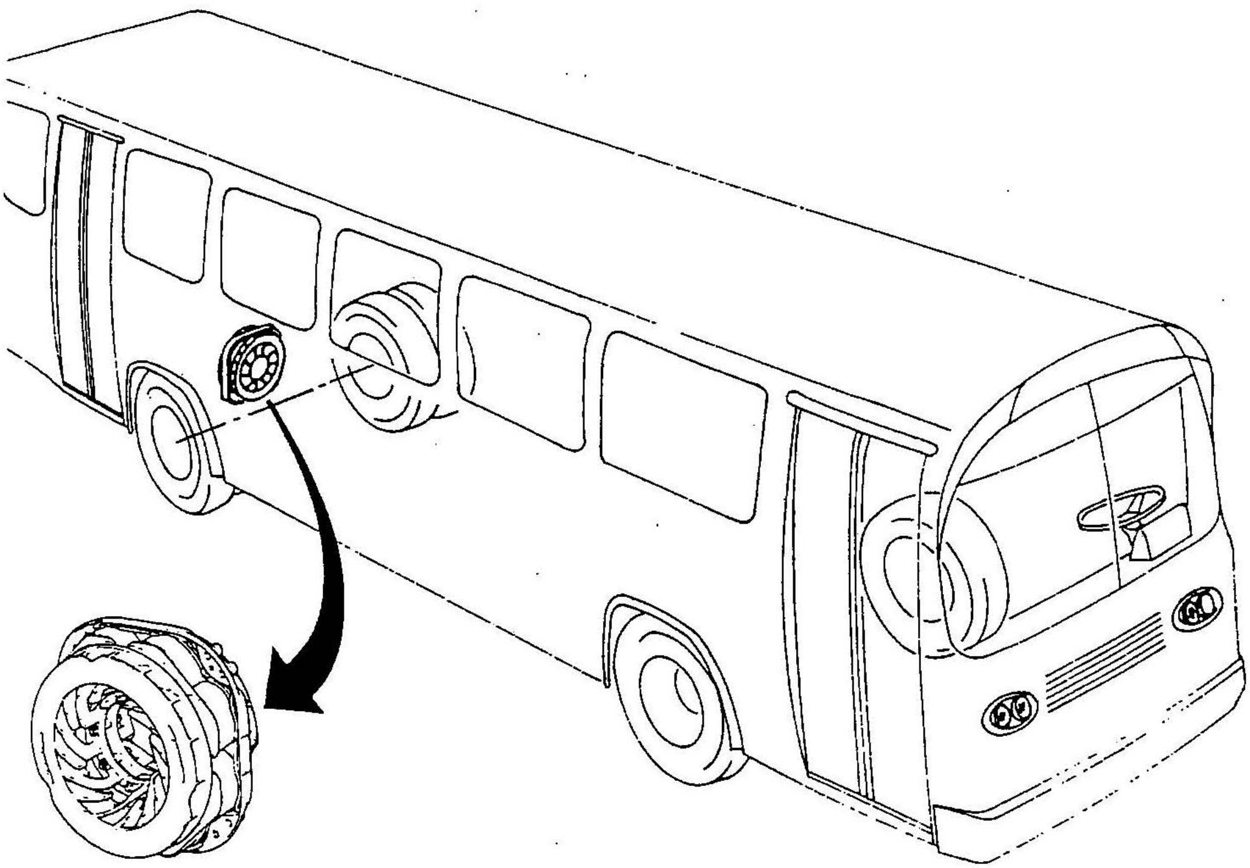
Check for abnormal rotor end play.
Check air gap.
Check for leaking seals.
Check U-joint condition.
Check retarder mounting, tightness, rubber shock mounts.
Check relay box and retarder ground connections.
Check relay box electrical connections and contact condition.
Check amperage draw of each stage.
Check light operation for each stage.
Check speed switch if applicable.

NOTE: Always road test for proper operation.

TABLE OF CONTENTS



A - RETARDER



I - ELECTRICAL CHARACTERISTICS
II - RESISTANCES CHECKING
III- CURRENT MEASUREMENT
IV- MAINTENANCE

FOCAL 130 : FB 331 _ _ _ FOCAL 155 : FC 311 _ _ _

FOCAL 170 : FD 311 _ _ _ coupling index

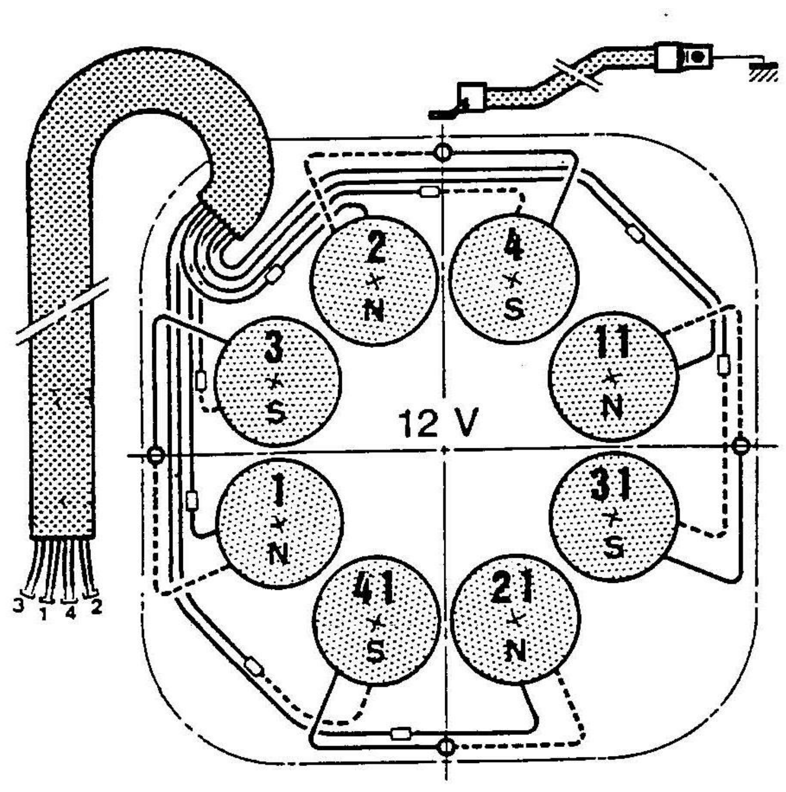
ELECTRICAL DATA

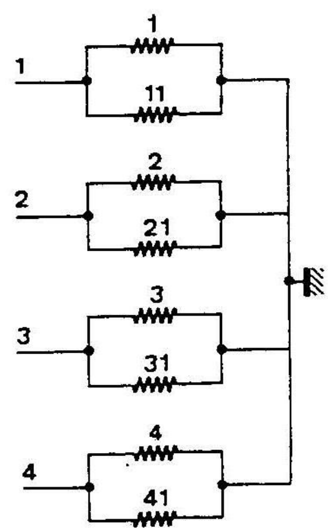
OPERATING VOLTAGE : 12 Volts only

INSULATION : ≥ 1MΩ

RETARDER TYPE	AVERAGE AIR-GAP in MM	RESISTANCE EACH CIRCUIT AT 20°C	RESISTANCE OF EACH COIL	CURRENT ACCORDING TO CONTROL SELECTION			
				1	2	3	4
FOCAL 130	1,3	0.240 Ω ±5%	0,480 Ω ±5%	50	100	150	200
FOCAL 155	1,9	0.231 Ω ±5%	0,462 Ω ±5%	52	104	156	208
FOCAL 170	1,4	0.231 Ω ±5%	0,462 Ω ±5%	52	104	156	208

INTERNAL CABLE LAYOUT 12 VOLTS





earth return

blue sleeve

red sleeve

FOCAL 130 : FB 332___   FOCAL 155 : FC 312 ___

FOCAL 170 : FD 312 ___

coupling index

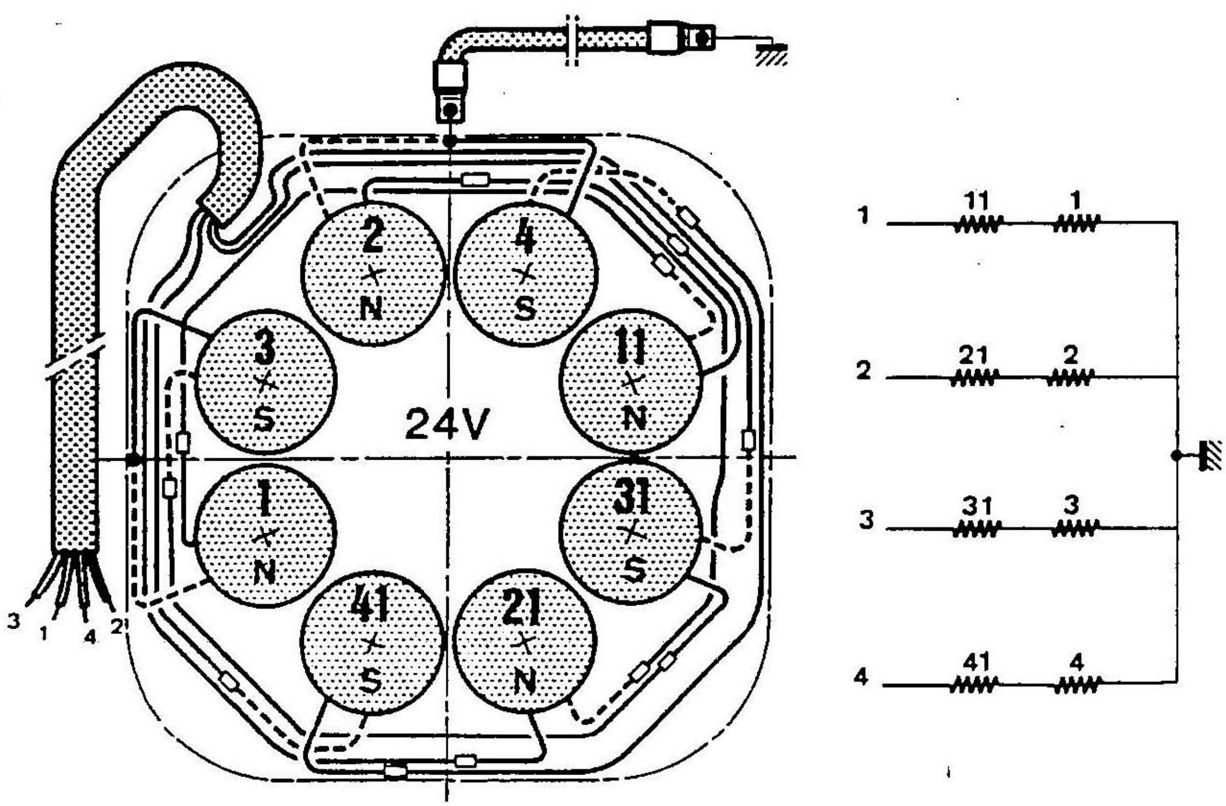
ELECTRICAL DATA

OPERATING VOLTAGE : 24 Volts only

INSULATION : $\geqslant$ 1MΩ

RETARDER TYPE	AVERAGE AIR-GAP in MM	RESISTANCE EACH CIRCUIT AT 20°C	RESISTANCE OF EACH COIL	CURRENT ACCORDING TO CONTROL SELECTION 1	2	3	4
FOCAL 130	1,3	0,960 Ω ±5%	0,480Ω±5%	25	50	75	100
FOCAL 155	1,9	0,924 Ω ±5%	0,462Ω±5%	26	52	78	104
FOCAL 170	1,4	0,924 Ω ±5%	0,462Ω±5%	26	52	78	104

INTERNAL CABLE LAYOUT 24 VOLTS



earth return

----- blue sleeve

—— red sleeve

II - RESISTANCES CHECKING

This check must be carried out with the battery disconnected.
It can be done :

- directly on retarder terminals
- on contactor box strip (Terminal M and successively I, II, III, IV)

The coil resistance can be found in the electrical characteristic chart. The resistance should be checked with an ohmmeter. The main check is to make sure all four circuits have the same indication.

III - CURRENT MEASUREMENT (Fig. 1)

This operation must be carried out when the retarder is energized. Short circuit terminals 4 and 5 of the stand still relay, so that the retarder can be energized while the bus is stopped.

- Connect a 200 A./100 mV shunt in series with the feeding cable (+) of the contactor box.
- Place the voltmeter on range 100 mV, so that the full scale will show a total current of 200 A.
- Energize the first position of the retarder and note current reading. Compare this value to the value on the retarder electrical characteristics chart (the value should be within 5%).
- When energizing the second position, the voltmeter will indicate double the current noted for position one. If a difference is noticed between the measured value and the one given on the chart, check all connections and resistances of the corresponding circuit.
- The 3rd and 4th positions are checked the same way.

ATTENTION : The current draw is very high in the retarder's last position. At this point a lower current could be read which may indicate a low battery. In this case measure voltage and current at the same time.
If an important voltage drop occurs, check the battery.

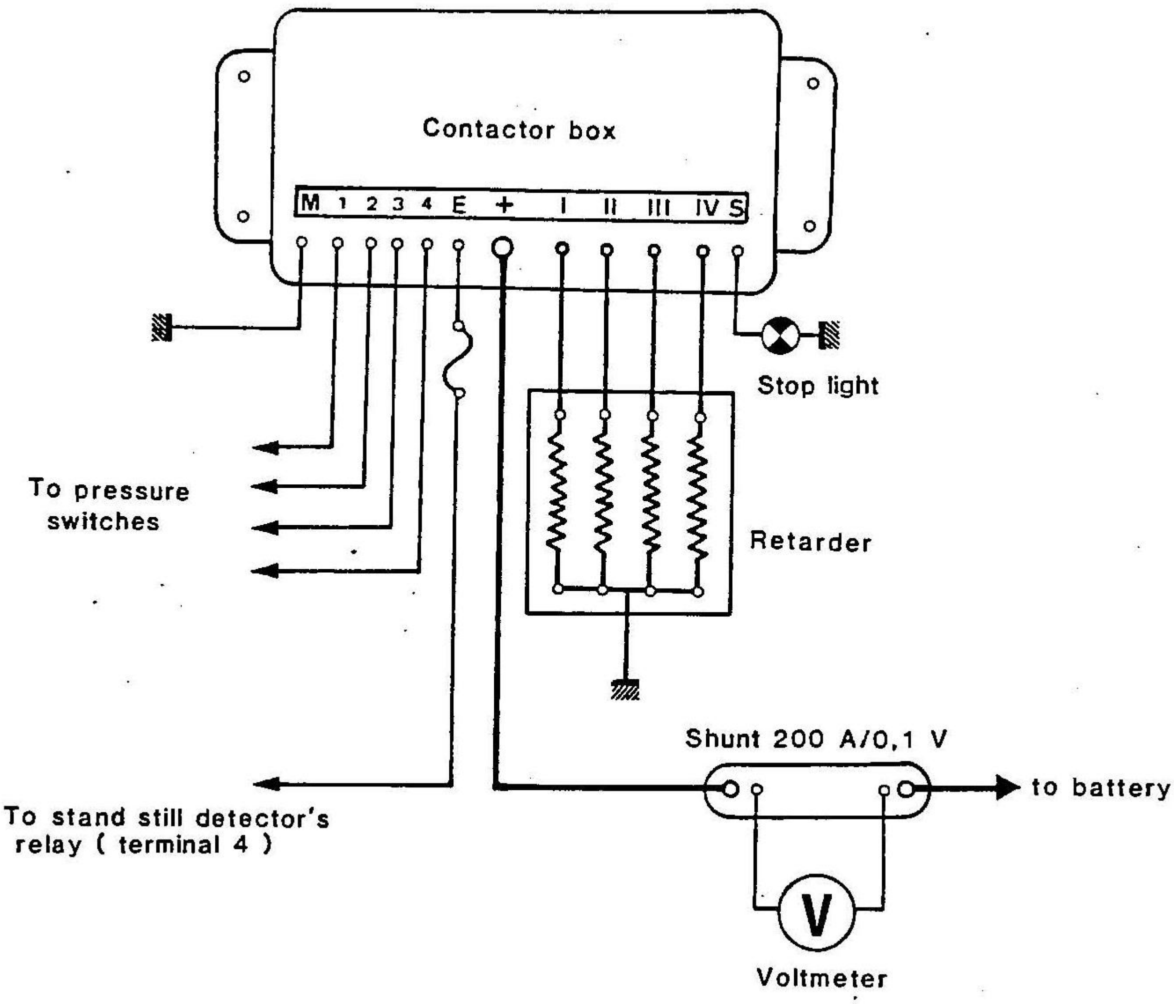

Contactor box
M 1 2 3 4 E + I II III IV S
Stop light
To pressure switches
Retarder
Shunt 200 A/0,1 V
to battery
To stand still detector's relay (terminal 4)
V
Voltmeter

FIGURE 1

IV - MAINTENANCE

It is recommended periodically to clean the retarder by using a jet of pure water in order to remove all traces of mud and grease.
This operation must be done when the retarder is cold.
The retarder should be then dried by using compressed air.

- Check tightening of all terminals, tighten if required.

- Check coils and their connections.

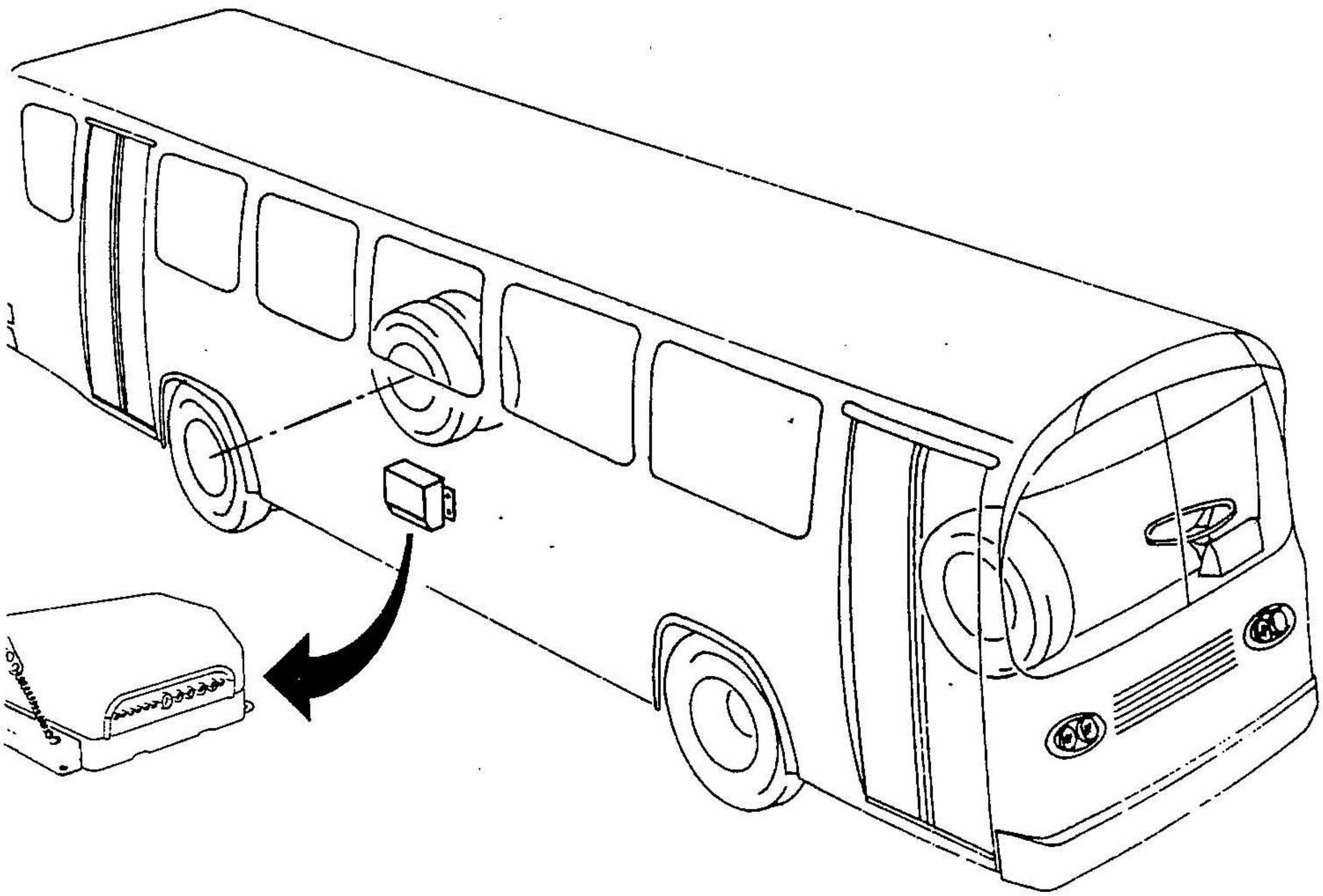
- Make sure that retarder harness is well attached to avoid any rubbing with moving parts.

- Check air-gap.

F 130	1,3 mm + 0 − 0,1	.051" + 0 − .004
F 155	1,9 mm + 0 − 0,1	.075" + 0 − .004
F 170	1,4 mm + 0 − 0,1	.055" + 0 − .004

The above air-gap is an average of all eight pole to rotor air-gaps.

B – CONTACTOR–BOX



I – DESCRIPTION
II – BASIC CIRCUIT DIAGRAM – OPERATION PRINCIPLE
III – MAINTENANCE
IV – ADJUSTMENT
V – CHECKING-REPAIR
VI – SPARE PARTS

I – DESCRIPTION

The contactor box consists of :

- 4 contactor relays(Fig. 2)
- 4 sets of protective diodes (Fig. 3)
- 1 connection strip (Fig. 2)

I.1 CONTACTOR RELAY

Each relay is composed of :

- a coil with protective diodes mounted parallel to the coil.
- a fixed contactor with built-in 50 AMP fuse (mounted at the end of the contactor).
- a moving contactor with a self-clearing system.

The closing on the relay is accomplished in two steps :
a) actuating
b) locking

Actuating brings the fixed and the moving contactor point into contact.

Locking generates a slight slipping and by that a cleaning operation occurs.

The spring R1 has to assure a free and fast return of the moving contactor during opening of the circuit. Spring R2 damps out any rebounding of the moving contactor during closing to avoid any damage of the points. (Fig 5) The anti-lock shim (S) ensures a quick release of the moving contact, by preventing any residual magnetic pull to delay the opening of the contacts, after the relay-coil is de-energized.

FIGURE 2

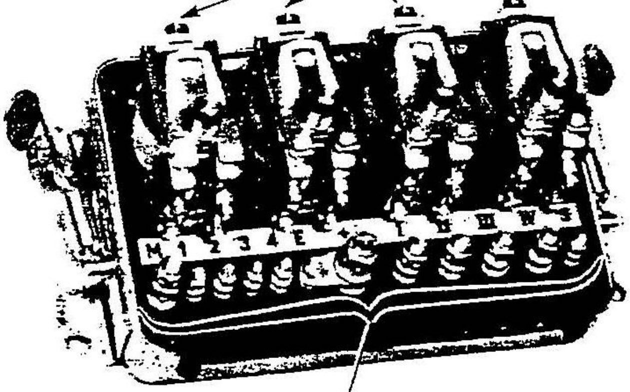


FIGURE 3

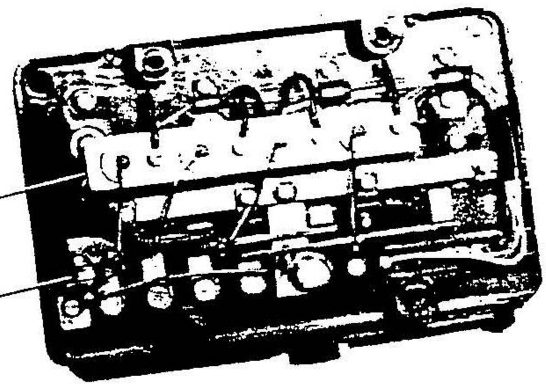


FIGURE 4

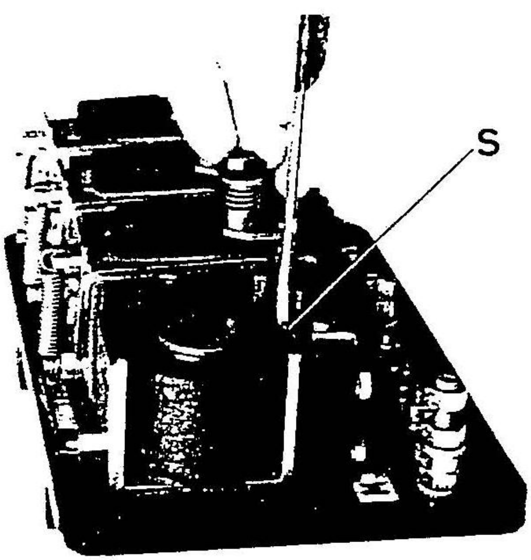
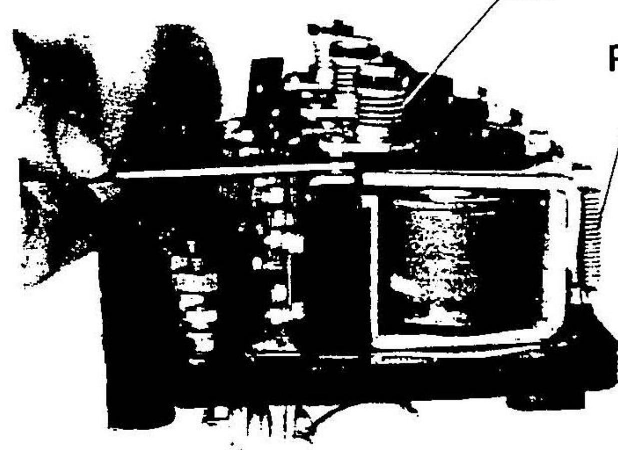


FIGURE 5



I.2 PROTECTIVE DIODES

Four set of diodes are mounted in the contactor box.

a) - Pressure switches protection diodes (Fig. 6)

Connected in parallel with the contactor coils, anodes to the ground, these protect the pressure switches against self-induction generated by the coils,when opening the circuit.

b) - Zener diodes (Fig. 6)

Zener diodes ensure a rapid opening of the moving contactors and avoid the contactor points from being damaged by sparks generated when the circuits open.

c) - Power contactors protective diodes (Fig. 7)

These are fixed on a heat sink located under the contactors support. They are connected in parallel with the retarder coils through the external harness and the connection strip (terminals I to IV).

d) - Stop light diode (Fig. 8)

Located under the contactors support, it prevents the positive polarity from going to the retarder circuit when the stop lights of the vehicle are energized through the brake pedal. (In case of connection between terminal 5 and stop light)

FIGURE 6

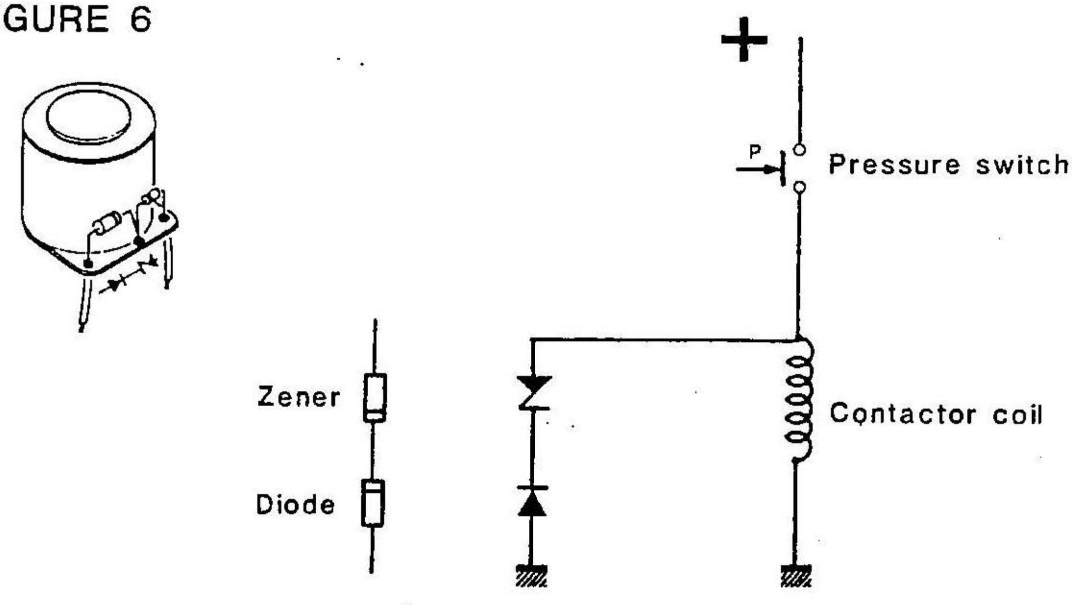


FIGURE 7

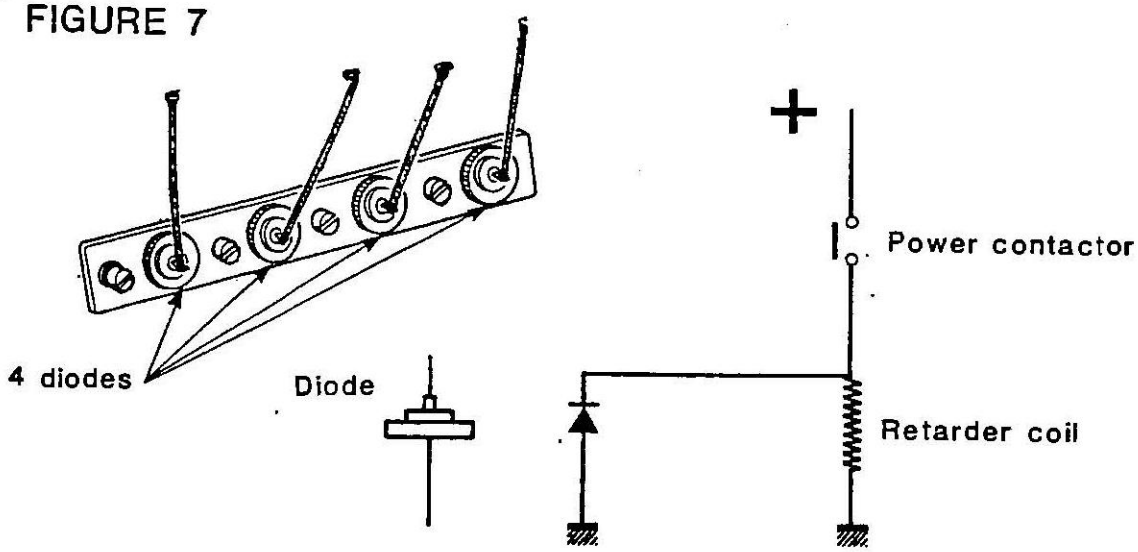
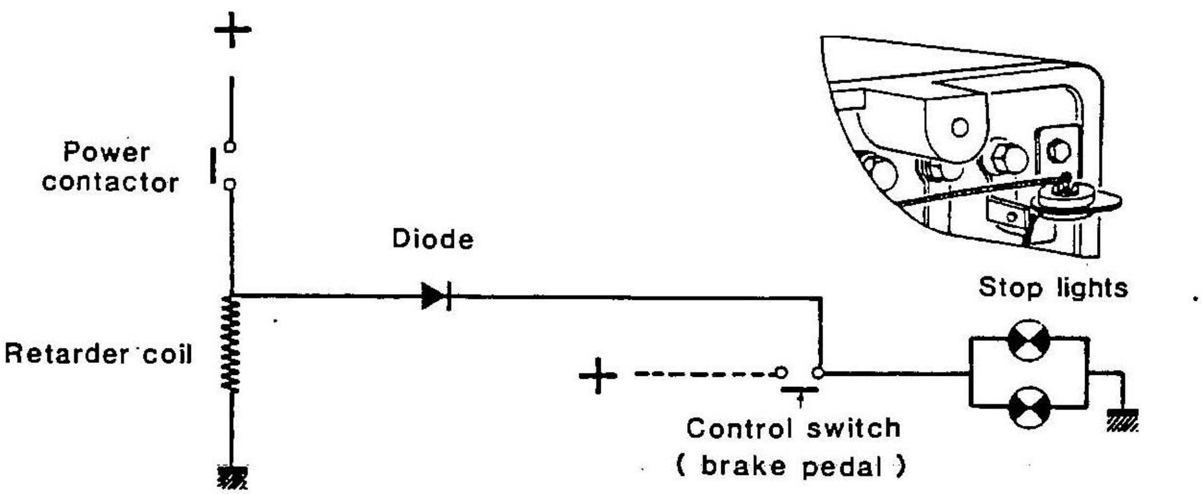


FIGURE 8



1.3 CONNECTION STRIP (Fig. 9)

M = Ground terminal

1 to 4 = Connecting terminals of harness coming from pressure switches

E = Feeding of the electronic speed switch

+ = Positive lead connected to the battery

I to IV = Connecting terminals of retarder harness

S = Stop light terminal

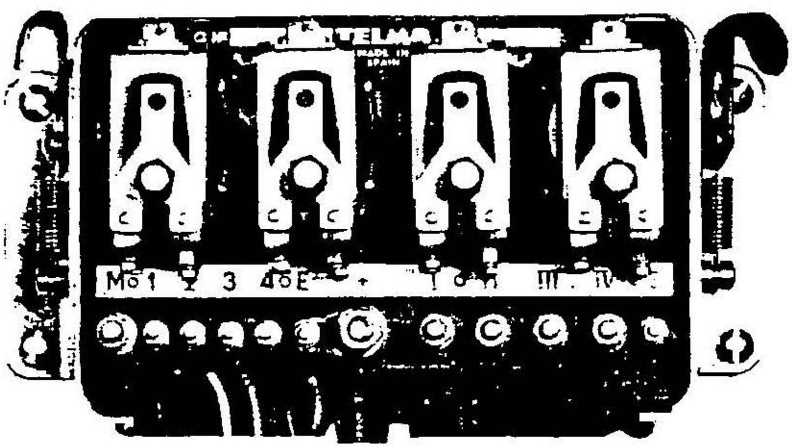


FIGURE 9

II - OPERATION PRINCIPLE (Fig. 10)

According to the signal sent by the electronic speed switch and the pressure switches, the contactor box will ensure the energizing of :

- 1 to 4 positions of the retarder
- 1 or 4 stop lights

- When the vehicle is running, the mini-generator mounted on the transmission sends a signal to the electronic speed switch. This will energize a relay which allows current to flow to the pressure switches. When pressing the brake pedal, 1 to 4 pressure switches will close (according to the pressure in the brake circuit) to ensure the feeding of the contactor coils. This will put 1 to 4 positions of the retarder into function as well as the stop lights.

- When the vehicle is stopped, no signal is sent to the electronic speed switch, which in turn will prevent current from energizing the contactor coils.

FIGURE 11
Connection strip

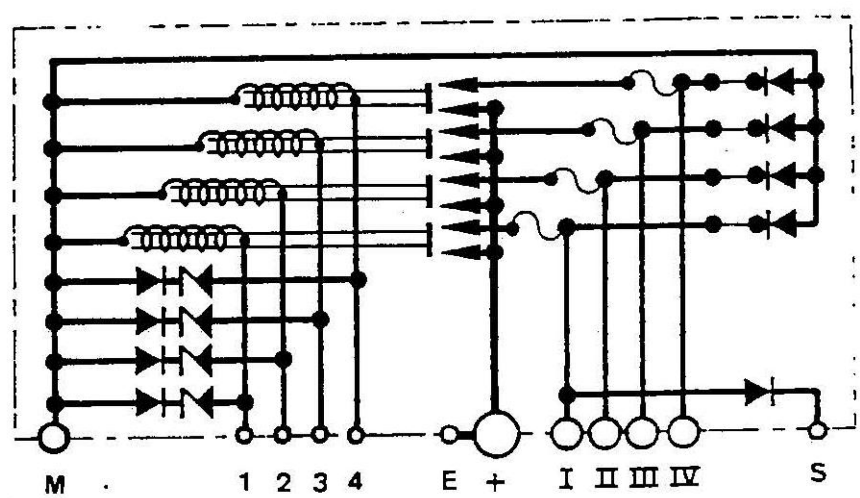
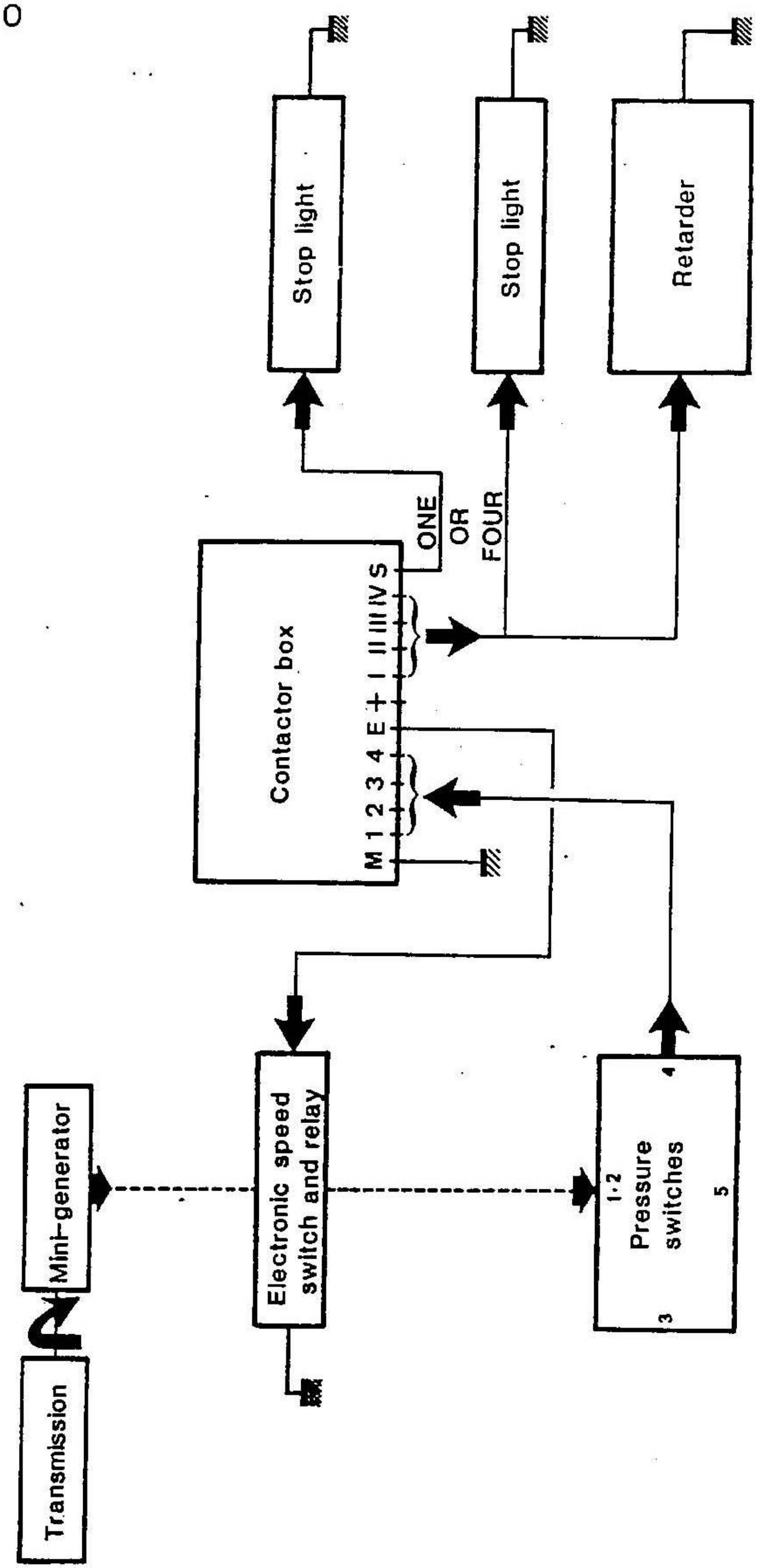


FIGURE 10


Stop light
Stop light
Retarder
ONE
OR
FOUR
Contactor box
M 1 2 3 4 E + I II III IV S
Transmission
Mini-generator
Electronic speed switch and relay
1·2
Pressure switches
3
4
5

III - MAINTENANCE

Contactor boxes are systematically checked in the factory.
However, a periodical maintenance is recommended.

- Blow out all the dust and humidity from the contactor box. This to ensure a smoothness of moving contactors and avoid sparks generating which causes fast wear of the points. This could also happen when the battery is unloaded.

- Make sure that all ground terminals are clean and well tightened on the chassis.

- Clean contactors points with special spray, never file or polish. When replacing contactors proceed always by pair (moving and fixed contactors).

- Check tightening of all screws and terminals.

- Before replacing a blown-out fuse investigate why it is blown.

- Never replace a fuse with a bigger one. Always use the recommended size.

- Check springs tension.

- Check clearance between contactor - points (see adjustment)

IV - ADJUSTMENT

Some adjustments have to be carried out, especially when replacing power contactors or coils.

IV.1 ADJUSTMENT OF THE CLEARANCE BETWEEN CONTACTOR POINTS (actuating distance)

This adjustment is made by loosing the fixed contactor bolts and sliding the fix contactors up and down to the proper setting (Fig. 12)

IV.2 CHECKING THE CLEARANCE BETWEEN MOVING CONTACTORS AND THEIR INSULATING BRACKET (locking distance)

This clearance is subject to the first one. In some cases, the recommended distance which must be about 1,2 (.047") to 1,4 mm (.055") is very difficult to obtain. If so, it is advised to replace the complete bracket of the moving contactor and the spring R1 (Fig. 13)

IV.3 SPRINGS R1 and R2 TENSION

These have been set at the factory and no adjustment is required or needed. In case of malfunction, it is recommended to replace them with new springs.

Clearance between contactor points

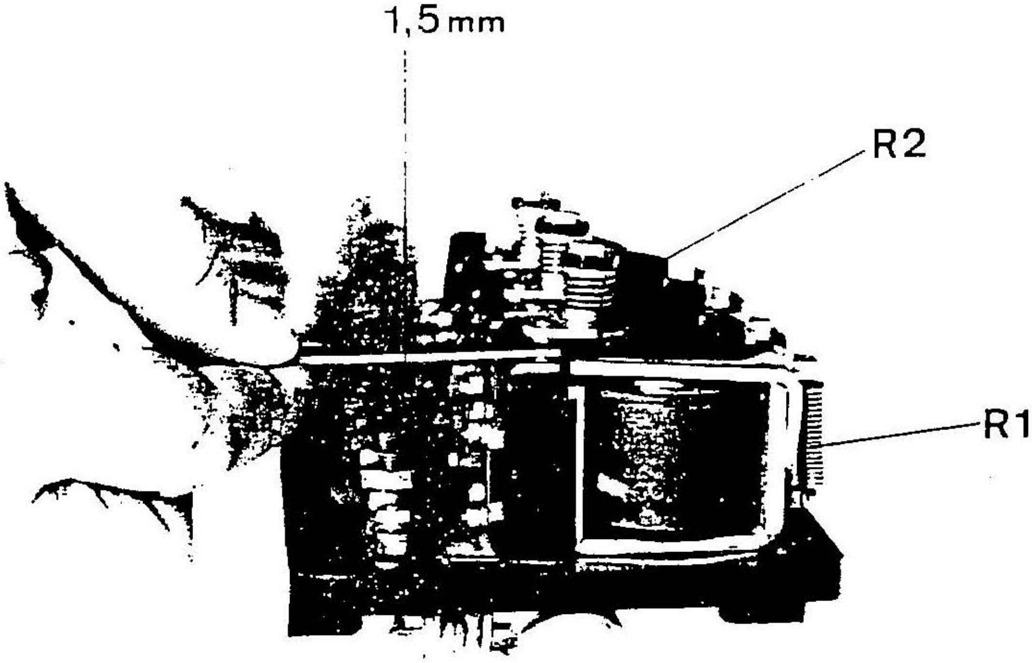


FIGURE 12

Clearance between moving contactor and bracket

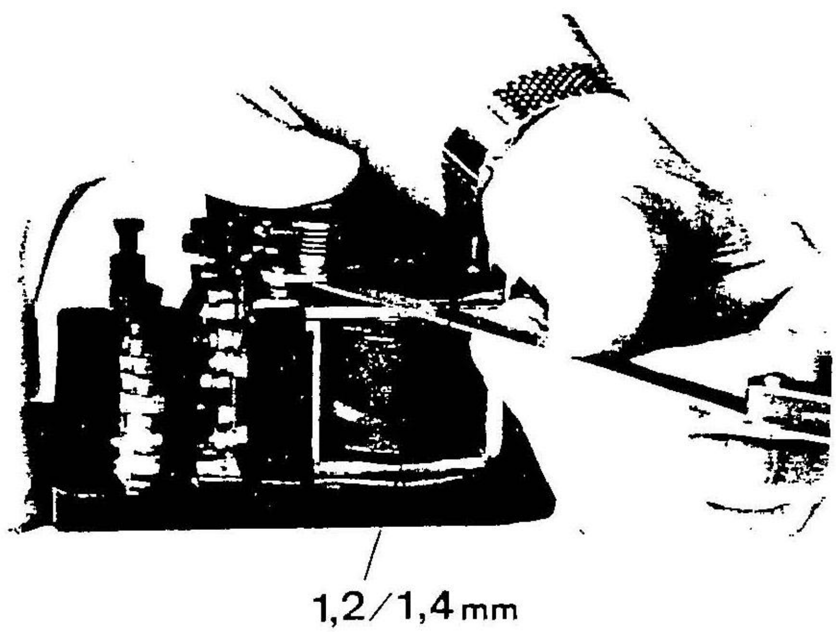


FIGURE 13

V - REPAIR-CHECKING (Fig. 14)

V.1 REPLACING CONTACTORS

In this case, contactors must be replaced by pair (moving and fixed).

a) - Fixed contactors

- remove holding screws 1
- replace contactors
- reset holding screws without tightening for needed adjustment

b) - Moving contactors

- remove nut 2
- remove spacer 3
- pull off washer 4 and spring R2
- replace contactor

Do not use a tool to tighten the spacer 3 when remounting.
Stop screwing when it rests on the moving contactor.

Use an 8 mm wrench and tighten nut slightly 2
Adjust replaced contactor (see adjustment).

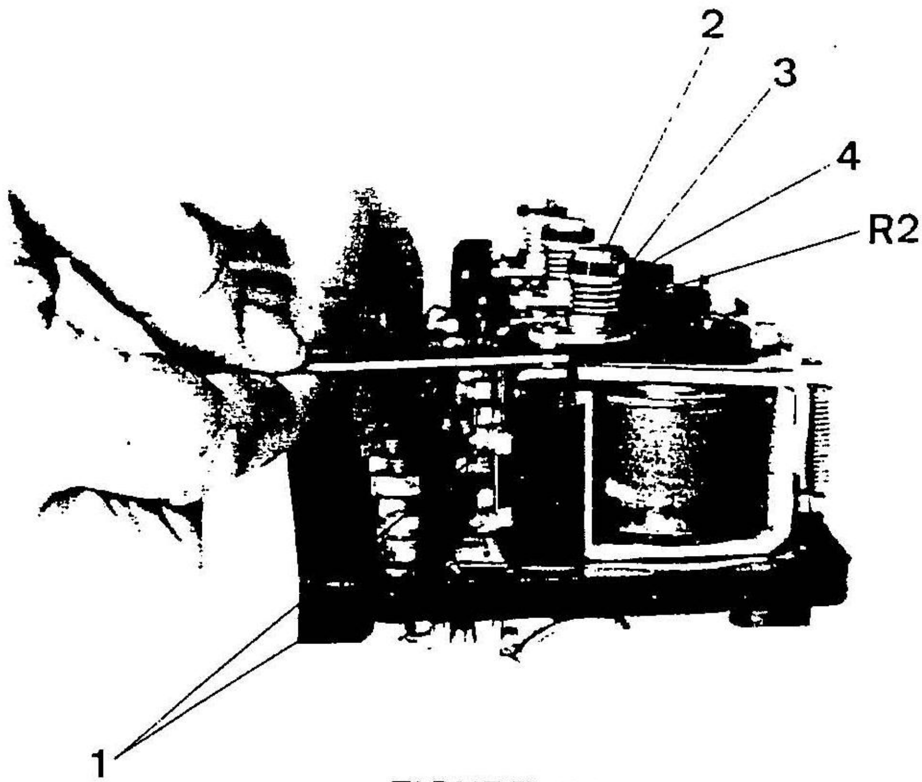


FIGURE 14

V.2 REPLACING OF MOVING CONTACTOR BRACKET (Fig. 15)

- remove screws 5
- pull off spring R1
- remove screw 6 and thrust 7
- replace bracket and reassemble
- adjust contactors (see adjustment)

V.3 COIL REPLACING

- remove plate assembly from bottom housing by removing four bolts
- loose power contactor diode plate
- loosen coil wire loom going to terminals
- locate bad coil wire and remove at terminal and power diode plate
- remove coil from coil bracket by removing coil nut, located on the inside of plate assembly
- attach new coil wires
- re-assemble

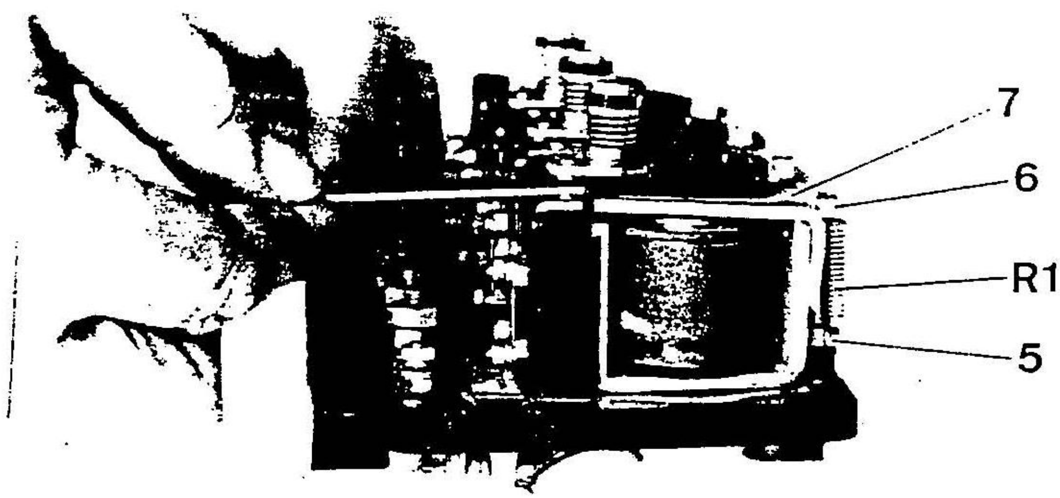


FIGURE 15

V.4 DIODES CHECKING

a) - Power diodes

- remove all wires from contactor box strip.
- use an ohmmeter allowing measurement of 500 to 1000 Ω resistances
- set positive test lead of the ohmmeter on terminal M in the contactor box
- set negative test lead successively on terminals I, II, III, and IV.

The measured value must be between 550 and 600 Ω.

When reversing ohmmeter test leads, the resistance must be infinite

b) - Stop light diode

- set test lead (+) of the ohmmeter on terminal I.
- set test lead (-) on terminal S

The measured value must be between 600 and 700 Ω

When reversing ohmmeter test leads, the resistance must be infinite

c) - Pressure switches protection diodes and Zener

- set test lead (-) of the ohmmeter on diodes common point (cathodes)
- set test lead (+) successively on coil terminals (anodes)

The measured value must be between 600 and 700 Ω.

In reverse the resistance must be infinite

V.5 COILS CHECKING

The measured value between terminal M and successively 1, 2, 3 and 4 must be :

26 Ω	± 5%	for 12 Volts contactor box	at 20°C
90 Ω	± 5%	for 24 Volts contactor box	at 20°C

This manual contains information on the operation and maintenance of the Electric Retarder.

The manual contains enough information for the general maintenance of the Electric Retarder and its components. Any repairs that are not covered or outlined in this manual should be done by a Jacobs approved distributor.

Before starting an inspection test or repair, total familiarization of all components and procedures is mandatory. Proper operation, maintenance and repair procedures will ensure excellent performance and dependable operation.

STATEMENTS MARKED WITH THIS SYMBOL ARE IMPORTANT FOR THE SAFE USE AND CARE OF THE JACOBS ELECTRIC RETARDER.

SECTION INDEX

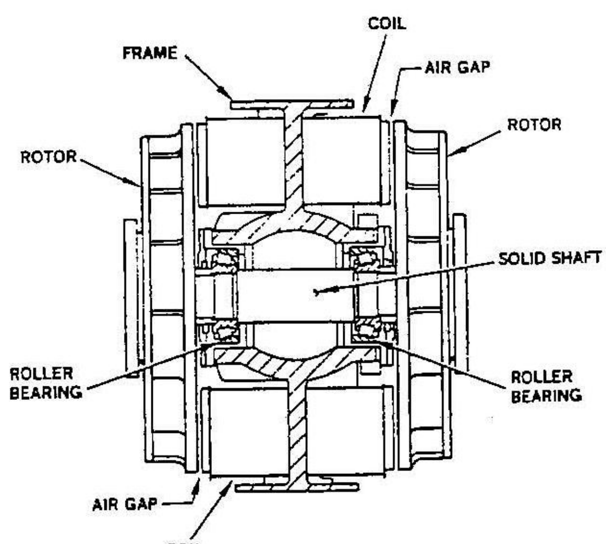
SECTION I

Description of The Retarder

The Jacobs Electric Retarder is a drive line mounted, power absorbing device which, unlike wheel brakes, does not depend upon friction to generate a retarding force. It consists of two air cooled steel rotors mounted on a solid shaft which is, in turn, supported by large tapered roller bearings. (Refer to illustration below)

An array of powerful D.C. electromagnets is attached to the stationary frame of the retarder unit with the steel end pole pieces separated from the inner face of the rotors by a small air gap. The rotors are cast in the form of centrifugal fans which pump cooling air through the rotors continuously.

The retarding force is developed by the action of the rotor shearing through lines of magnetic force produced by electrically energized coils. As in wheel brakes, considerable heat is generated. However in the retarder, the heat is produced by the flow of electrical currents within the rotors themselves and is dissipated by the flow of air through the rotors. As a result, the force reacts on the driveline of the vehicle and slows the vehicle down.



SECTION II

Component Description And Operation for The Electric Retarder

What Is A Jacobs Electric Retarder?

The Jacobs Electric Retarder — Jake"ER"® is a self-contained unit that is attached to the vehicle driveline. It consists of a number of stationary electromagnets and two rotating discs, or rotors. When activated, the electric retarder generates powerful electric currents in the rotating discs. These currents result in retarding force which is transmitted to the vehicles' driveline.

Jake"ER"® IS A VEHICLE SLOWING DEVICE NOT A VEHICLE STOPPING DEVICE. IT IS NOT A SUBSTITUTE FOR THE SERVICE BRAKING SYSTEM. THE VEHICLE'S SERVICE BRAKES MUST BE USED TO BRING THE VEHICLE TO A COMPLETE STOP.

Location And Operation of Controls

The controls for Jake"ER"® are divided into two categories: Driver-Operated and Automatic.

Driver-operated Controls:

- **The Master "ON-OFF" switch** is located on the dashboard of the vehicle. It must be turned to the "ON" position in order to activate the retarder. Normally, the switch should be in the "ON' position whenever the vehicle is in use.
- **Multipositional switches:**

  Note: Either hand or foot controls are installed on a vehicle. Both the hand-control and the foot-control are multipositional switches. Activating either one through its successive positions progressively increases retarding power. As soon as the control is placed in the first operating position, a dash-mounted indicator light* is illuminated.
- **Hand-control switch** is usually mounted on the steering column. It must be manually engaged by moving the lever to various positions (1st, 2nd, 3rd, 4th) for desired retarding force. When the vehicle has stopped, the selector lever should be placed in the "OFF" position, or discharging of the batteries will occur. At the same time, the dash mounted indicator light* will go out.

CAUTION: NEVER ACCELERATE WITH VEHICLE IN THE RETARDING MODE, ALWAYS RELEASE ACCELERATOR PEDAL BEFORE ENERGIZING THE RETARDER.

- **The Foot-Control Switch** is mounted in such a way as to be activated when the brake pedal is depressed slowly through each position. There are 4 positions available for the desired retarding power before the service brakes are actually applied.
- **Retarder Reserve Switch** is dash mounted and located for operating convenience. By pushing the switch down and holding, 4th position is automatically energized when hand or foot control is in 4th position.

  Some light duty differentials are not capable of handling the full four positions of retarder output without experiencing premature wear on the gearing. In these applications the retarder's capability for normal operation is restricted to a fixed number of positions.

  The Retarder Reserve Switch use should be limited to situations where additional retarding is required to compensate for retarder fade on long downhill grades. The switch should be used intermittently along with service brakes.

*If the vehicle is equipped with a low speed shut-off switch, the dashboard indicator light will not come ON until the vehicle has exceeded 8 mph (12 km/hr.) and the light will go OUT when the vehicle's speed is below 5 mph (8 km/hr.)

Automatic Controls:

The following controls are automatic:

- **Contactor (Relay) Box** connects Jake"ER"® to the electrical system of the vehicle. It is normally located in an area where exposure to contaminants is minimized.
  Vehicles are equipped with contactor boxes with or without time delay. Contactor boxes with time delay provide a slight delay between positions 2 and 3, and 3 and 4 to prevent sudden torque increases to rearend components.

ADJUSTMENTS TO THE CONTACTOR BOX SHOULD ONLY BE MADE BY AN AUTHORIZED DISTRIBUTOR.

- **Low Speed Shut-Off Switch** is usually located in series with the speedometer drive, and is located either at the speedometer, transmission, or at the front wheel. It can be used with either hand control or foot control switches. The switch automatically turns the retarder off at road speeds below 5 mph (8 km/hr.), this prevents battery drain while vehicle is stopped.

THE SERVICE BRAKES MUST BE USED TO BRING THE VEHICLE TO A COMPLETE STOP.

NOTE: Dashboard indicator light is usually located near the master switch and is illuminated when the hand or foot control is actuated, not by the master switch.

IF THE VEHICLE IS EQUIPPED WITH A LOW SPEED SHUT-OFF SWITCH, THE DASHBOARD INDICATOR LIGHT WILL NOT COME ON UNTIL ROAD SPEED IS ABOVE 8 mph (12 km/hr.)

Operation of The Jacobs Electric Retarder

Jake"ER"® may be used for descending grades, in city traffic, approaching stop lights, and in general whenever vehicle retarding is required. Use of Jake"ER"® leaves the service brakes cooler, and more effective, for emergency stops. The more you use your Jake"ER"® the less you use your service brakes.

The multi-position control system on the Jake"ER"® provides variable retarding for various road and traffic conditions. When it is necessary to slow down, step through your positions until you get the desired rate of deceleration. Service brakes should be used for final stopping, or when more rapid braking is required. Since operation of any vehicle under slippery conditions is unpredictable, a good general rule is to gradually apply each position for best control of your vehicle.

TOO MUCH RETARDING TOO FAST CAN CAUSE LOSS OF CONTROL

Extended Retarder Use

When the Jake"ER"® is used for extended periods of time, heat build-up will occur, resulting in diminished performance. The heat build-up is a function of time and switch position.

It is recommended that when long descents are encountered (5 minutes or more), the appropriate vehicle speed be obtained using the retarder in second (2nd) position. During long descents, third and fourth positions must only be used for short periods of time to minimize the heat build-up and the possibility of bearing damage. Select 3rd and 4th positions as the retarding force decays.

After descending long grades, and the rotors are hot, a cool down period of at least 5 minutes is necessary. Keep the vehicle moving so that the retarder rotors continue to rotate (minimum 15 mph) with the retarder turned off. The cooling period is necessary to prevent overheating.

Does Engine RPM Affect Jake"ER"®?

Engine rpm does not affect Jake"ER"® retarding power.

Does Vehicle Speed Affect Jake"ER"®?

Jake"ER"® performance is proportional to drive shaft rpms (i.e., road speed) so more retarding power is available as drive shaft rpms are increased.

Do's And Don'ts of Operating The Jake"ER"®

DO turn on master switch whenever the vehicle is in use.
DO release accelerator pedal before energizing any retarder position.
DO use service brakes to bring the vehicle to a complete stop.
DO position hand control switch to the "OFF" position when vehicle has stopped to prevent battery drain.
DO allow for cool down period of the rotors after long descents, at least 5 minutes while vehicle is moving.
DO operate your Jacobs Electric Retarder carefully under slippery road conditions.
DO NOT use Retarder when accelerating.
DO NOT use 4th position for long durations on long descents to avoid overheating.

DO NOT INSTALL ELECTRIC RETARDER ON VEHICLES CARRYING FLAMMABLE LOADS. ELECTRIC RETARDER SHOULD NOT BE USED IN EXPLOSIVE ATMOSPHERES.

SECTION III
Electric Retarder Maintenance

Normally the only maintenance Jake"ER"® requires is an occasional "wash down" of the unit with water and periodic lubrication of the bearings.

NORMAL "WASH-DOWN": Allow rotors to cool to the touch, then hose them down with high pressure water. Make sure all dirt is dislodged from cooling fins of rotors and around coils.

- **DO NOT** wash while the retarder is hot or damage could occur.
- **DO NOT** use any sharp instruments to dislodge dirt from around coils or damage to the coils could result.
- **DO NOT** use caustic solution in wash down as it will initiate terminal corrosion.
- Off-highway vehicles require more frequent care of keeping cooling fins dislodged of dirt due to environment.

Lubrication

Lubrication intervals depend on the severity of the operation, number of miles traveled, and amount of retarder use. In general, it is recommended that Jake"ER"® be lubricated at the intervals shown below with a high quality NLGI Grade 2 Lithium base grease with 180°C (356°F) minimum drop point. Typical lubricants are as follows:

MANUFACTURER	TYPE
Molykote	BR2-S
Mobil	Mobilgrease MP
Shell	EP Alvania 2
Texaco	Regal AFB2

The Electric Retarder must be greased with an approved lubricant. A quantity of grease 2.5-3.0 oz. (70-85 gr.) shall be added in accordance with the following schedule:

First 4,500 Miles	Every 1,500 Miles
After 4,500 Miles	Long Distance over Highway Every 4,000 Miles
	City usage school bus, ambulance, utility vehicle — Every 2,000-2,500 miles
CONTINUOUS HEAVY USAGE — EVERY 4 HOURS OF USE	

At each grease interval, check vent tube for obstruction; pass small diameter wire .03 in (.76 mm) approx. 6" long up vent hole to insure an open passage. **"DO NOT TURN SOCKET SCREW IN VENT AS DAMAGE WILL OCCUR."**

Periodic Inspection Checklist

(Perform Every 25,000 Miles)

- ☐ VERIFY THAT WIRES DO NOT RUN ADJACENT TO GAS, AIR AND HYDRAULIC LINES.
- ☐ CHECK WIRES FOR ABRASION
- ☐ INSPECT TO SEE IF SAFETY LOOPS AROUND DRIVE SHAFT ARE SECURE.

- ☐ Check point gap per Procedure III, Page 11.
- ☐ Inspect flange and mounting bolts on Retarder. If they are missing or loose, replace and torque to values on Page 15, Table 1.
- ☐ Inspect rubber shock mounts for the Retarder and related hardware. If damaged, replace as shown in Procedure I, Page 7.
- ☐ Inspect condition of Electric Retarder electrical wiring, if damaged repair or replace as shown in Procedure V, Page 12.
- ☐ *Inspect for evidence of a grease leak by checking backside of the rotors and surrounding area. It may mean a faulty grease seal.
- ☐ Check air gap (See Procedure VII, Page 15.
- ☐ Check rotors for distortion, See Procedure II, Page 9.
- ☐ Inspect hand or foot control for mechanical operation.
- ☐ If equipped with low speed switch inspect for operation and installation. Refer to automatic controls, Page 4.
- ☐ Check for corroded terminals and connections. Replace as required using correct method and crimping tools. See Procedure V, Page 12.
- ☐ *Visually inspect all welds on mounting hardware of the Retarder for separations and cracks. Check all hardware and frame rails for fatigue cracks or bending.
- ☐ Inspect coils for damage.
- ☐ Inspect for excess heating on chassis due to rotor heat build-up. Insulate as required.
- ☐ *Check for excessive end play as described in Procedure IV, Page 12.

CAUTION: IF END PLAY IS NOT TO SPECIFICATIONS, SEVERE DAMAGE COULD OCCUR.

NOTE: If the vehicle is equipped with a low speed shut-off switch it must be electrically by-passed before inspecting the following items. (See Wiring Schematic, Page 17.)

- ☐ Inspect dash indicator light by energizing hand or foot control, after master switch is in the "ON" position. Replace bulb if not operating.
- ☐ Remove cover of contactor box and check condition of relays, contact points and operation by activating foot or hand control after master switch has been electrically energized.

Disconnect Batteries before Attempting Inspection or Maintenance of the Retarder and Controls unless Otherwise Noted.

*If the indicated conditions exist, they should be corrected by a Jacobs Authorized Distributor.

SECTION IV
Repair And Inspection Procedures

Equipment Required for Repairs and Inspection

- Heavy duty transmission jack (1000 lbs. min. capacity)
- Metric sockets and wrenches (5 mm to 27 mm)
- D.C. shunt ammeter (0-300 amp. scale)
- Wire and cable crimpers for #14 awg. to #1/0 awg.
- Dial indicator (.000- 030 in.)
- Arbor press ½ ton capacity
- Feeler gauges (.000-.025 in.)
- Torque wrenches (10-50 lbs. in.) and (35-90 lb.ft.)

Procedure I

A) Removing Press-in Type Rubber Mount
B) Removing Bolt-in Type Rubber Mount

A) Removing Press-in Type Mount

Step 1

Using transmission jack to craddle retarder, jack up retarder until the weight is taken off the rubber mounts.

Step 2

Remove both large support bolts (18 mm) on the damaged side.

Step 3

Remove side support plate bolts (14 mm) and remove side support plate.

Step 4

Press out damaged rubber mount as shown in Figure 1.

Step 5

Press in new mount (Note direction of ass'y.) until bottomed on bracket and install in the proper direction using special installation tool P/N 004648). As shown in Figure 2, Page 8.

Step 6

Reverse procedure to reassemble. (Note order of ass'y. of hardware, see Figure 1). Torque all bolts per Table 1, Page 15.

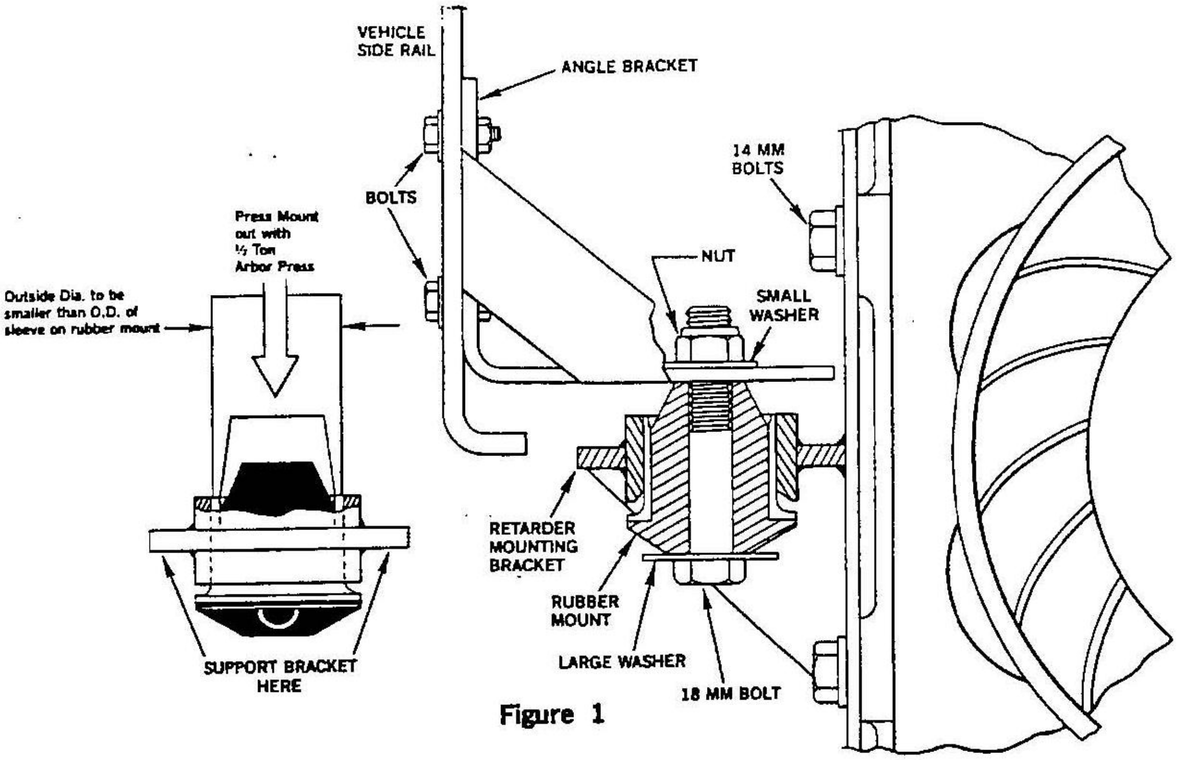


Figure 1

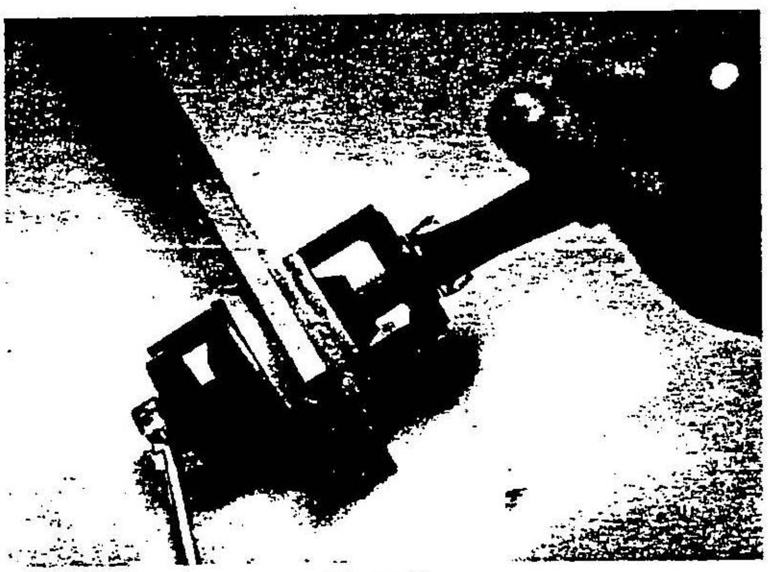


Figure 2

B) Removing Bolt-in Type Mount

Step 1

Using transmission jack to craddle retarder, jack up retarder until the weight is taken off the rubber mounts.

Step 2

Remove large support bolt (18 mm) from damaged mount.

Step 3

Remove the (3) 8 mm bolts from rubber shock mount and remove shock mount. (Note direction of assy.)

Step 4

Install new shock mount. (Note direction of assy.)

Step 5

Reverse procedure to reassemble. Torque all bolts per Table 2, Page 15.

Procedure II

Checking Rotors For Distortion From Over-Heating.

Preferred Method

Step 1

Connect dial indicator to frame of retarder.

Step 2

Dial Pointer to "0" on dial after stylus is placed against rotor's inside face as shown in Figure 3.

Step 3

Mark rotor at indicator's position and rotate rotor 360° (one revolution). If dial indicator registers more than .025 in. (.635 mm) **total** indicator reading a correction must be made.

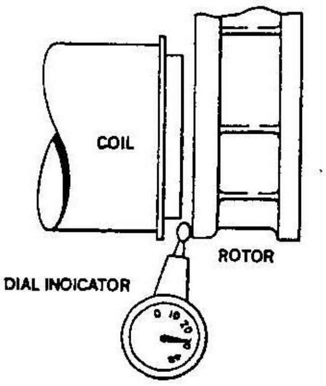


Figure 3

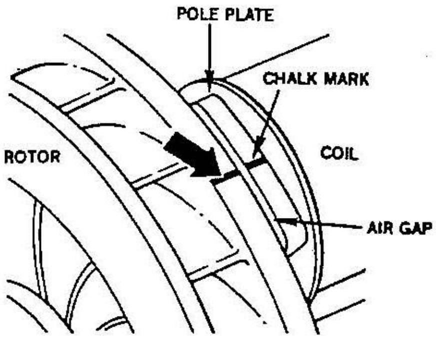


Figure 4

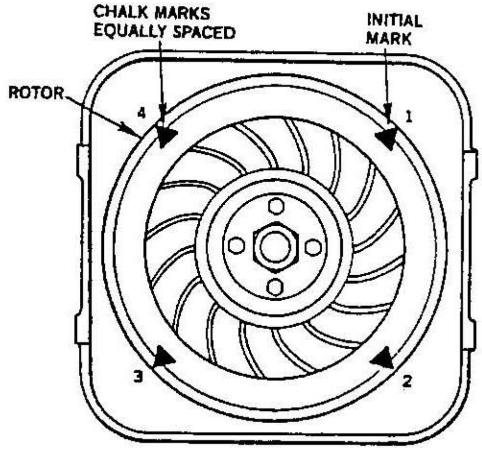


Figure 5

Alternate Method

Using A Feeler Gauge Proceed As Follows:

Step 1

Mark one (1) pole plate and (1) position adjacent to each other on the rotor with colored chalk. Figure 4

Step 2

Mark off 3 other positions on the rotor as illustrated. Figure 5

Step 3

Line up one mark on rotor with marked pole plate and measure air gap with a feeler gauge and record.

Step 4

Measure the air gaps at the other 3 positions on the rotor at the same pole plate and record.

Step 5

Subtract the lowest (smallest air gap) reading from the largest (largest air gap) reading. If the number is greater than .025 in. (.635 mm), a correction must be made. (See Example)

CONSULT YOUR DISTRIBUTOR

Example: Model 520 has around .04 in. (0.10 mm) air gap.

Initial Reading @ Mark # 1 = .045 in. air gap
Rotate Rotor for Reading @ Mark # 2 = .050 in. air gap
Rotate Rotor for Reading @ Mark # 3 = .039 in. air gap
Rotate Rotor for Reading @ Mark # 4 = .058 in. air gap

Now subtract the lowest reading from the highest reading.

Mark #4 .058 Air Gap
Mark #3 −.039 Air Gap
.019 Total Runout

Thus, .019 in. (.609 mm) is within the .025 in. (.635 mm) that we specify.

Procedure III

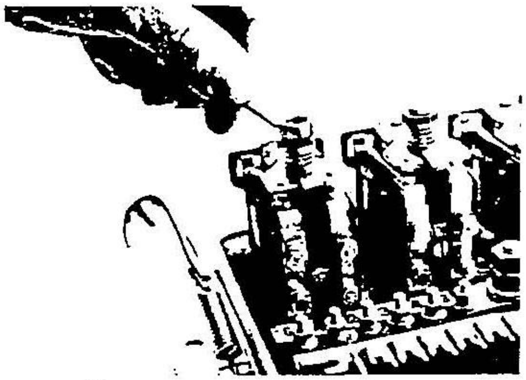
Replacing And Adjusting Relay Points in Contactor Box

OBSERVE THE SAME PRECAUTIONS YOU WOULD IN WORKING WITH ANY HIGH AMPERAGE BATTERY ENERGIZED SYSTEM BEFORE REMOVING CONTACTOR BOX COVER.

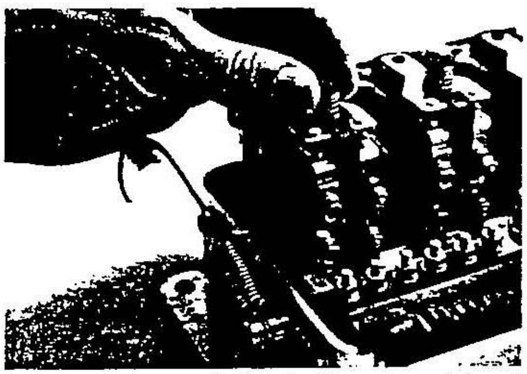
Procedure to replace pitted or burned points (Lower & Upper)

Procedure to adjust and set point gap. See Figures 6 & 7.

Remove upper points by removing hardware as shown.



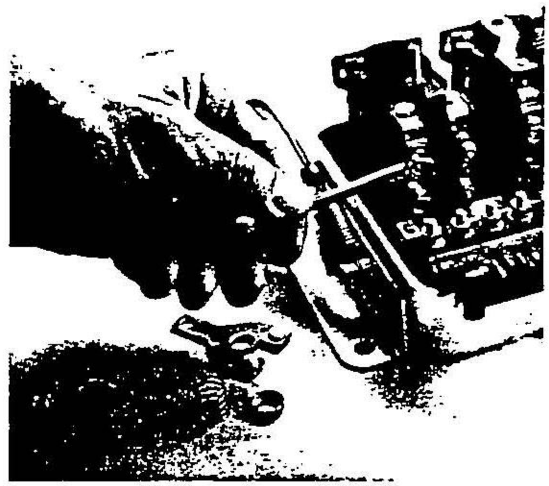
STEP 1 Remove upper crown nut.



STEP 2 Remove black plastic nut and hardware for spring.

STEP 3 Remove upper points and install new points by reversing procedure. See Figure 7, page 11 for setting black plastic nut height to preload spring. After setting hold in place and tighten crown nut.

Remove lower points by removing hardware as shown.

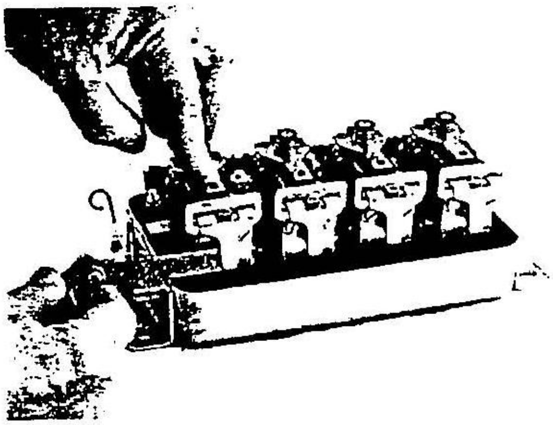


STEP 1 Remove screws and nuts as shown.

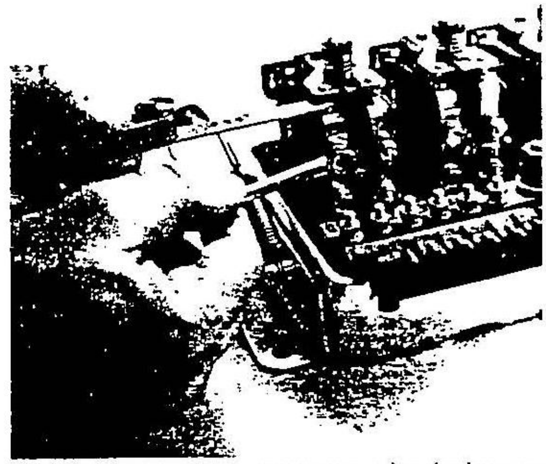
STEP 2 Slide out points and install new points by reversing procedure. Do not tighten screws until point gaps are set.

STEP 3
Set gap as shown using feeler gauge .045-.050 in. (1.14-1.27 mm).

CAUTION: ALWAYS CHECK THIS GAP PRIOR TO INSTALLATION OF NEW UPPER OR LOWER POINTS, THEN PROCEDE TO STEP 5.



STEP 4 Press down on upper points until armature bottoms on Point "A", see Fig. 6, then set gap by bending tab on armature with needle nose pliers or slightly tapping in tab with plastic hammer as required.
(See Illustration Figure 6 for details)



STEP 5 Set Point Gap as shown using feeler gauge .047-.059 in. (1.194-1.498 mm).

Loosen screws as shown and set each lower point separately to gap specified.
(See Illustration Figure 7 for details.)

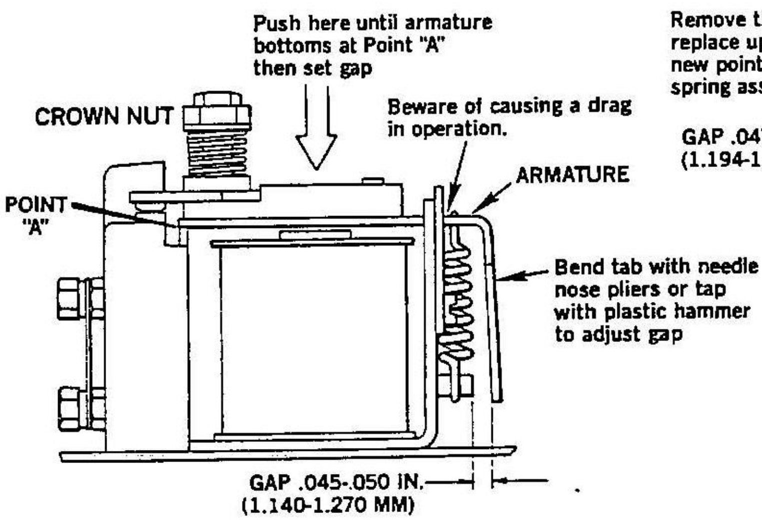


Figure 6

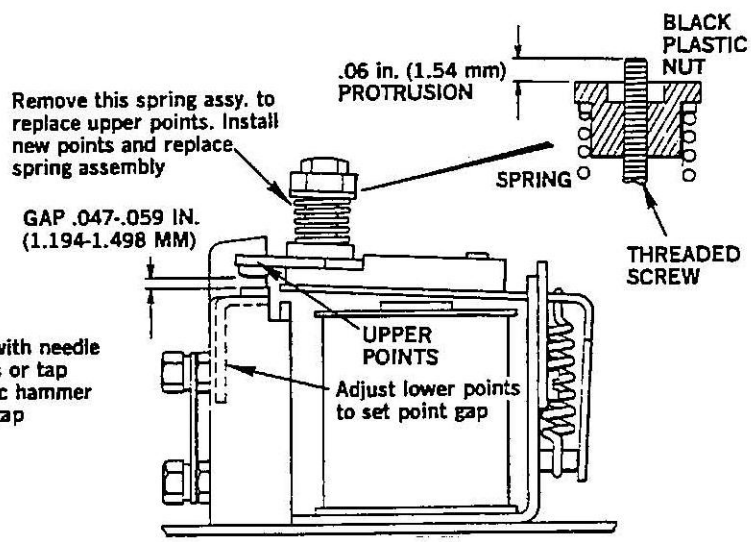


Figure 7

CAUTION: WHEN TIGHTENING SCREWS AND NUTS DO NOT OVER-TIGHTEN.

See Table 2, Page 15 For Torque Specifications.

Procedure IV

To Check for Excessive Play on Roller Bearings

Step 1

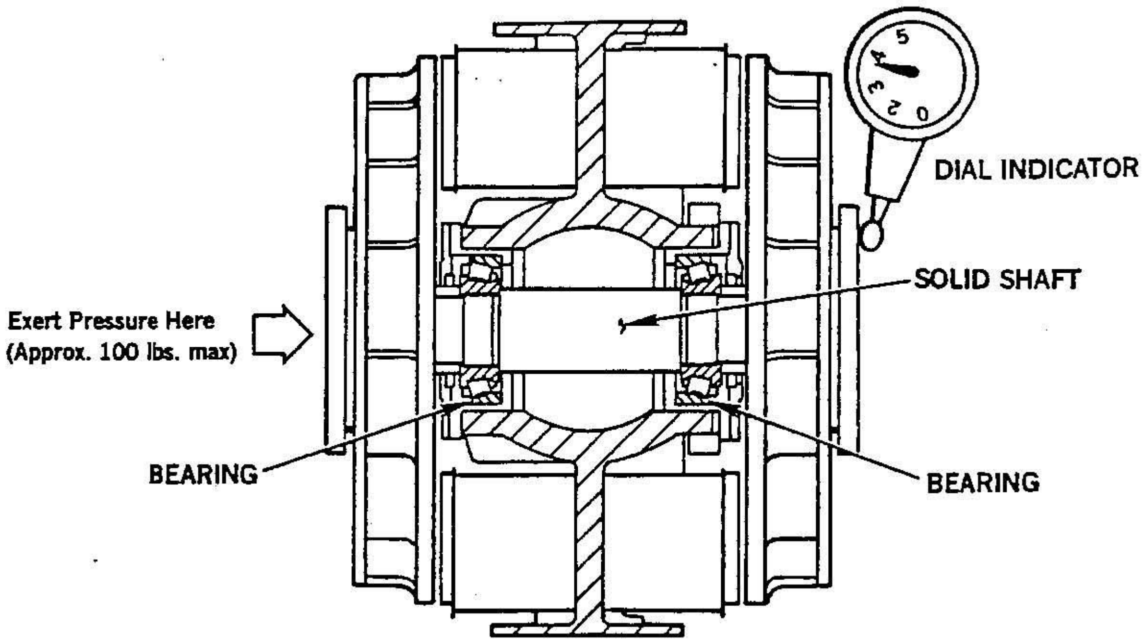
Disconnect flange yokes from Retarder.

Step 2

Set up dial indicator as shown in illustration. Exert a force as shown (approx. 100 lbs. maximum), while holding pressure set dial indicator at "0", then release the exerted force. Now without moving the dial indicator, exert a force against the opposite flange of the Retarder and take the reading from the dial indicator.

If reading exceeds .004 in. (.10 mm), then bearing end play must be adjusted.

CONSULT YOUR DISTRIBUTOR



Procedure V

Replacing Damaged Wires or Corroded Terminals

Wiring schematics A, B, C, and D are provided to aid in troubleshooting, replacing electrical components and re-routing of damaged wires. See pages 17, 18, and 19 for wiring schematics.

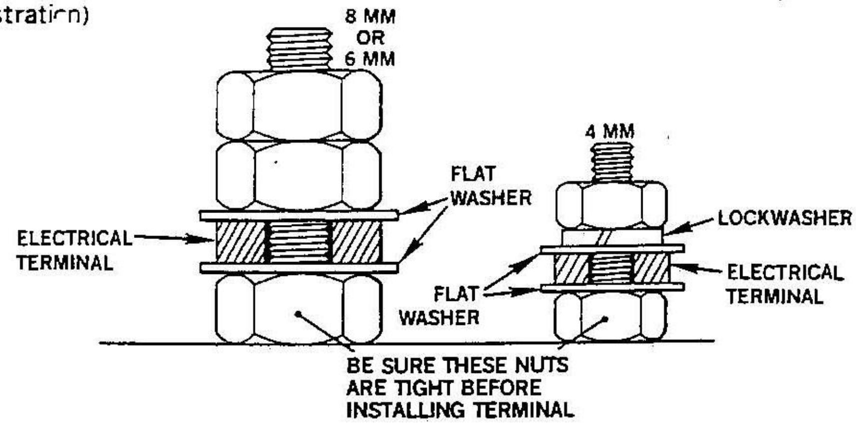
The schematics are for **NEGATIVE GROUND VEHICLES ONLY.**

Wire sizes are listed below for replacing damaged wires, and sizes are also indicated on wiring schematics.

WIRE SIZE	FROM	TO
#1/0 AWG	Battery DUVAC®/Isolator Alternator Retarder	Battery Contactor Box DUVAC®/Isolator Ground
#6/4 AWG	Contactor Box	Electric Retarders Main Terminal Block
#16/4 AWG	Hand Control and Foot Control Units	Contactor Box

NOTE: For All General Low Current Wiring #14 AWG Should Be Used

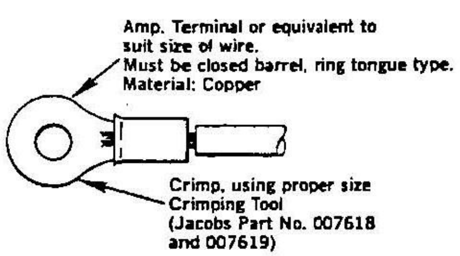
When replacing terminals on wire ends for contactor box, note order of assy. When replacing wires. (See Illustration)

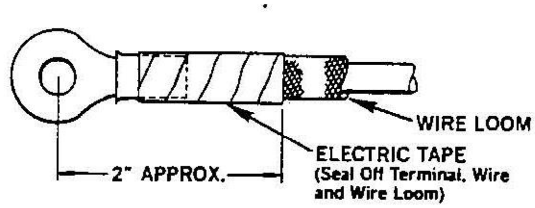


Terminal Chart

JACOBS PART NO.	AMP® PART NO.	TYPE OF TERMINAL	FOR WIRE SIZE	STUD SIZE	MATERIAL AND COATING
007805	321598	Solistrand Ring Tongue	#6 AWG	1/4"	Tin Coated Copper
007806	321867	Solistrand Ring Tongue	#1/0 AWG	5/16"	"
007807	321866	"	"	1/4"	"
007808	36919	"	"	1/2"	"
007809	36918	"	"	7/16"	"
007810	31902	PIDG Ring Tongue	#14-16 AWG	8 mm	"
007811	31903	"	"	10 mm	"
007812	60211-2	PIDG Receptacle	#14-16 AWG	Spade Size 1/4"	Tin Coated Brass
007813	60212-2	"	"	"	"
007814	35244	Butt-Splice Plasti-Grip	#14-16 AWG	~	Tin Coated Copper
007865	34136	Parallel Splice Plasti-Grip	#10-12 AWG	~	"
007877	31907	PIDG Ring Tongue	#14-16 AWG	5/16"	"

NOTE: Wiring loom should be used around wires to provide protection from abrasion and possible flying debris. Use loom to harness wires if possible. Where loom terminates with wire (or wires in a harness) seal off with electrical tape or shrink tubing. (See below)





Typical wire ending when replacing damaged wires or corroded terminals.

NOTE: After replacing terminal to its proper location, torque nuts per Table 2, page 15 and then apply Loctite #290. Coat all terminals and nuts on retarder ONLY with KOPR - SHIELD® From Thomas & Betts Corp. for electrical connections. All wire lengths should be long enough as not to cause any tension on connections.

DO NOT ROUTE WIRES ADJACENT TO FUEL, AIR OR HYDRAULIC LINES. USE INSLUATED CLAMPS AND TIES WHERE NECESSARY TO BUNDLE WIRES, AT LEAST EVERY 18" APART.

Fuses:

FUSE between master switch and hand or foot control is a 6 amp. fuse, replace as required.

MAIN FUSE between power source and contactor box are listed below, replace as required.

(See Table 2, Page 15 for Torque Specifications)

MODEL	VOLTS	JACOBS FUSE PART NO.	AMP. RATING
300	12	008714	225
320	12	008713	275
500	12	008712	200
520	12	008714	225
720	12	008714	225
520	24	008712	200
720	24	008712	200
740	24	008712	200
920	24	008712	200

Procedure VI

Checking Coil Amperage Draw

Install a 0-300A ammeter into the circuit to (+) terminal of Contactor Box. Start engine, run at approximately 1000 rpm, switch on retarder and record current and voltage at terminal (+) of contactor box for each coil retarding position. See Table 1 for correct values for each position for each model number.

Table 1

Electrical Requirements

@ 20°C (68°F)

MODEL NO.	POSITION #1 AMPS.	POSITION #2 AMPS.	POSITION #3 AMPS.	POSITION #4 AMPS.
J300/12 Volt	43 to 50	86 to 100	129 to 150	172 to 200
J320/12 Volt	56 to 64	112 to 128	168 to 192	224 to 256
J500/12 Volt	36 to 41	72 to 82	108 to 123	144 to 164
J520/12 Volt	43 to 50	86 to 100	129 to 150	172 to 200
J720/12 Volt	43 to 50	86 to 100	129 to 150	172 to 200
J520/24 Volt	36 to 42	72 to 84	108 to 126	144 to 168
J720/24 Volt	33 to 38	66 to 76	99 to 114	132 to 152
J740/24 Volt	33 to 38	66 to 76	99 to 114	132 to 152
J920/24 Volt	38 to 44	76 to 88	114 to 132	152 to 176

NOTE: Test should be performed as fast as possible to avoid coil heating.

IF TESTS DO NOT MEET TABLE 1 REQUIREMENTS CONSULT YOUR DISTRIBUTOR.

Procedure VII

Checking Air Gap

Check air gap at each pole plate using a feeler gauge. Below is a table for each model and its specific air gap.

MODEL NO.	AIR GAP ±.004 in. (±.10 mm)
J 300	.035 in. (.900 mm)
J 320	.035 in. (.900 mm)
J 500	.043 in. (1.10 mm)
J 520	.043 in. (1.10 mm)
J 720	.055 in. (1.39 mm)
J 740	.055 in. (1.39 mm)
J 920	.055 in. (1.39 mm)

If air gap is not to specifications, consult your distributor.

Section V
Table 2

Torque Specifications

LOCATION	JACOBS PART NO.	BOLT OR NUT SIZE	TORQUE LB./FT./N•m	REMARKS
Retarder Mtg. Bolts	004313	14 x 2 mm	80-85/108-115	Class 5 Only
Rubber Mount Bolts Model 300 & 320	004315	8 x 1.25 mm	35-45/48-61	Class 5 Only
Mtg. Bolts for Rubber Mounts	004312	18 mm	75-85/102-115	Class 5 Only
Flange Bolts Class 8	008770	3/8"	45-50/61-68	1600 & 1700 Flange
	008777	3/8"	45-50/61-68	1800 Flange
	004421	7/16"	75-80/102-108	1400 Flange
	005627	1/2"	80-85/108-115	1500 Flange
Angle Bracket Bolts	—	1/2"	80-85/108-115	Class 5 Bolt
		5/8"	95-105/128-130	2" Long
Contactor Box & Retarder Terminal Nuts	004845	4 mm	10-15 lb.in./1.13-1.70	After Torquing Apply Loctite #290
	004741	6 mm	20-25 lb.in./2.26-2.83	
	004743	8 mm	40-50 lb.in./4.52-5.65	
	004733	5 mm	10-20 lb.in./1.13-2.26	
Alternator, Duvac, Isolator, Terminal Nuts	—	TORQUE PER MANUFACTURER'S RECOMMENDATIONS		After Torquing Apply Loctite #290
Fuse Block for Main Fuse Nuts	008715	5/16"	22-26/30-35	Loctite #290 or equivalent
Nuts for Terminal Block Caps on Retarder	004595	5 mm	6-8 lb.in./.68-.90	Loctite #290 or equivalent

SECTION VI
Jacobs Electric Retarder
Trouble-shooting And Schematics

BE CAREFUL — HIGH AMPERAGE SYSTEM

If the unit fails to operate properly, the master "ON-OFF" switch should be shut off until the unit can be inspected. Failure of Jake "ER"® can usually be traced to the electrical system. As in all trouble-shooting procedure, always check the simple things first. If the following simple steps do not isolate the problem, then consult a Jacobs Electric Retarder Distributor.

RETARDER FAILS TO OPERATE

TO CHECK

Column I

- If vehicle is not equipped with a low speed shut-off switch.
- • Turn master switch on
  • Activate hand or foot control
- Audible click is not heard from contactor box in any position
- Audible click is heard from contactor box in every position
- Check Retarder Ground Wire
- Check main fuse between alternator/battery to contactor box
- Check Retarder connections
- If the above are correct, check with a Jacobs Authorized Distributor for probable cause.

TO CHECK

- Verify if Master Switch is on.
- Check 6 Amp. In-line Fuse
- Check contactor box ground wire.
- Check hand or foot control connections and operation
- Check Wire to ignition switch
- Check battery connections
- Remove contactor box cover and inspect points and relay coils
- If the above are correct, check with a Jacobs authorized distributor for probable cause.

TO CHECK

- If vehicle is equipped with a low speed shut-off switch.
- Visually check these possible causes
- If the above is correct, by-pass low speed switch with jumper wire and Check Column 1, (See Wire Schematic Page 17)

Retarder fails to shut-off

- Disconnect battery lead to contactor box
- Remove 6 amp. fuse from lead to ignition switch

Vibration occurs

CHECK FOR

- Broken weld joints on mounting brackets
- Rubber mounts loose or damaged
- Flange bolts missing or loose
- Worn universal joints
- Dirt lodged in cooling fins in rotors
- Chipped out casting sections or cracked rotors
- Bent axle shaft
- Axle shaft end play
- Loose mounting brackets
- Worn axle bearings

Loss of Retarding Power

CHECK FOR

- Battery output
- Contactor box relay points
- Coil damage
- Coil amperage check
- Hand or foot control connections
- Wire connections at each terminal block on Retarder
- Air gap at rotors

Wiring Schematics

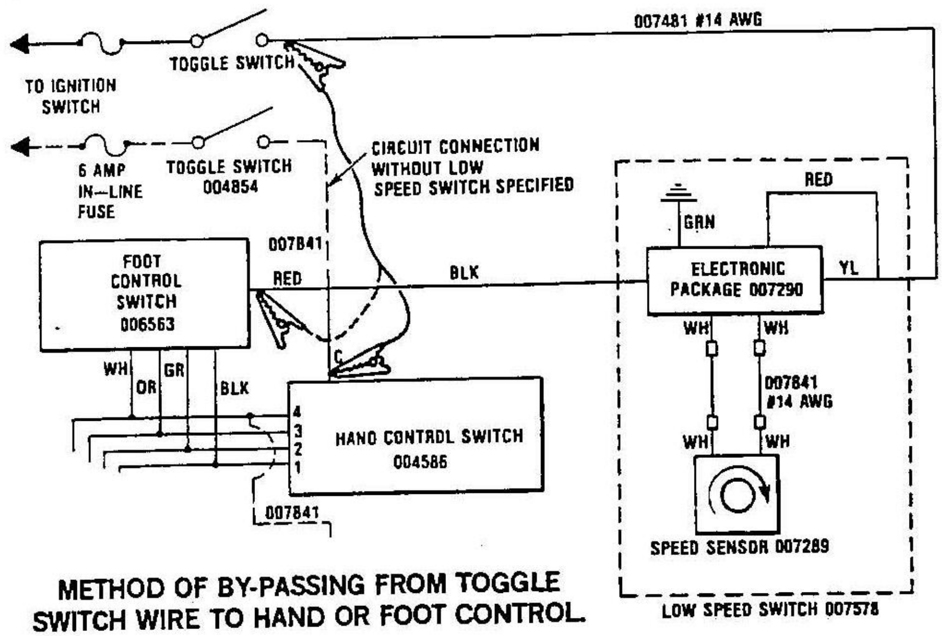
For Low Speed Shut-off Switch (By-pass)

Illustrated below are several methods of by-passing the low speed shut-off switch for periodic maintenance check
· Electric Retarder's electrical components.

sing electrical clips and #14 awg. wire, pierce insulation on wires or connect to terminals as shown below.

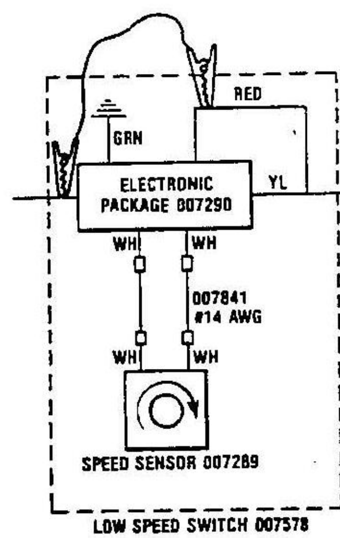
NOTE: If wire insulation is pierced, wrap pierced area with electrical tape.

BE CAREFUL NOT TO GROUND JUMPERS TO SPEED SENSOR HOUSING OR 6 AMP FUSE WILL SHORT OUT.



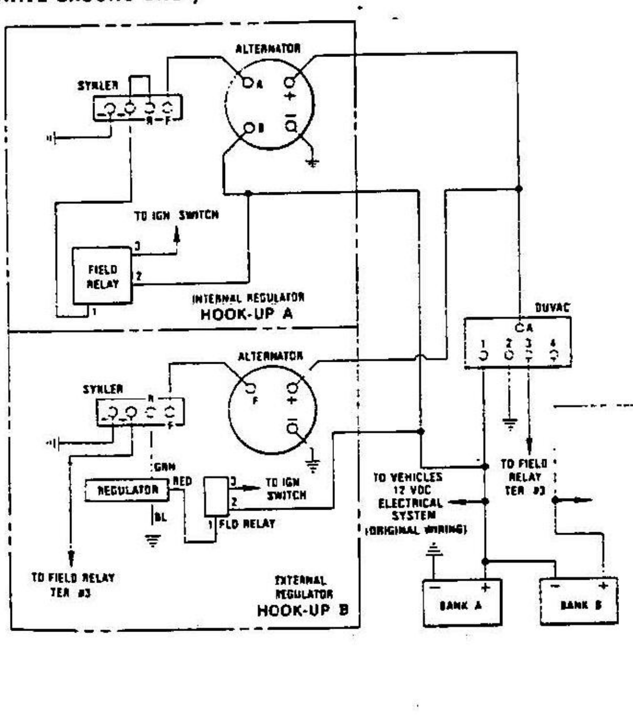
METHOD OF BY-PASSING FROM TOGGLE SWITCH WIRE TO HAND OR FOOT CONTROL.

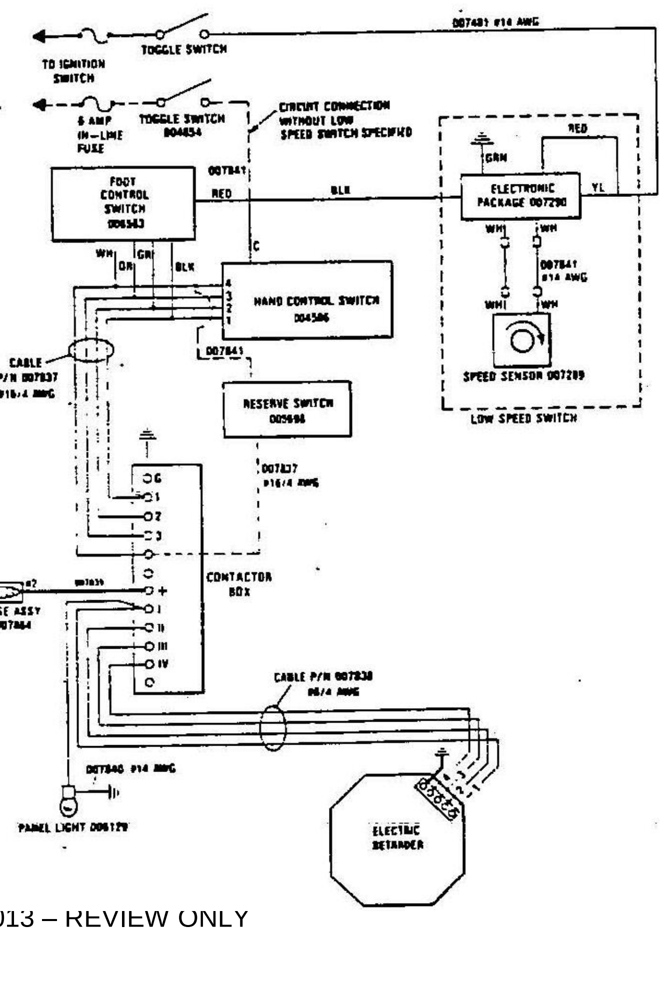
METHOD OF BY-PASSING AT THE SPEED SWITCH



WIRING SCHEMATIC FOR 24 VOLT RETARDER ON A *12 VOLT OR **12/24 VOLT VEHICLE

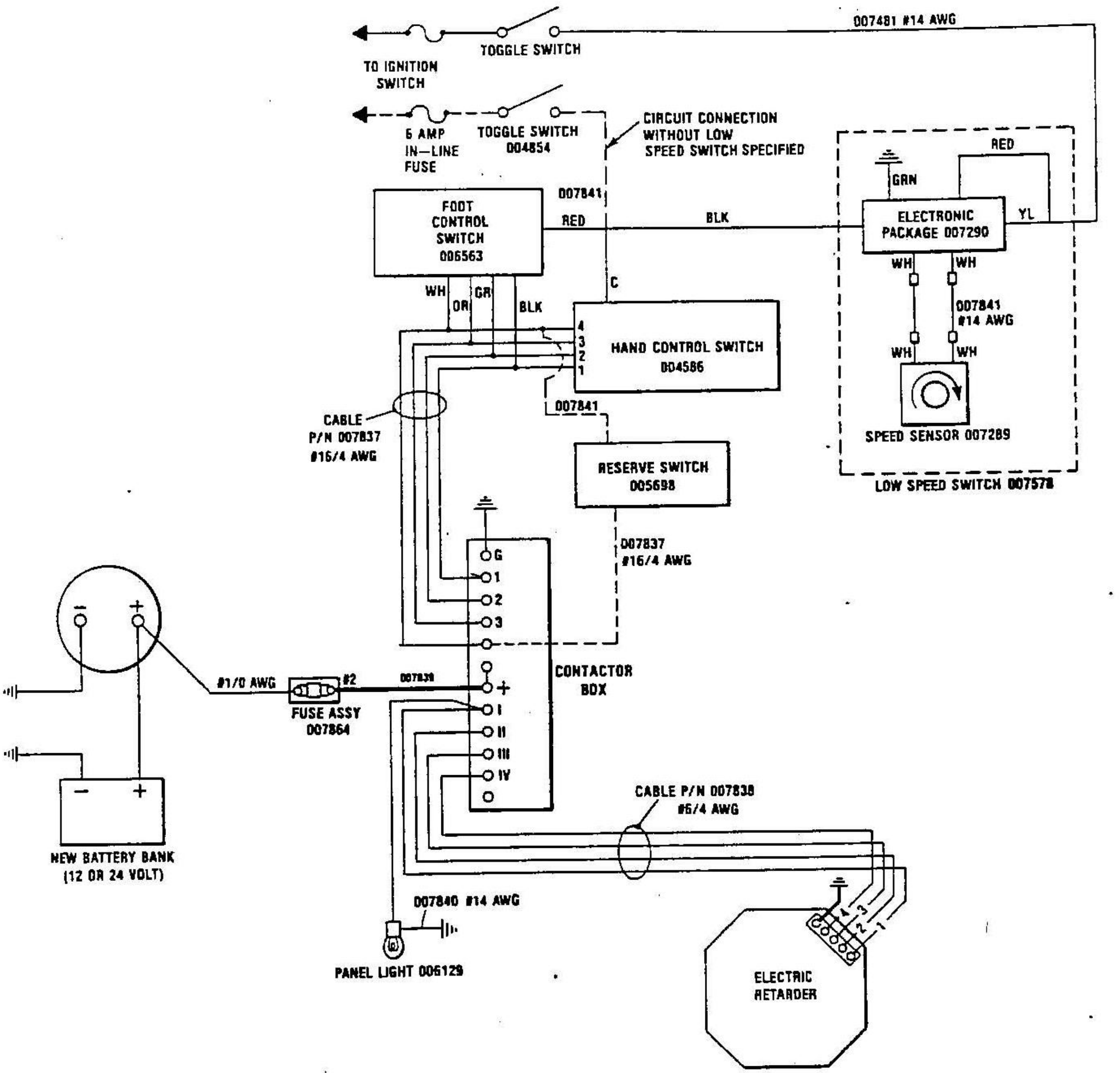
*** THIS WILL REQUIRE CHANGE OF STARTER MOTOR FROM 12 VOLT TO 24 VOLT**
****REMOVE SERIES PARALLEL SWITCH. (REPLACE WITH DUVAC®/SYKLER®)**
(NEGATIVE GROUND ONLY)





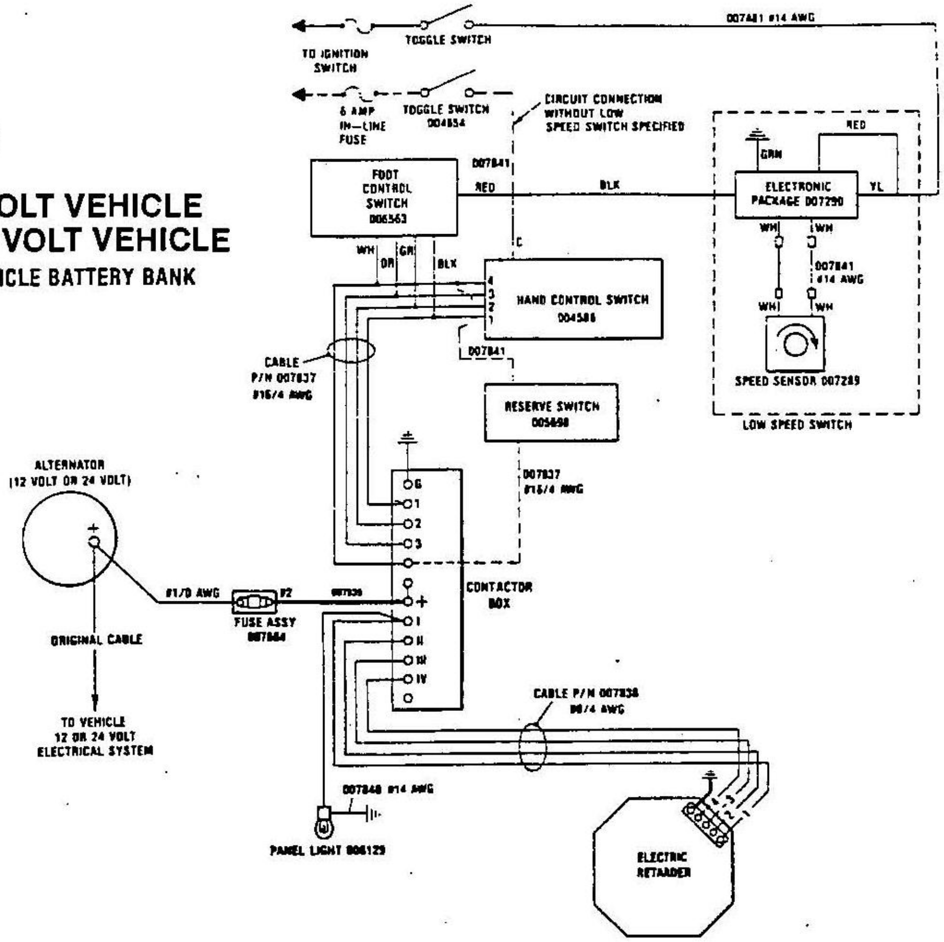
WIRING SCHEMATIC FOR 12 OR 24 VOLT RETARDER WITH INDEPENDENT ALTERNATOR & BATTERY BANK

(NEGATIVE GROUND ONLY)



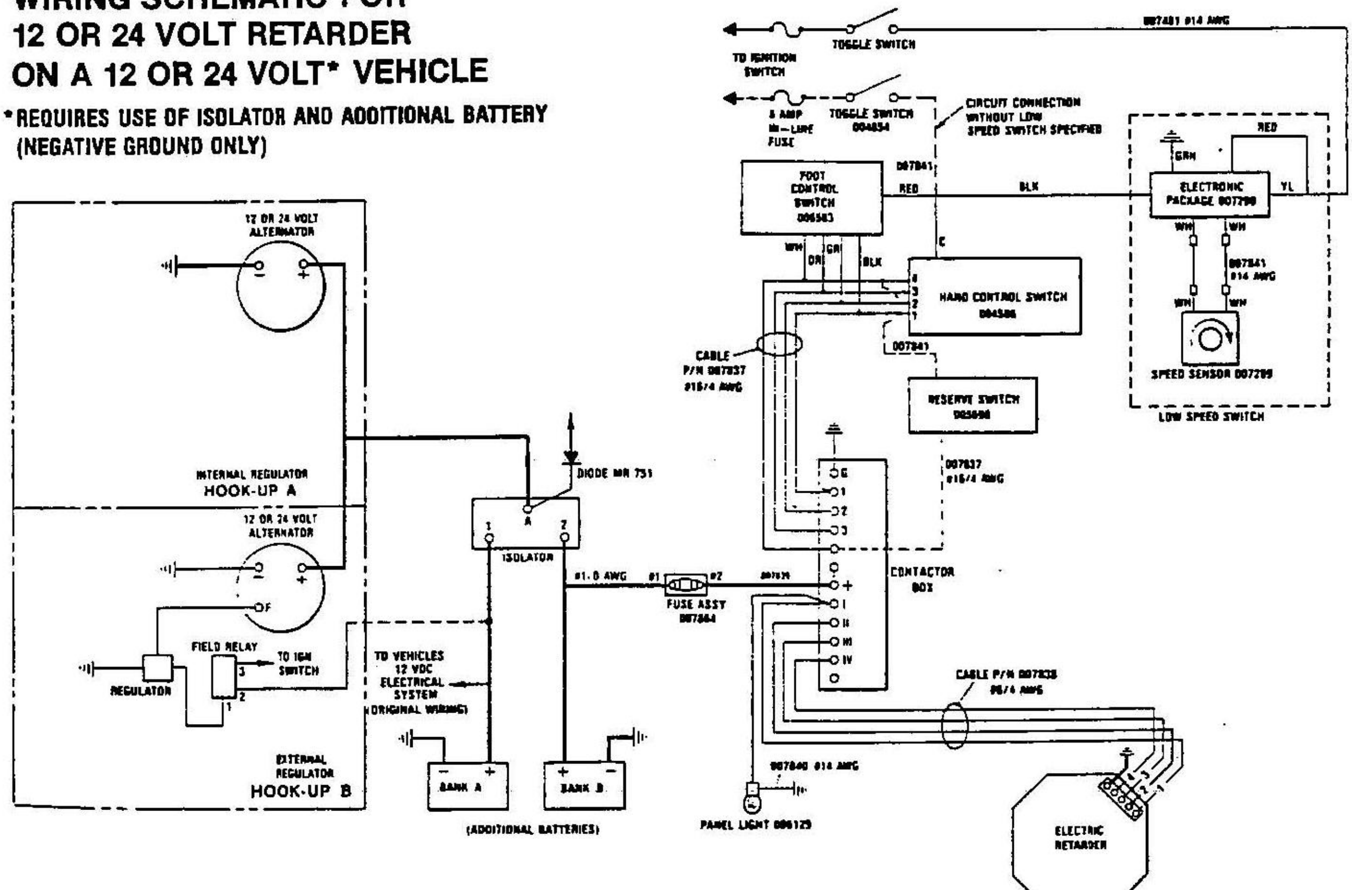
WIRING SCHEMATIC
FOR
12 VOLT RETARDER ON A 12 VOLT VEHICLE
OR 24 VOLT RETARDER ON A 24 VOLT VEHICLE

* WILL REQUIRE ADDITIONAL BATTERIES IN VEHICLE BATTERY BANK
TO PROVIDE REQUIRED CAPACITY.
(NEGATIVE GROUND ONLY)



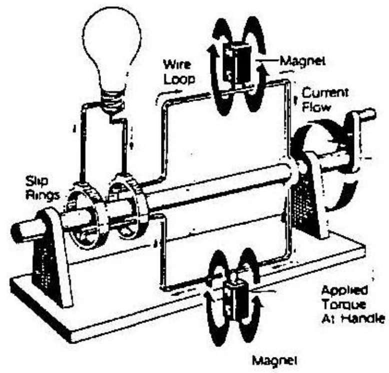
WIRING SCHEMATIC FOR
12 OR 24 VOLT RETARDER
ON A 12 OR 24 VOLT* VEHICLE

*REQUIRES USE OF ISOLATOR AND ADDITIONAL BATTERY
(NEGATIVE GROUND ONLY)



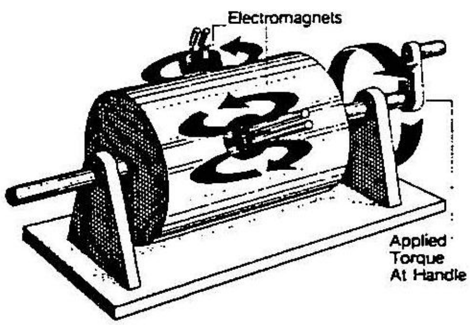
HOW DOES AN ELECTRIC RETARDER WORK?

The Klam Electric Retarder is a self-contained unit that fits in the drive line of a vehicle and can be visualized as a simple yet powerful electromagnet with its power used for retarding.



CURRENT IS GENERATED ELECTROMAGNETICALLY

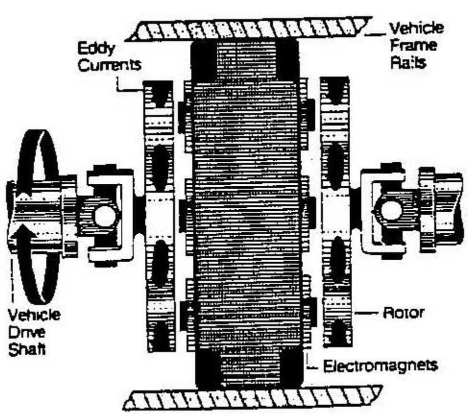
To understand the concept of the Klam Electric Retarder, think first of an electric generator. The schematic shows a simple model made with two magnets and a loop of wire. When the wire is rotated between the magnets by an applied torque, the action of the wire cutting through the lines of magnetic force causes a current to flow. The current is picked up by slips rings connected to each end of the loop of wire. It could be used for some practical purpose, such as lighting a bulb.



EDDY CURRENT RECIRCULATES, AND THUS RETARDS

Next, think of strong electromagnets acting on a drum rotated by applied torque. Areas of the drum under magnetic influence generates currents due to the action of the drum cutting across lines of force, similar to the generator.

But in this case, there is no path for the current to flow out of the drum shell. Thus, it recirculates in the drum. These currents, called eddy currents, set up a magnetic reactive force which works against the external force and tends to slow the rotation of the drum. The electrical energy is transformed into heat which must be dissipated.



A KLAM ELECTRIC RETARDER: THE RETARDING PRINCIPLE, APPLIED

Now, here's how the principle of retarding is applied to the Klam. As shown in the above diagram, the retarder contains a number of electromagnets (actually 16 coils, 8 on each side). These coils produce eddy currents in the rotors. These eddy currents create a strong magnetic drag force which tends to slow the rotors. The rotors are connected to the drive shaft of the vehicle. The coils are mounted in a frame which is fixed to the frame rails of the vehicle.

The electromagnetic force creates heat in the rotors, but they are spinning in open air and have cooling vanes which help dissipate heat as it is generated. However, continuous operation of the Klam will result in a decrease in retarding horsepower over time due to heat build up.

ELECTRIC KLAM RETARDER

OPERATION OF THE KLAM RETARDER

The manual 4-position hand control is located on the dash or steering column. The Contactor (Relay) Box connects the KLAM to the electrical system of the vehicle. It is normally located in an area where exposure to contaminants is minimized.

THE SERVICE BRAKES MUST BE USED TO BRING THE VEHICLE TO A COMPLETE STOP.

IF THE VEHICLE IS EQUIPPED WITH A LOW SPEED SHUT-OFF SWITCH, THE RETARDER AND DASHBOARD INDICATOR LIGHTS WILL NOT COME ON UNTIL ROAD SPEED IS ABOVE 8 mph (12 km/hr).

The Klam may be used for descending grades, in city traffic, approaching stop lights, and in general whenever vehicle retarding is required. Use of the Klam leaves the service brakes cooler, and more effective, for emergency stops. The more you use your Klam the less you use your service brakes.

The multi-position control system on the Klam provides variable retarding for various road and traffic conditions. When it is necessary to slow down, step through your positions until you get the desired rate of deceleration. Service brakes should be used for final stopping, or when more rapid braking is required. Since operation of any vehicle under slippery conditions is unpredictable, a good general rule is to gradually apply each position for best control of your vehicle.

TOO MUCH RETARDING TOO FAST CAN CAUSE LOSS OF CONTROL

Extender Retarder Use

When the Klam is used for extended periods of time, heat build-up will occur, resulting in diminished performance. The heat build-up is a function of time and switch position.

It is recommended that when long descents are encountered (5 minutes or more), the appropriate vehicle speed be obtained using the retarder in second (2nd) position. During long descents, third and fourth position should only be used for short periods of time to minimize the heat build-up and the possibility of damage. Select 3rd and 4th positions as the retarding force decays.

After descending long grades, and the rotors are hot, a cool down period of at least 5 minutes is necessary. Keep the vehicle moving so that the retarder rotors continue to rotate (minimum 15 mph) with the retarder turned off. The cooling period is necessary to prevent overheating.

Does Engine RPM Affect Klam?

Engine rpm does not affect Klam retarding power.

ELECTRIC KLAM RETARDER

Does Vehicle Speed Affect Klam?

Performance is proportional to drive shaft rpms (i.e., road speed) so more retarding power is available as drive shaft rpms are increased.

Do's and Don'ts of Operating The Klam

DO release accelerator pedal before energizing any retarder position.

DO use service brakes to bring the vehicle to a complete stop.

DO position hand control switch to the "OFF" position when vehicle has stopped to prevent battery drain.

DO allow for cool down period of the rotors after long descents, at least 5 minutes while vehicle is moving.

DO operate your Klam Electric Retarder carefully under slippery road conditions.

DO NOT use Retarder when accelerating.

DO NOT use 4th position for long durations on long descents to avoid overheating.

DO NOT INSTALL ELECTRIC RETARDER ON VEHICLES CARRYING FLAMMABLE LOADS. ELECTRIC RETARDER SHOULD NOT BE USED IN EXPLOSIVE ATMOSPHERES.

The Klam Electric Retarder is a drive line mounted, power absorbing device which, unlike wheel brakes, does not depend upon friction to generate a retarding force. It consists of two air cooled steel rotors mounted on a solid shaft which is, in turn, supported by large tapered roller bearings. (See Figure 1)

An array of powerful D.C. electromagnets is attached to the stationary frame of the retarder unit with the steel end pole pieces separated from the inner face of the rotors by a small air gap, cast in the form of centrifugal fans which pump cooling air through the rotors continuously.

The retarding force is developed by the action of the rotor shearing through lines of magnetic force. As in wheel brakes, considerable heat is generated. However in the retarder, the heat is produced by the flow of electrical currents within the rotor themselves and is dissipated by the flow of air through the rotors.

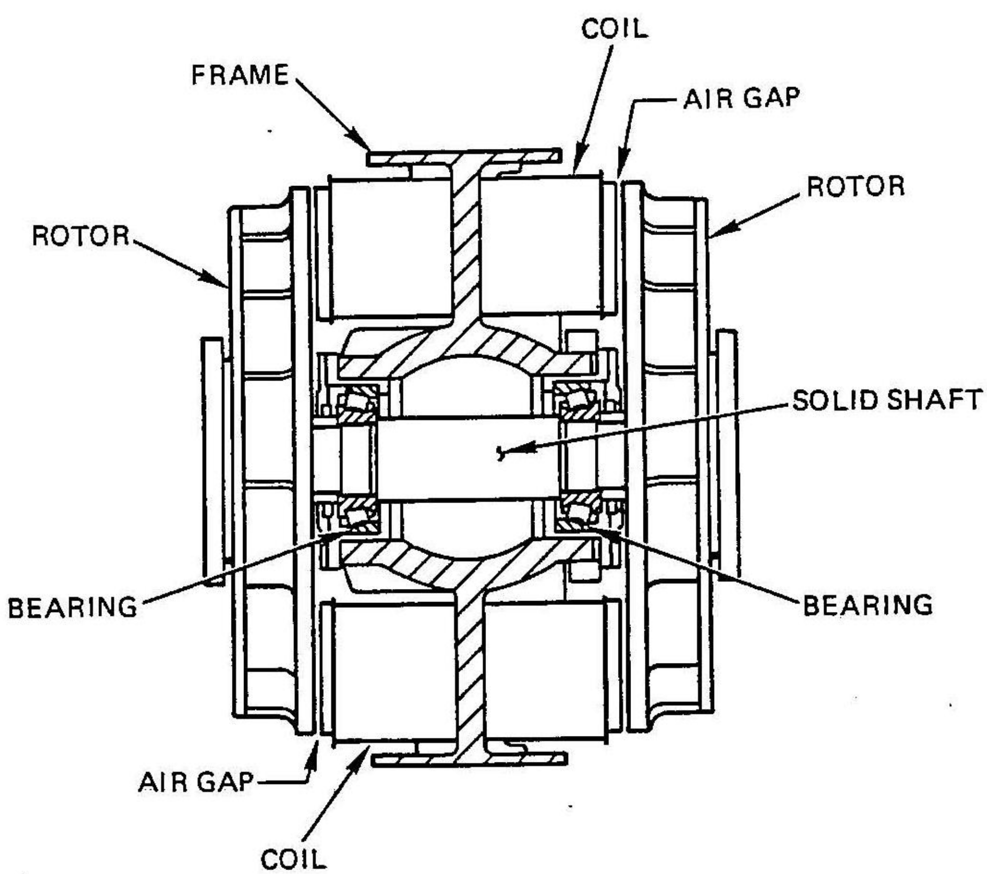
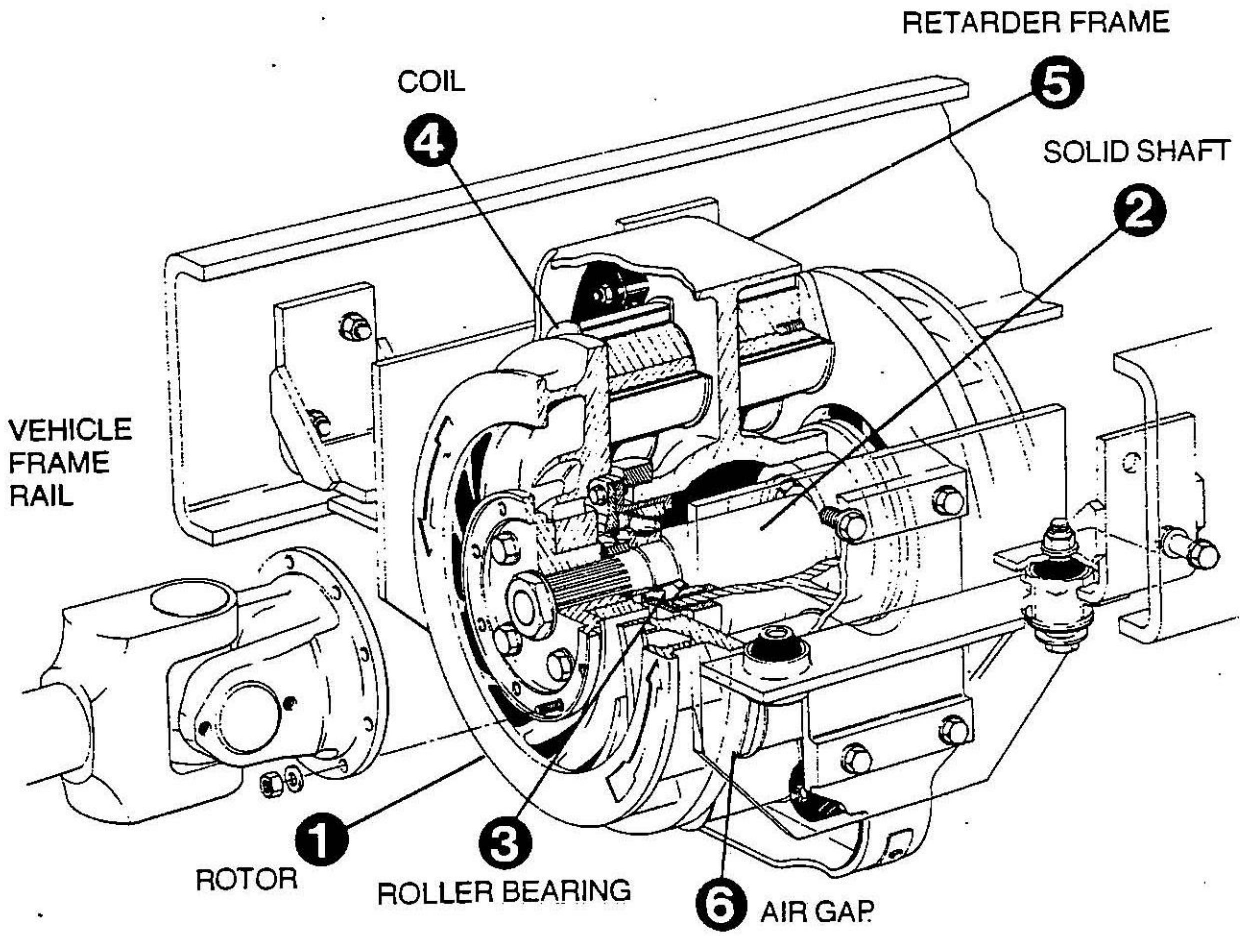


Figure 1.

The Klam Electric Retarder uses powerful electromagnetic coils to create a very strong force for retarding virtually all types of vehicles. The following description of the Klam operation refers to the cutaway below.

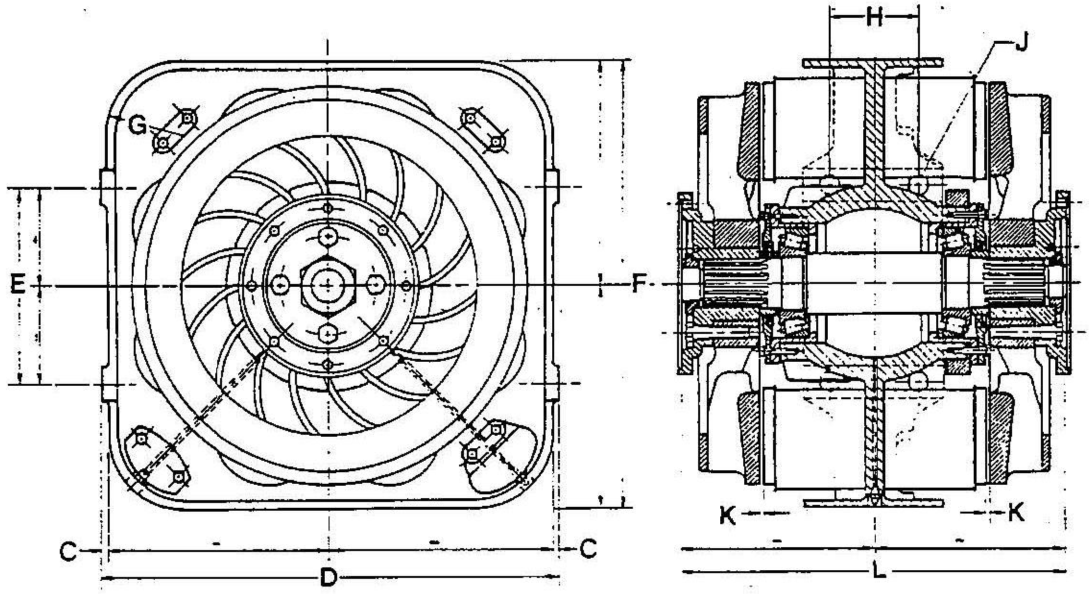
The retarder consists of two air-cooled steel rotors (1) mounted on a solid shaft (2). The shaft, in turn, is supported by large, tapered roller bearings (3). Sixteen electromagnetic coils (4) are attached to the stationary retarder frame (5) of the unit, and these are separated from the inner surface of the rotors by a small air gap (6).

The Klam Electric Retarder comes complete with all attaching parts and in-cab controls. A wide range of models is available.



ELECTRIC KLAM RETARDER

KLAM K-SERIES RETARDER DIMENSIONS

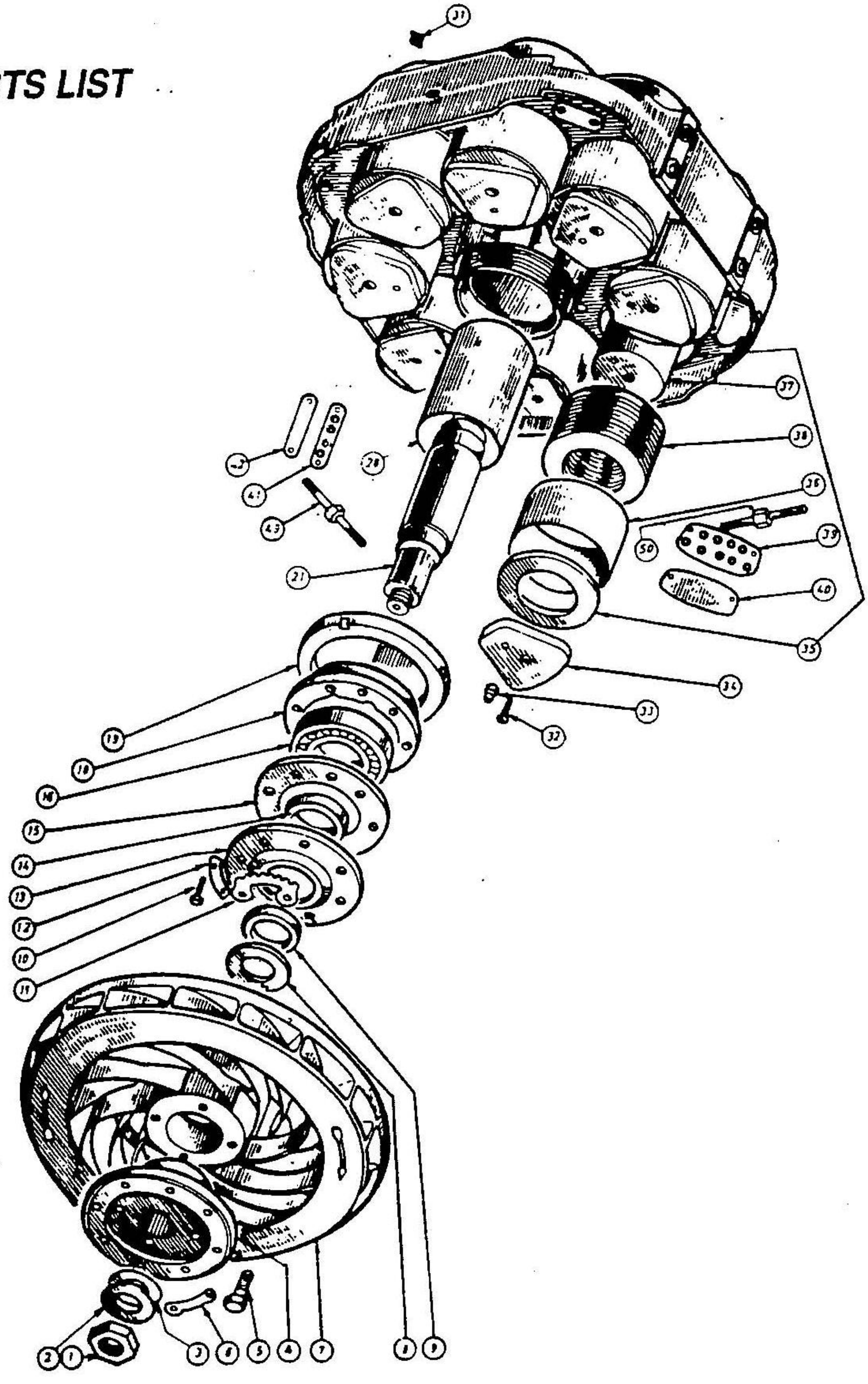


RETARDER SERIES	C	D	E	F	G	H	I	J	K
K40	.196	14.56	5.51	13.08	1.57	2.75	0.59	14mm	.035 to .040
K70	.196	14.96	7.08	14.56	3.30	3.54	.059	14 mm	.035 to .040
K100	.433	16.22	7.08	15.35	3.30	3.54	.059	14 mm	.035 to .040
K140	.275	17.53	7.08	18.97	4.72	3.54	.059	14 mm	.035 to .040
K145C	.275	19.53	7.08	18.97	4.72	3.54	.059	14 mm	.040 to .045
K160	.275	19.53	7.08	18.97	4.72	3.54	.059	14 mm	.040 to .045
K200	.315	21.81	7.08	21.18	5.90	3.54	.059	14 mm	.050 to .055
K250	.315	21.81	7.08	21.18	5.90	3.54	.059	14 mm	.050 to .055
K300	.315	21.81	7.08	21.18	5.90	3.54	.059	14 mm	.050 to .055
K320	.315	23.22	7.08	22.64	6.69	3.54	.059	14 mm	.050 to .055
K400	.315	24.40	7.08	23.82	6.69	3.54	.059	14 mm	.050 to .055
K450	.315	21.81	7.08	24.41	6.69	3.54	.059	14 mm	.050 to .055
K480	.315	21.81	7.08	24.41	6.69	3.54	.059	14 mm	.050 to .055

RETARDER SERIES	L				
	1410 FLANGES	1500 FLANGES	1600 FLANGES	1700 FLANGES	1800 FLANGES
K40	11.03	11.03	–	–	–
K70	14.90	14.90	14.96	15.35	–
K100	14.90	14.90	14.96	15.35	–
K140	14.90	14.90	14.96	15.35	–
K145	14.90	14.90	14.96	15.35	–
K160	–	–	16.53	16.53	–
K200	–	–	16.93	16.93	16.93
K250	–	–	17.71	17.71	17.71
K300	–	–	18.11	18.11	18.11
K320	–	–	18.11	18.11	18.11
K400	–	–	17.71	17.71	17.71
K450	–	–	18.11	18.11	18.11
K480	–	–	18.11	18.11	18.11

ELECTRIC KLAM RETARDER

PARTS LIST



ELECTRIC KLAM RETARDER

NO.	PART NAME	QTY UNIT
1	NUT - AXLE	2
2	WASHER - Belleville	2
4	FLANGE (For Coupling 1400)	2
4	FLANGE (For Coupling 1500)	2
4	FLANGE (For Coupling 1600)	2
4	FLANGE (For Coupling 1700)	2
4	FLANGE (For Coupling 1800)	2
4	FLANGE (For Coupling DIN 165)	2
4	FLANGE (For Coupling DIN 180)	2
5	BOLT - Hex Head	8
6	WASHER - Belleville	8
7	FLYWHEEL - Front	1
7	FLYWHEEL - Rear	1
8	SHIM - Air Gap	AR
8	SHIM - Air Gap	AR
8	SHIM - Air Gap	AR
8	SHIM - Air Gap	AR
9	COLLAR - Wear	2
10	BOLT - Seal Plate	16
11	TAB - Locking	1
12	PLATE - Locking	7
13	PLATE - Seal	2
15	GASKET - Seal Plate	2
16	BEARING - Roller	2
18	RETAINER - Bearing	2
19	NUT - Adj. Axial Play	1
21	AXLE - Splined	1
31	FITTING - Grease	1
32	SCREW - Pole Plate	16
34	PLATE - Pole	16
35	WASHER - Insulating	32
36	COIL - Tub	16
37	INSULATOR - Pole	16
38	COIL - Electric	16
39	BLOCK - Terminal	1
40	CAP - Terminal	1
49	STRAP - Connector (short)	6
50	STRAP - Connector (long)	2

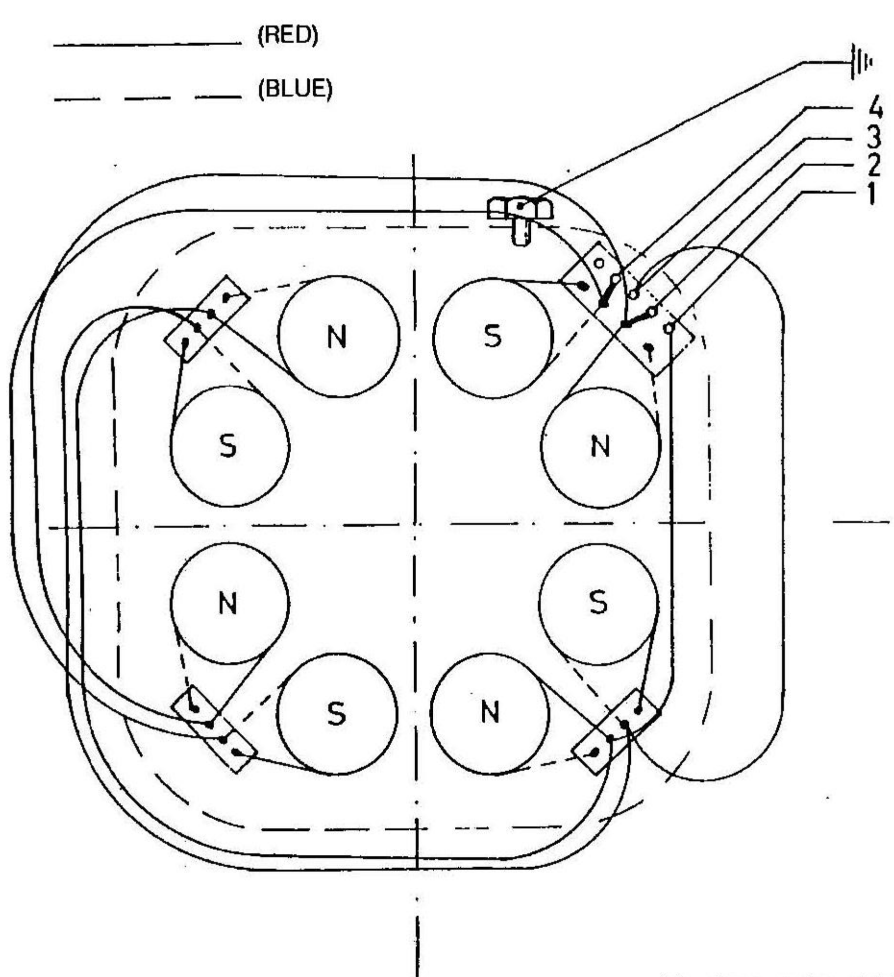
K SERIES PARTS LIST

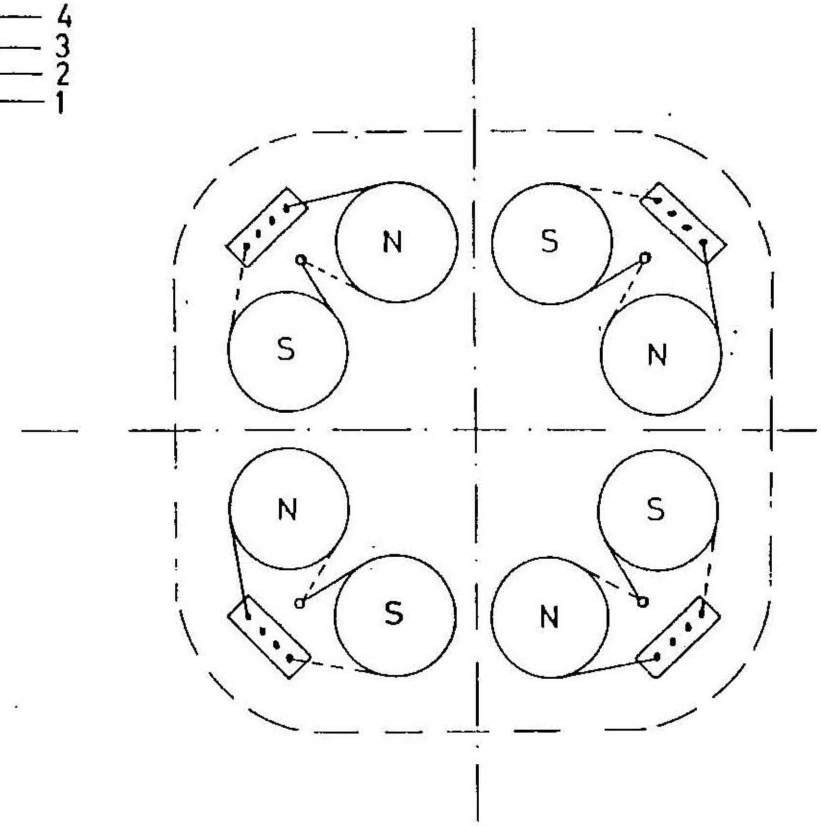
REF.	DESCRIPTION	K-70 NO.	K-100 NO.	K-130 NO.	K-140 NO.	KR-140 NO.	K-145 NO.	K-160 NO.	K-200 NO.
1	NUT- AXLE	10010	10010	10010	10010	10010	10010	10010	16010
2	WASHER - BELLEVILLE	10020	10020	10020	10020	10020	10020	10020	16020
4	FLANGE (for coupling) N. DIN 130	10030	10030	10030	10030	10030	10030	10030	–
4	FLANGE (for coupling) N. DIN 150	10031	10031	10031	10031	10031	10031	10031	–
4	FLANGE (for coupling) MERCEDES	10032	10032	10032	10032	10032	10032	10032	–
4	FLANGE (for coupling 1410)	10040	10040	10040	10040	10040	10040	–	–
4	FLANGE (for coupling 1500)	10045	10045	10045	10045	10045	10045	–	–
4	FLANGE (for coupling 1600)	10046	10046	10046	10046	10046	10046	10046	16046
4	FLANGE (for coupling 1700)	10047	10047	10047	10047	10047	10047	10047	16047
4	FLANGE (for coupling 1800)	–	–	–	–	–	–	–	16048
4	FLANGE (for coupling PEGASO)	10049	10049	10049	10049	10049	10049	10049	16049
4	FLANGE - DIN-165	–	–	–	–	–	–	–	16008
4	FLANGE - DIN-180 (Ø 16)	–	–	–	–	–	–	–	16009
4	FLANGE - DIN-180 (Ø 14)	–	–	–	–	–	–	–	16006
4	FLANGE (for coupling 70°)	–	–	–	–	–	–	–	16040
4	FLANGE (for coupling SCANIA)	–	–	–	–	–	–	–	16041
5	BOLT - HEX HEAD	10050	10050	10050	10050	10050	10050	10050	16050
6	WASHER - FLANGE	10064	10064	10064	10064	10064	10064	10064	16066
7	FLYWHEEL - FRONT	70070	10070	11070	12070	13070	12070	12070	16070
7	FLYWHEEL - REAR	70071	10071	11071	12071	13071	12071	12071	16071
8	SHIM - AIR GAP	10082	10082	10082	10082	10082	10082	10082	16082
8	SHIM - AIR GAP	10083	10083	10083	10083	10083	10083	10083	16083
8	SHIM - AIR GAP	10084	10084	10084	10084	10084	10084	10084	16084
8	SHIM - AIR GAP	10085	10085	10085	10085	10085	10085	10085	16085
9	COLLAR - WEAR	70090	10090	12090	12090	12090	12090	13090	16090
10	BOLT - SEAL PLATE	100	100	100	100	100	100	100	100
11	TAB - LOCKING	110	110	110	110	110	110	110	110
12	PLATE - LOCKING	10120	10120	12120	12120	12120	12120	12120	16120
13	PLATE - SEAL	10130	10130	12130	12130	12130	12130	12130	16130
14	RING - SEAL	10140	10140	12140	12140	12140	12140	12140	16140
15	RING - SEAL (STENCO)	–	–	–	–	12145	–	12145	16145
15	BEARING - ROLLER	10150	10150	12150	12150	12150	12150	12150	16150
16	RETAINER - BEARING	10160	10160	12160	12160	12160	12160	12160	16160
18	NUT - ADJ. AXIAL PLAY	10180	10180	12180	12180	12180	12180	12180	16180
19	NUT - BEARING	10190	10190	12090	12090	12090	12090	12190	16190
21	AXLE - SPLINED	70210	10210	12210	12210	12211	12210	12200	16210
31	FITTING - GREASE	310	310	310	310	310	310	310	310
32	SCREW - POLE PLATE	300	300	300	300	300	300	300	320
33	PIN - POLE PLATE	330	330	330	330	330	330	330	330
34	PLATE POLE	10340	10340	11340	12340	12340	12340	12340	16340
35	WASHER - INSULATING	70350	10350	11350	12350	12350	12350	12350	16350
36	PROTECTION - COIL	10360	10360	14360	14360	14360	14360	26360	16360
37	WASHER - INSULATING	10370	10370	12370	12370	12370	12370	26370	16370
38	COIL - ELECTRIC	70380(AL)	10380(AL)	13380(AL)	14380(AL)	14380(AL)	–	26380(AL)	16380(AL)
38	COIL - ELECTRIC	70381(C)	10381(C)	13381(C)	14381(C)	14381(C)	14381(C)	26381(C)	163801(C)
39	BLOCK - TERMINAL	390	390	390	390	390	390	390	390
40	CAP - TERMINAL	400	400	400	400	400	400	400	400
41	BLOCK - CABLE	410	410	410	410	410	410	410	410
42	CAP - CABLE	420	420	420	420	420	420	420	420
49	STRAP - LARGE	12490	12490	12490	12490	12490	12490	12490	12490
50	STRAP - SHORT	12500	12500	12500	12500	12500	12500	12500	12500

K SERIES PARTS LIST

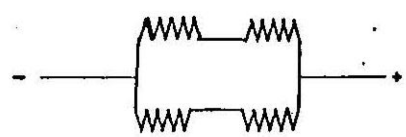
REF.	K-250 NO.	KR-250 NO.	K-300 NO.	KR-300 NO.	K-400 NO.	K-450 NO.	KR-450 NO.	K-480 NO.	KR-480 NO.
1	16010	16010	16010	16010	16010	16010	16010	16010	16010
2	16020	16020	16020	16020	16020	16020	16020	16020	16020
4	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–
4	16046	16046	16046	16046	16046	16046	16046	16046	16046
4	16047	16047	16047	16047	16047	16047	16047	16047	16047
4	16048	16048	16048	16048	16048	16048	16048	16048	16048
4	16049	16049	16049	16049	16049	16049	16049	16049	16049
4	16008	16008	16008	16008	16008	16008	16008	16008	16008
4	16009	16009	16009	16009	16009	16009	16009	16009	16009
4	16006	16006	16006	16006	16006	16006	16006	16006	16006
4	16040	16040	16040	16040	16040	16040	16040	16040	16040
4	16041	16041	16041	16041	16041	16041	16041	16041	16041
5	16050	16050	16050	16050	16050	16050	16050	16050	16050
6	16066	16066	16066	16066	16066	16066	16066	16066	16066
7	16220	16221	16225	16226	17240	17240	17241	17240	17241
7	16230	16231	16235	16236	17250	17250	17251	17250	17251
8	16082	16082	16082	16082	16082	16082	16082	16082	16082
8	16083	16083	16083	16083	16083	16083	16083	16083	16083
8	16084	16084	16084	16084	16084	16084	16084	16084	16084
8	16085	16085	16085	16085	16085	16085	16085	16085	16085
9	16091	16091	16095	16095	16092	16092	16092	16092	16092
10	100	100	100	100	100	100	100	100	100
11	110	110	110	110	110	110	110	110	110
12	16120	16120	16120	16120	16120	16120	16120	16120	16120
13	16130	16130	16130	16130	16130	16130	16130	16130	16130
14	16140	16140	16140	16140	16140	16140	16140	16140	16140
15	16145	16145	16145	16145	16145	16145	16145	16145	16145
15	16150	16150	16150	16150	16150	16150	16150	16150	16150
16	16160	16160	16160	16160	16160	16160	16160	16160	16160
18	16180	16180	16180	16180	16180	16180	16180	16180	16180
19	16190	16190	16190	16190	16190	16190	16190	16190	16190
21	16215	16216	16215	16217	16215	16215	16217	16215	16217
31	310	310	310	310	310	310	310	310	310
32	320	320	320	320	320	320	320	320	320
33	330	330	330	330	330	330	330	330	330
34	16340	16340	16345	16345	17340	17340	17340	17340	17340
35	16350	16350	16350	16350	17355	17355	17355	17355	17355
36	26360	26360	26360	26360	47360	47360	47360	47360	47360
37	26370	26370	26370	26370	27370	27370	27370	27370	27370
38	26380(AL)	26380(AL)	26385(AL)	26385(AL)	37380(AL)	–	–	–	–
38	–	–	26375(C)	26375(C)	–	37381(C)	37381(C)	47380(C)	47380(C)
39	390	390	390	390	390	390	390	390	390
40	400	400	400	400	400	400	400	400	400
41	410	410	410	410	410	410	410	410	410
42	420	420	420	420	420	420	420	420	420
49	12490	12490	12490	12490	12490	12490	12490	12490	12490
50	12500	12500	12500	12500	12500	12500	12500	12500	1250

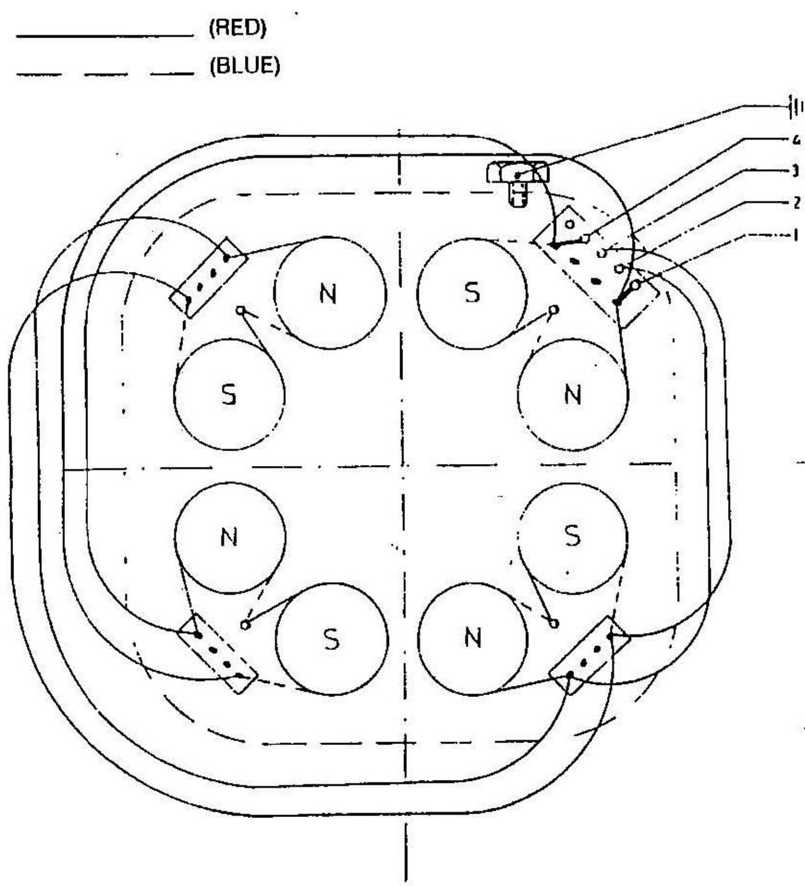
REF.	DESCRIPTION	KA-160 NO.	KA-220 NO.	KA-250 NO.	KA-330 NO.
1	FLYWHEEL LEFT	17001	18001	19001	33001
2	FLYWHEEL RIGHT	17002	18002	19002	33002
3	MOORING STAR	17003	18003	19003	33003
4	INTERCALATION	17004	18004	19004	33004
5	BOLT	17005	18005	19005	33005
6	BLOCK - TERMINAL	17006	18006	19006	33006
7	STRAP	17007	18007	19007	33007
8	CAP - TERMINAL	17008	18008	19008	33008
9	WASHER - INSULATING	17009	18009	19009	33009
10	COIL - ELECTRIC (CU)	17010	18010	19010	33010
11	PROTECTION - COIL	17011	18011	19011	33011
12	PIN - POLE PLATE	17012	18012	19012	33012
13	PLATE POLE	17013	18013	19013	33013
14	SCREN - POLE PLATE	17014	18014	19014	33014
15	SCREN - GEAR-BOX	17015	18015	19015	33015
16	SCREN - CAP TERMINAL	17016	18016	19016	33016
17	NUT - BLOCK CABLE	17017	18017	19017	33017
18	BLOCK - CABLE	17018	18018	19018	33018
19	NUT - INTERCALATION	17019	18019	19019	33019
20	BOLT - FLYWHEEL	17020	18020	19020	33020
21	BOLT - MOORING STAR	17021	18021	19021	33021
22	STATOR	17022	18022	19022	33022

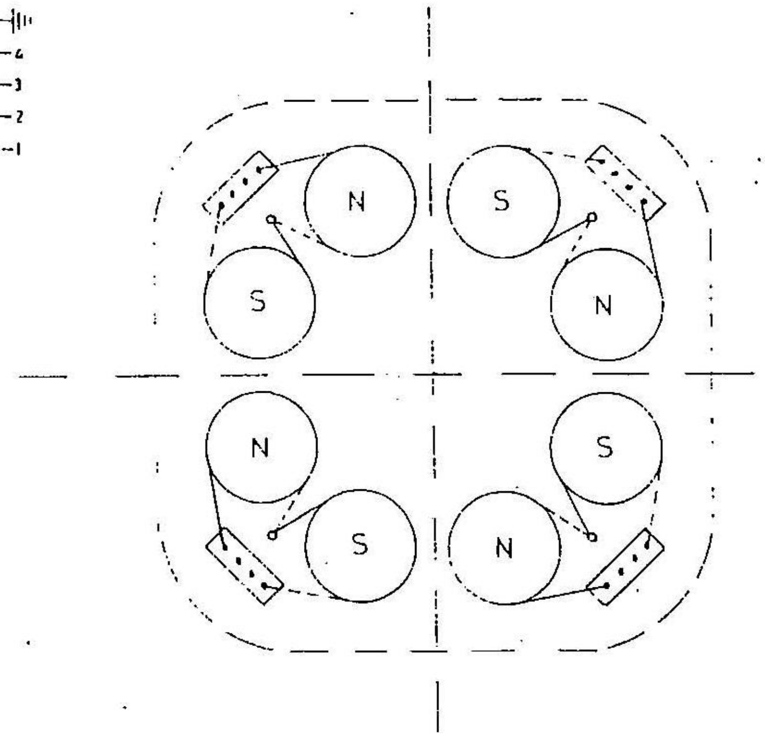


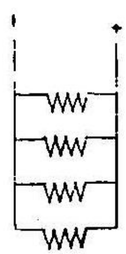


K - 120, 140, 160, 200, 230, 12 V.
K - 400, 320
K-300, 270, 260, 250, 230, 200, 160, 140, 120, 24 V.









ELECTRIC RETARDER COIL RESISTANCE PROCEDURE

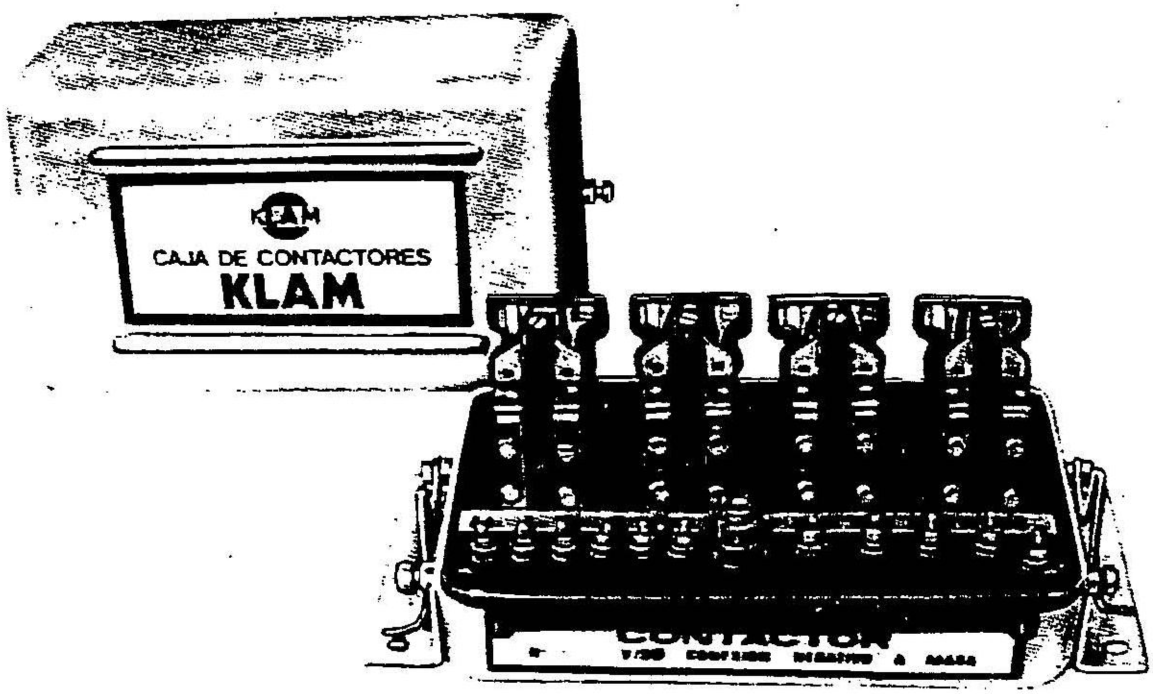
K - 400 & 320 12 V.

ADDITIONAL COMPONENTS

1) CONTACTOR BOX

The electric retarder may be progressively activated by a multi-position control. In this case a selector switch operates heavy-duty relays (located in the contactor box) which connect a current supply from the vehicle's battery to the retarder.

CONTACTOR BOX

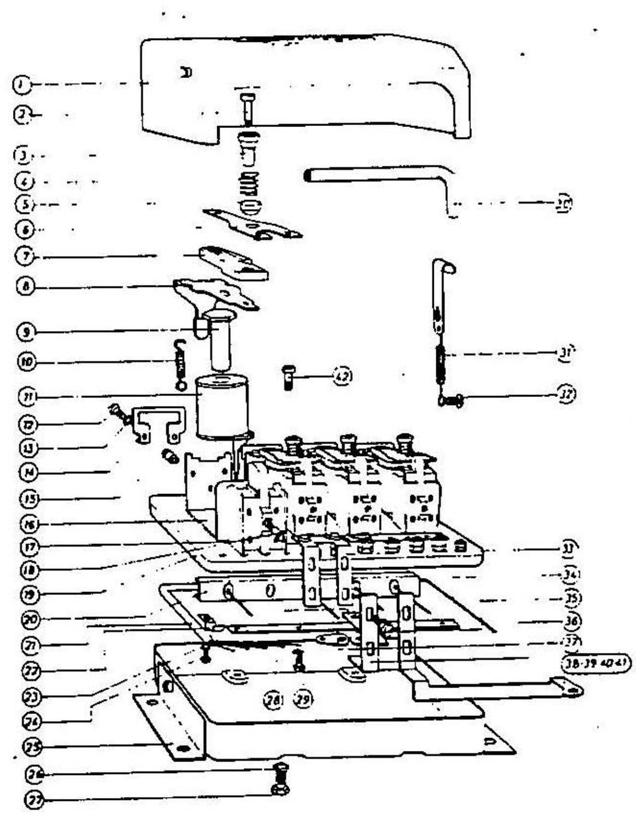


With diodes	12 V.	Negative Ground	4402000
"	12 V.	Positive Ground	4402100
"	24 V.	Negative Ground	4403000
"	24 V.	Positive Ground	4403100

ELECTRIC
KLAM
RETARDER

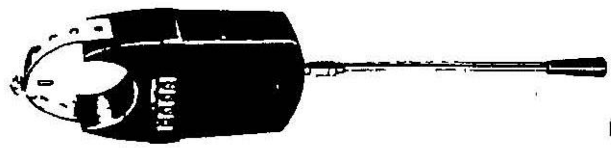
1

PARTS LIST

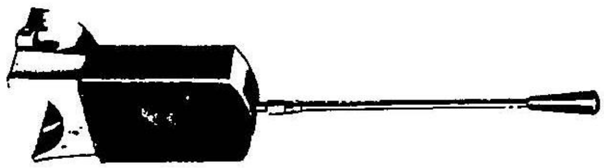


NO.	PART NO.	PART NAME	QTY. UNIT	NO.	PART NO.	PART NAME	QTY. UNIT
1	4400015	Contactor Box Assembly	1	22	3400037	Nut - Hex	1
2	1603009	Nut - Crown	4	23	1640001	Washer	8
3	3400017	Guide - Spring	4	24	1603005	Bolt - Hex Coil	8
4	3400016	Spring - Relay	4	25	4400013	Contactor Box Assembly	1
5	3400015	Seat - Spring	4	26	1640002	Washer Lock	8
6	4400005	Contact - (upper)	4	27	1601006	Screw - Hex Head	8
7	3400014	Insulator (contact - upper)	4	28	1640001	Washer Lock	4
8	3400011	Armature - Movable	4	29	1603001	Screw - Coil	4
9	3400008	Coil Post - Threaded	4	30A	3400045	Isolator - Upper	1
10	3400013	Spring - Armature	4	30B	3400045/1	Isolator - Lower	1
11A	4402001	Coil - Relay (12 VDC)	4	31	3400024	Spring - Box Assembly	2
11B	4403001	Coil - Relay (24 VDC)	4	33	4400006	Contact - Lower (short)	8
12	1603001	Screw - Guard	8	34	3400033	Common Connection	1
13	1640001	Washer - Guard	8	35	1603002	Screw	16
14	3400012	Guard - Armature	4	37	3400034	Contact - Lower (long)	8
15	3400007	Coil - Threaded	4	38	3400021	Common Connection (1st)	1
16	3400006	Bracket - Relay	4	39	3400020	Common Connection (2nd)	1
17	3400009	Insulator (contact - lower)	4	40	3400019	Common Connection (3rd)	1
18	1603003	Screw - Slotted	4	41	3400018	Common Connection (4th)	1
19	3400031	Base - Relay	1	42A	1721001	Diode - Positive	1
20	3400030	Diode - Base	1	42B	1721002	Diode - Negative	4

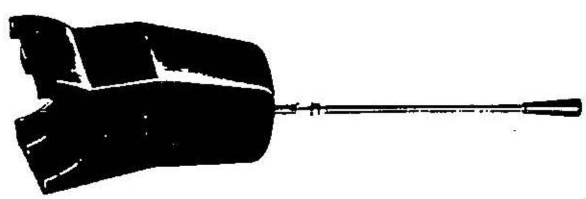
MODELS OF HAND CONTROL



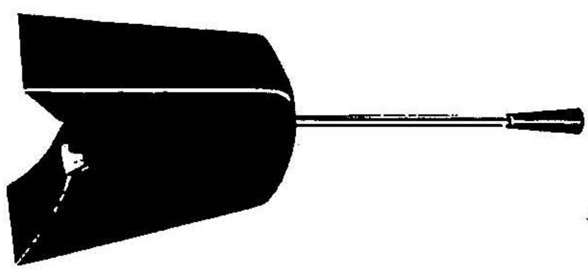
REF. 4021000



REF. 4022000



REF. 4023000



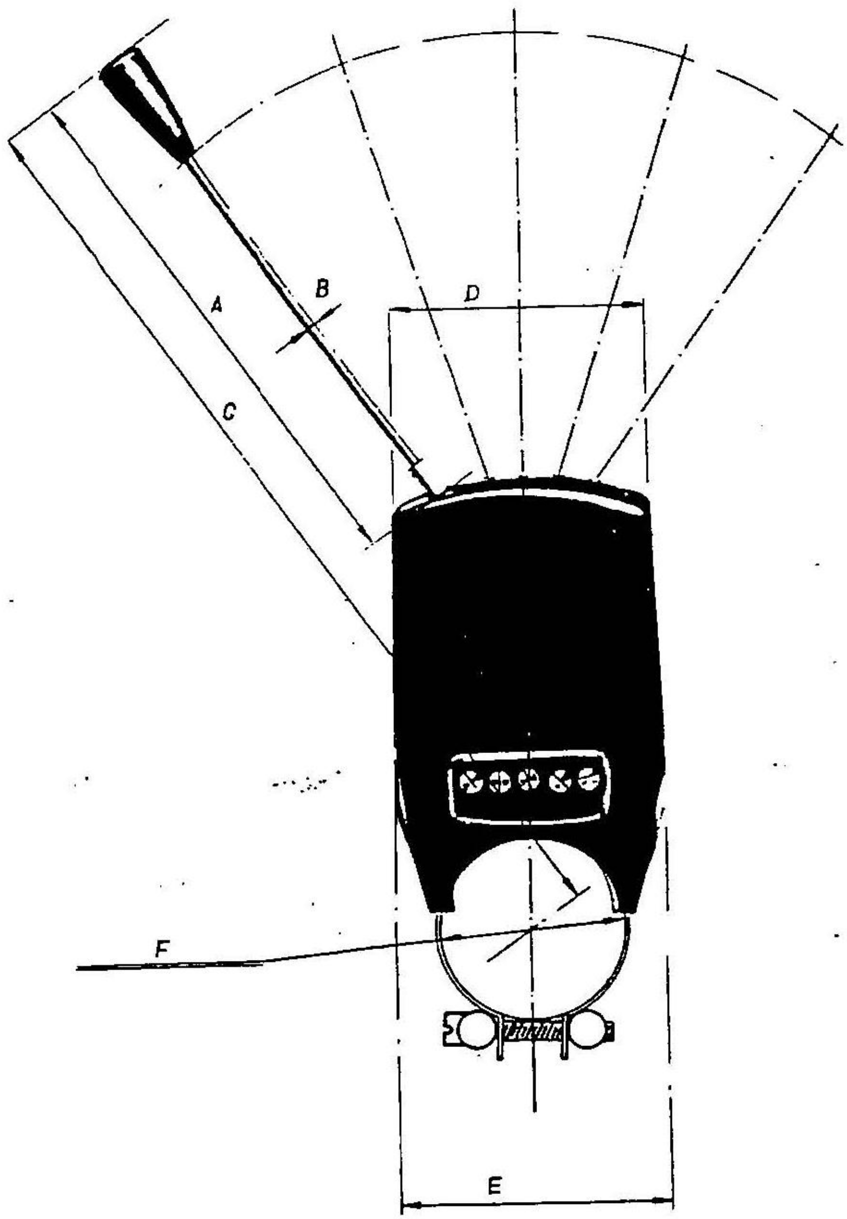
4024000

2) HAND CONTROL

The fingertip control is recommended for use on trucks and tractors and some industrial equipment. The multi-position lever is mounted on the steering column or dash. The retarder is operated by moving the control lever through the four positions, thereby providing progressive retarding power. An automatic time delay facture assures a smooth application of retarding power.

ELECTRIC KLAM RETARDER

HAND CONTROL FUNCTIONAL DIMENSIONS



	A	B	C	D	E	F
Dimensions	7.28	.197	12.6	2.83	3.22	1.18 to 3.93

ELECTRIC KLAM RETARDER

DRIVESHAFT AND RETARDER FLANGE TABULATION

KLAM RETARDER MODEL	DRIVELINE SERIES	RETARDER PILOT & BOLT PATTERN	USE THIS DRIVELINE FLANGE NO.
K450C	1810	7 3/4" PILOT	6.5-2-329
	1760	12 BOLT PATTERN	6.3-2-19
	1710	7/16" HOLE	* 6-2-1159 or
			6-2-739
K300C	1810	7 3/4" PILOT	6.5-2-329
	1760	12 BOLT PATTERN	6.3-2-19
	1710	7/16" HOLE	* 6-2-1159 or
			6-2-739
K200C	1810	7 3/4" PILOT	** 6.5-2-329
	1760	8 BOLT PATTERN	** 6.3-2-19
	1710	3/8" HOLE	6-2-749
K145C	1610	6 5/8" PILOT	5-2-279
	1550	8 BOLT PATTERN	4-2-689
	1480	3/8" HOLE	3-2-499
K130C	1610	6 5/8" PILOT	5-2-279
K100C	1550	8 BOLT PATTERN	4-2-689
K70C	1480	3/8" HOLE	3-2-499
K130C	1550	3 3/4" PILOT	4-2-669
K100C	1480	4 BOLT PATTERN	3-2-479
K70C	1410		3-2-159
K130C	1410	2 3/4" PILOT	3-2-159
K100C	1350	4 BOLT PATTERN	3-2-119
K70C	1310		2-2-479

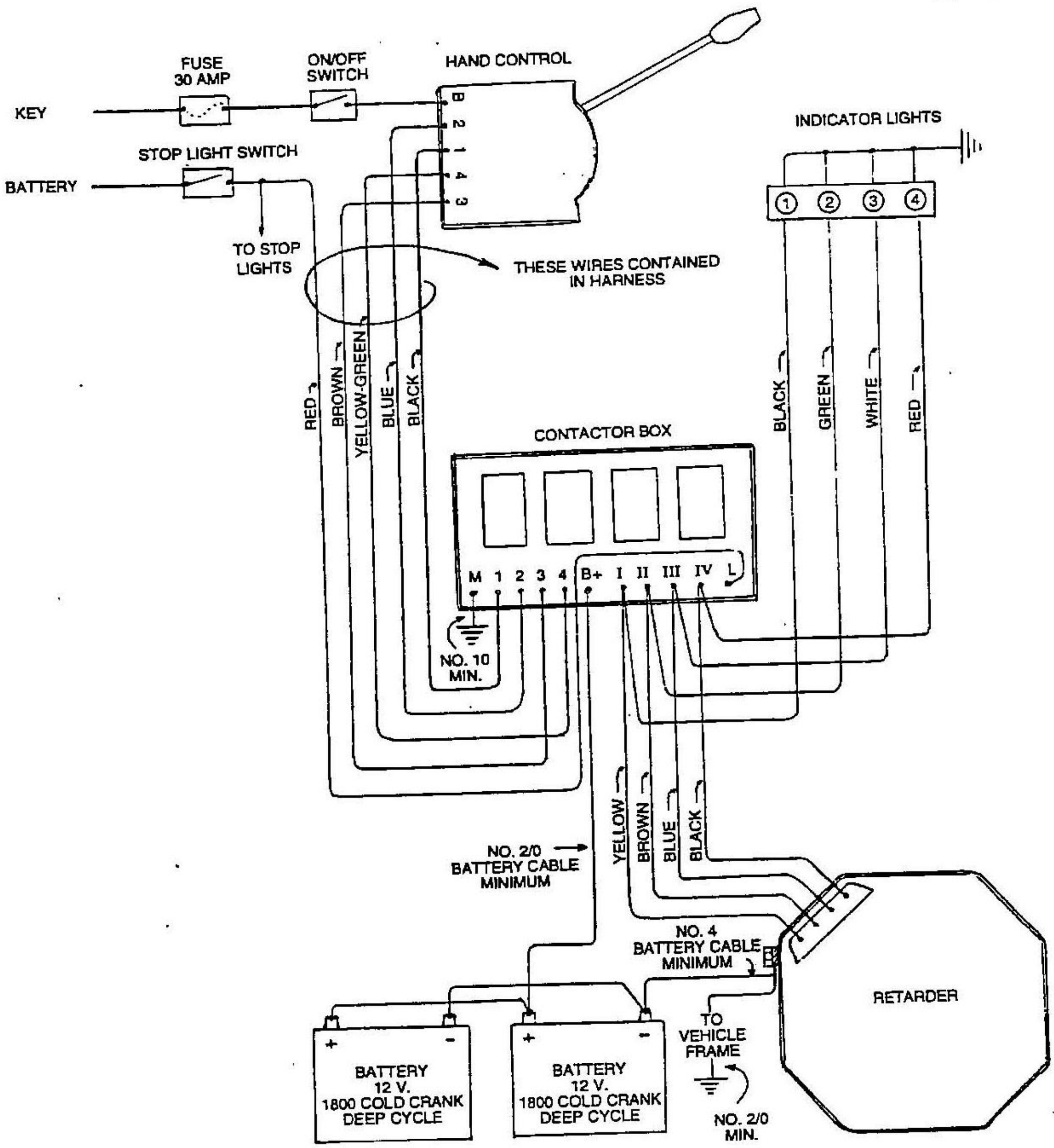
NOTE:

* This flange can be used on a 12 bolt pattern. 7/16" bolt holes.
** This flange can be used on an 8 bolt pattern. 7/16" bolt holes.

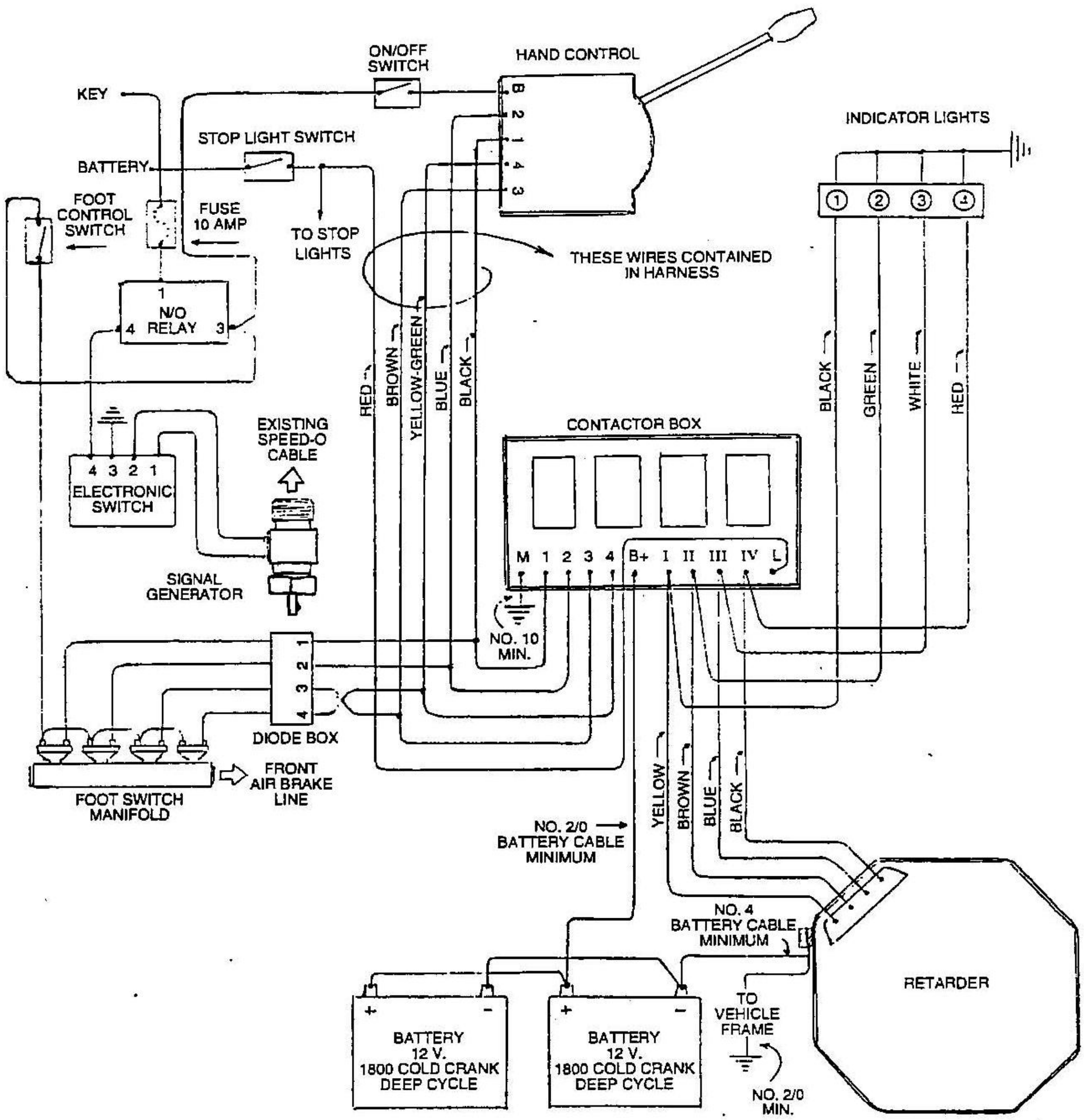
The part numbers used are Spicer numbers, and can be found in the Spicer Manual J300P.

ELECTRIC KLAM RETARDER

12 V. RETARDER WIRING SCHEMATIC (EFF. 11-91) USING HAND CONTROL



12 V. RETARDER WIRING SCHEMATIC (EFF. 11-91)
WITH FOOT CONTROL - AIR



ELECTRIC KLAM RETARDER

MAINTENANCE

Normally the only maintenance the Klam requires is an occasional "wash down" of the unit with water and periodic lubrication of the bearings.*

NORMAL "WASH-DOWN": Allow rotors to cool to the touch, then hose them down with high pressure water. Make sure all dirt is dislodged from cooling fins of rotors and around coils.

- DO NOT wash while the retarder is hot or damage could occur.
- DO NOT use any sharp instruments to dislodge dirt from around coils or damage to the coils could result.
- DO NOT use caustic solution in wash down as it will initiate terminal corrosion.
- Off-highway vehicles require more frequent care of keeping cooling fins dislodged of dirt due to environment.

Lubrication

Lubrication intervals depend on the severity of operation, number of miles traveled, and amount of retarder use. In general, it is recommended that the Klam be lubricated at the intervals shown below with a high quality NLGI Grade 2 Lithium base grease with 180°C (360°F) minimum drop point. Typical lubricants are as follows:

MANUFACTURER	TYPE
Mobil	Mobilgrease MP
Shell	EP Alvania 2
Amoco	Lithium MP
	Amolith 2 MP
Chevron	Ultraduty 2
	Molygrease 2
Conoco	EP Conolith 2
	Super Sta M
Citgo	JT6
Long Distance– Over Highway	**City Usage– Off Highway**
Every 4000 Miles	Every 2000 Miles or 30 Days

The Electric Retarder must be greased with an approved lubricant. A quantity of grease 2.5-3.0 oz. (7*-85 gr) shall be added.

At each grease interval, check vent tube for obstruction; pass small diameter wire .03 in (.76mm) approx. 6" long up vent hole to insure an open passage. **"DO NOT TURN SOCKET SCREW IN VENT AS DAMAGE WILL OCCUR."**

**Some units are equipped with sealed bearings and require no lubrication. Check with your distributor.*

ELECTRIC KLAM RETARDER

Periodic Inspection Checklist

- ☐ **VERIFY THAT WIRES DO NOT RUN ADJACENT TO GAS, AIR AND HYDRAULIC LINES.**
- ☐ **CHECK WIRES FOR ABRASION.**
- ☐ **INSPECT TO SEE IF SAFETY LOOPS AROUND DRIVE SHAFT ARE SECURE.**

- ☐ Check point gap.
- ☐ Inspect driveshaft-to-retarder mounting bolts. If they are missing or loose, replace.
- ☐ Inspect rubber shock mounts for the Retarder and related hardware. If damaged, replace.
- ☐ Inspect conditions of Electric Retarder electrical wiring, if damaged repair or replace.
- ☐ Inspect for evidence of a grease leak by checking backside of the rotors and surrounding area. It may mean a faulty grease seal.
- ☐ Check air gap.
- ☐ Check rotors for distortion.
- ☐ Inspect hand control for mechanical operation.
- ☐ Check for corroded terminals and connections. Replace as required using correct method and crimping tools.
- ☐ Visually inspect all welds on mounting hardware of the Retarder for separations and cracks. Check all hardware and frame rails for fatigue cracks or bending.
- ☐ Inspect coils for damage.
- ☐ Inspect for excess heating on chassis due to rotor heat build-up. Insulate as required.

ELECTRIC KLAM RETARDER

To Check for Excessive Play on Roller Bearings

Step 1 Disconnect flange yokes from Retarder.

Step 2 Set up dial indicator as shown in illustration. Exert a force as shown (approx. 100 lbs. maximum), while holding pressure set dial indicator at "0", then release the exerted force. Now without moving the dial indicator, exert a force against the opposite flange of the Retarder and take the reading from the dial indicator. If reading exceeds .004 in. (10mm), then bearing end play must be adjusted.

REPLACING RUBBER MOUNTS (SILENT BLOCKS)

A) Removing Press-in Type Rubber Mount

B) Removing Bolt-in Type Rubber Mount

A) Removing Press-in Type Mount

Step 1 Using transmission jack to cradle retarder, jack up retarder until the weight is taken off the rubber mounts.

Step 2 Remove both large support bolts (18mm) on the damaged side.

Step 3 Remove side support plate bolts (14mm) and remove side support plate.

Step 4 Press out damaged rubber mount as shown in Figure 1.

Step 5 Press in new mount (Note direction of ass'y.) until bottomed on bracket and install in the proper direction.

Step 6 Reverse procedure to reassemble. (Note order of ass'y. of hardware.)

ELECTRIC KLAM RETARDER

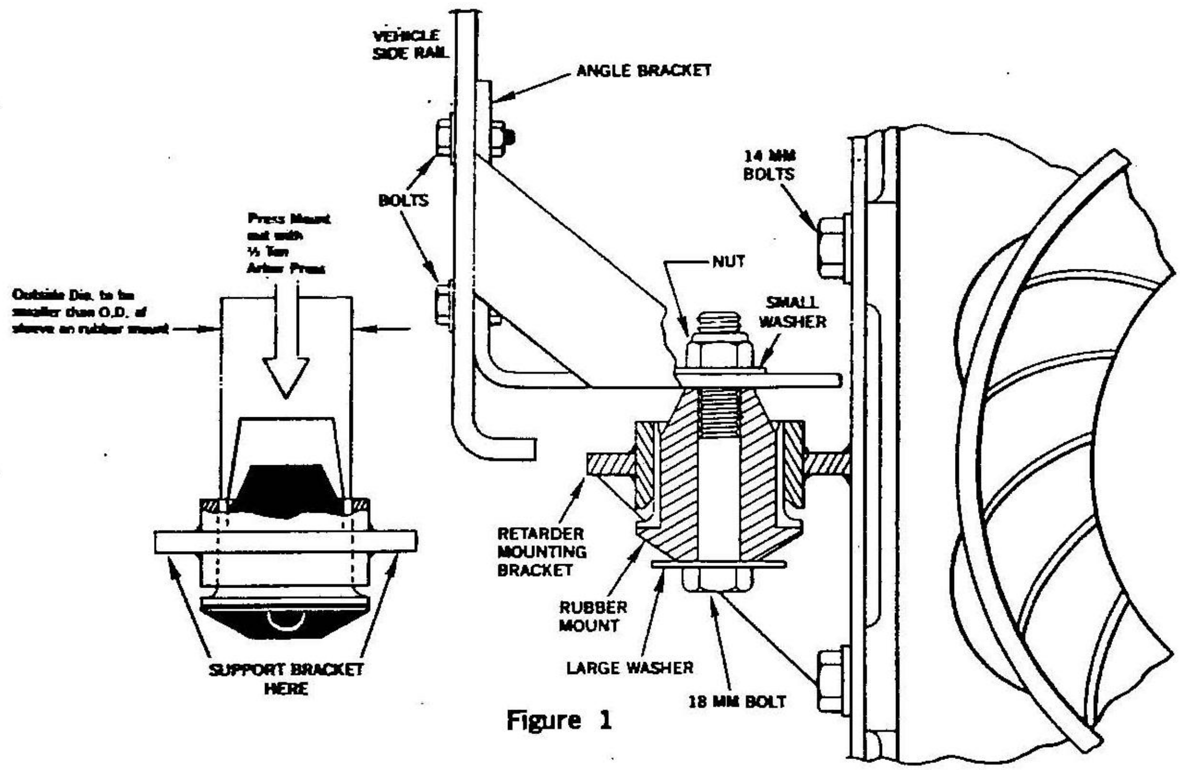
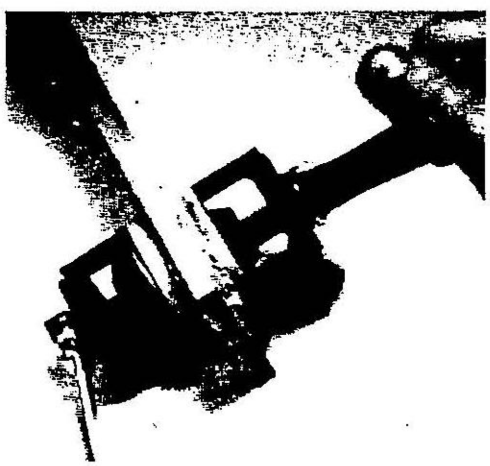


Figure 1



B) Removing Bolt-in Type Rubber Mount

Step 1 Using transmission jack to cradle retarder, jack up retarder until the weight is taken off the rubber mounts.

Step 2 Remove large support bolt (18mm) from damaged mount.

Step 3 Remove the (3) 8 mm bolts from rubber shock mount and remove shock mount. (Note direction of ass'y).

Step 4 Install new shock mount. (Note direction of ass'y).

Step 5 Reverse procedure to reassemble.

Checking Rotors for Distortion and Proper Air Gap

Preferred Method

Step 1 Connect dial indicator to frame of retarder.

Step 2 Dial Pointer to "0" on dial after stylus is place against rotor's inside face as shown in Figure 3.

Step 3 Mark rotor at indicator's position and rotate rotor 360° (one revolution). If dial indicator registers more than .025 in. (.635 mm) total indicator reading a correction must be made.

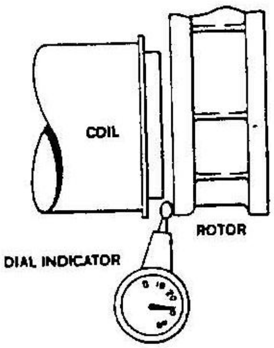


Figure 3

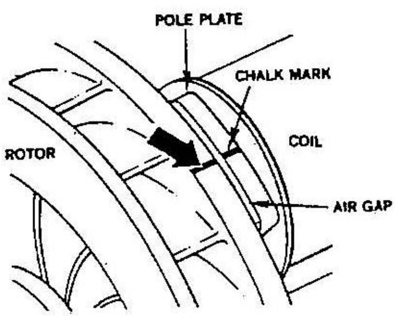


Figure 4

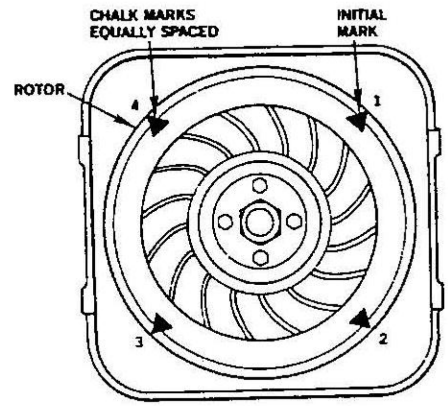


Figure 5

Alternate Method

Using a Feeler Gauge Proceed As Follows:

Step 1 Mark one (1) pole plate and (1) position adjacent to each other on the rotor with colored chalk. Figure 4.

Step 2 Mark off 3 other positions on the rotor as illustrated. Figure 5.

Step 3 Line up one mark on rotor with marked pole plate and measure air gap with a feeler gauge and record.

Step 4 Measure the air gaps at the other 3 positions on the rotor at the same pole plate and record.

Step 5 Subtract the lowest (smallest air gap) reading from the largest (largest air gap) reading. If the number is greater than .025 in. (635 mm), a correction must be made. (See Example)

Example: Model 520 has around .04 in. (0.10 mm) air gap.

Initial Reading	Mark 1 = .045 in. air gap
Rotate Rotor for Reading	Mark 2 = .050 in. air gap
Rotate Rotor for Reading	Mark 3 = .039 in. air gap
Rotate Rotor for Reading	Mark 4 = .058 in. air gap

Now subtract the lowest reading from the highest reading.

Mark 4		.058 Air Gap
Mark 3	–	.039 Air Gap
		.019 Total Runout

Thus, .019 in. (609 mm) is within the .025 in. (635 mm) that we specify.

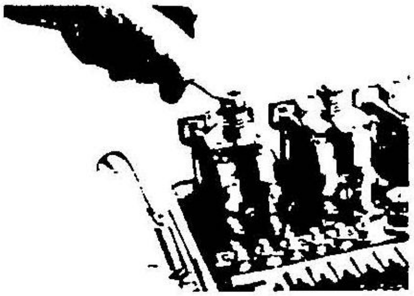
Replacing and Adjusting Relay Points in Contactor Box

OBSERVE THE SAME PRECAUTIONS YOU WOULD IN WORKING WITH ANY HIGH AMPERAGE BATTERY ENERGIZED SYSTEM. BEFORE REMOVING CONTACTOR BOX COVER, DISCONNECT BATTERY POWER LEAD TO CONTACTOR BOX PRIOR TO INSPECTION.

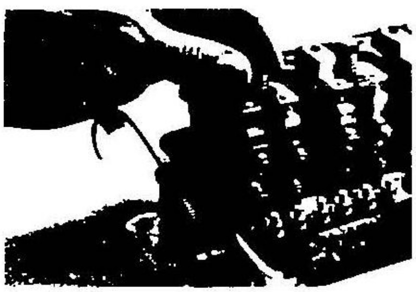
Procedure to replace pitted or burned points (Lower & Upper)

Procedure to adjust and set point gap. See Figures 6 & 7.

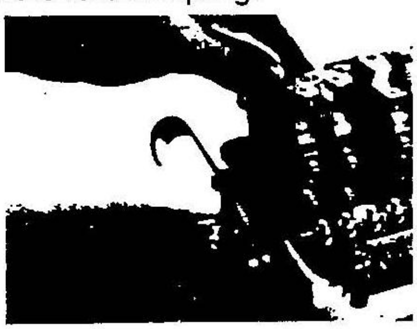
Remove upper points by removing hardware as shown.



Step 1 Remove upper crown nut.

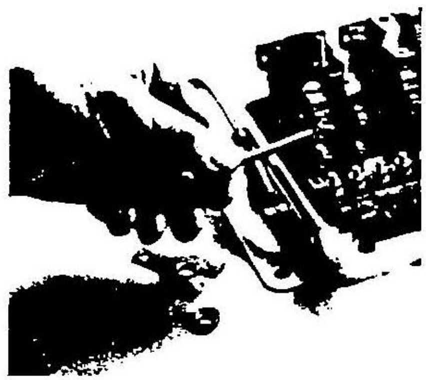


Step 2 Remove black plastic nut and hardware for spring.



Step 3 Remove upper points and install new points by reversing procedure. See Figure 7, for setting black plastic nut height to preload spring. After setting hold in place and tighten crown nut.

Remove lower points by removing hardware as shown.

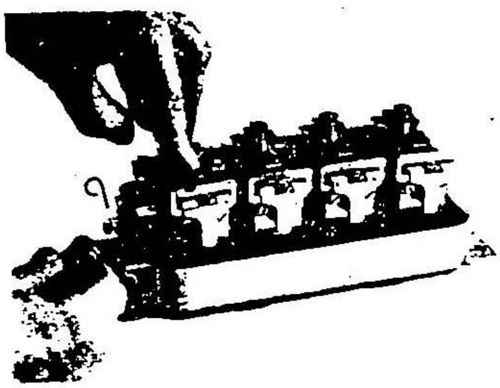


Step 1 Remove screws and nuts as shown.

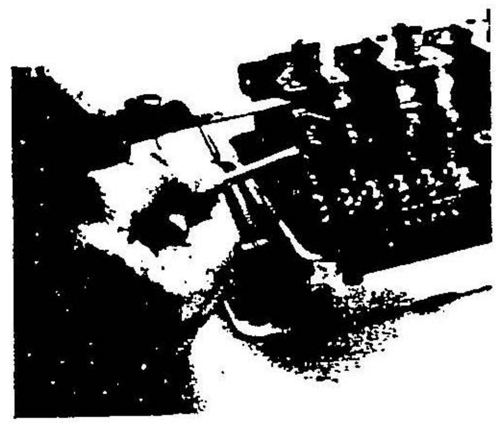
Step 2 Slide out and install new points by reversing procedure. Do not tighten screws until point gaps are set.

Step 3 Set gap as shown using feeler gauge.

CAUTION: ALWAYS CHECK THIS GAP PRIOR TO INSTALLATION OF NEW UPPER OR LOWER POINTS, THEN PROCEED TO STEP 5



Step 4 Press down on upper points until armature bottoms on Points "A", see Fig. 6, then set gap by bending tab on armature with needle nose pliers or slightly tapping in tab with plastic hammer as required. (See illustration Figure 6 for details.)



Step 5 Set Point Gap as shown using feeler gauge .047-.059 in. (1.194-1.498 mm). NOTE: It is important that both points contact at the same time. Loosen screws as shown and set each lower point separately to gap specified. (See illustration Figure 7 for details.)

ADJUSTING RELAY POINTS IN CONTACTOR BOX

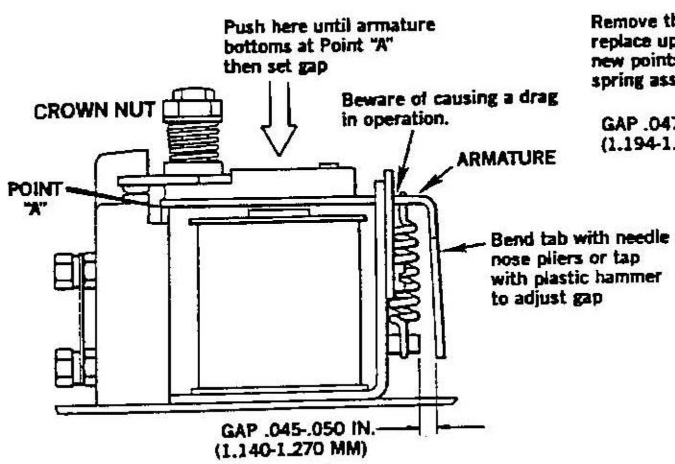


Figure 6

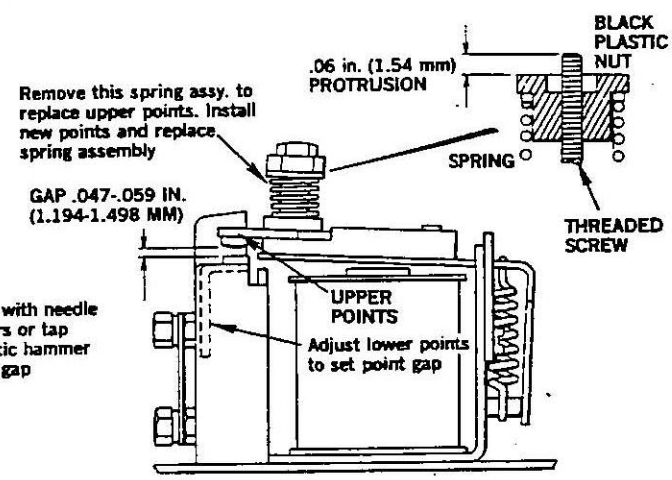


Figure 7

CAUTION: WHEN TIGHTENING SCREWS AND NUTS DO NOT OVER-TIGHTEN

ELECTRIC KLAM RETARDER

KLAM Electric Retarder Trouble-Shooting

WARNING	***BE CAREFUL – HIGH AMPERAGE SYSTEM***

If the unit fails to operate properly, the master "ON-OFF" switch should be shut off or battery power lead to contactor box disconnected until the unit can be inspected. Failure of the Klam can usually be traced to the electrical system. As in all trouble-shooting procedures, always check the simple things first.

SYMPTOM	PROBABLE CAUSE	POSSIBLE SOLUTION
Retarder does not function	Master switch (if installed) is off	1. Turn on master switch.
	In line fuse blown	2. Replace fuse.
	Low speed cut-off switch (if installed) is not functioning/ defective	3. By-pass low speed cut-off switch with jumper wire. If retarder functions, check connections and/ or replace low speed cut-off switch.
	Hand control not functioning/ defective	4. Check in line fuse for being blown.
		5. Using a 12 volt test lite, check for power in 4 lead wires (wires leading to the contactor box) as the handle is moved to positions 1, 2, 3 & 4. If power is detected in the hand control input wire from the fuse or on/off switch, and cannot be detected in the 4 lead wires to contactor box as outlined above, then replace the hand control.
	Contactor box not grounding	6. Check ground connections at contactor box and where the contactor box grounds to the vehicle frame or battery.
	Bad battery connections	7. Examine and clean battery terminal connections.
	Retarder not grounding	8. Check ground connections at retarder and where retarder grounds to the vehicle frame or battery.
	Relay points and/or coils not functioning	9. Check condition and adjustment of contacts, points and coils as outlined in "REPLACING AND ADJUSTING RELAY POINTS IN CONTACTOR BOX."

SYMPTOM	PROBABLE CAUSE	POSSIBLE SOLUTION
Retarder fails to shut off	Defective hand control NOTE: See high amperage warning	10. Switch hand control to off position. Using a 12 volt test lite, check for power in any lead wires to contactor box. If power is detected, replace hand control.
	Points closed in contactor box NOTE: See high amperage warning	11. Disconnect battery cables leading to contactor box. Remove contactor box cover and examine contact points for being closed. (Use continuity tester to verify contact if necessary). If points are closed, check for damage to contacts. Replace or adjust relay points as outlined in "REPLACING AND ADJUSTING RELAY POINTS IN CONTACTOR BOX."
Loss of retarding power	Insufficient battery output NOTE: See high amperage warning	12. Check condition, and specification of batteries (use only 1800 cold crank deep cycle batteries). 13. Check alternator output to batteries (most applications are 160 amp max output minimum).
	Contactor box not grounding	14. Refer to No. 6.
	Bad battery connections	15. Refer to No. 7.
	Retarder not grounding	16. Refer to No. 8.
	Relay points and/or coils not functioning	17. Refer to No. 9.
	Loose or defective connections	18. Check all connections at the hand control, contactor box, battery and retarder for proper, clean connection.
	Improper air gap at rotors	19. Check for proper rotor air gap as outlined in "CHECKING ROTORS FOR DISTORTION AND PROPER GAP."
Vibration occurs	NOTE: These probable causes and solutions for vibration are based on the vehicle not having drive train vibrations prior to the retarder install.	
	Retarder mounted at improper angle	20. Recheck all angles and calculations as outlined in Section 3.
	Driveshafts improperly balanced	21. Recheck dynamic balance of driveshafts or have driveshafts balanced.
	Broken welds on retarder mounting brackets	22. Re-weld bracket and insure that retarder is at proper angle for driveshafts.

Vibration occurs	Loose or missing driveshaft flange bolts	23. Replace with new bolts and secure threads with thread locking compound.
	Worn U-joints	24. Check and replace as necessary.
	Dirt lodged in rotors	25. Inspect and clean rotors
	Loose mounting brackets	26. Inspect and secure as necessary.

WARRANTY

The Klam Electric Retarder, is sold with the following warranty:

"The Klam Electric Retarder, is warranted to be free of any defects in construction and operation under normal use and service. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON FACE HEREOF.

Under this warranty our factory is obligated to replace, without charge, any part or parts returned to us which our examination shall disclose to our satisfaction to have been defective, within the time period indicated below, from the date of delivery of the product in question to the original user.

This warranty will not apply to any part or parts which have been altered or repaired outside of our factory, nor to parts which have been subjected to misuse, abuse, neglect or accident, nor to parts which have been improperly applied or installed. Improper installations or application, or substitution of parts not manufactured or approved by us, shall void this warranty.

Klam will also pay for all repairs to damaged vehicle components in which a Klam Electric Retarder has been properly installed, provided the damage is shown to be a direct result of a defect of the Electric Retarder under normal operation.

KLAM LIABILITY IS LIMITED TO THE OBLIGATIONS SET FORTH HEREIN, AND KLAM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES.

Warranty Coverage:

Electric Retarder assembly and related attaching parts supplied by one year or 100,000 miles (160,000 kilometers), whichever shall first occur.

All control system components, switches, controls and contactor supplied by Klam six months or 50,000 miles (80,500 kilometers), whichever shall first occur.

ADDITIONAL INFORMATION

Web Sites

www.allisontransmission.com
www.jakebrake.com
www.klamamerica.com
www.schoolbusfleet.com
www.telma.com
www.truckinginfo.com
www.truck.eaton.com
www.voith.com

MOBILITY AID LIFT AND SPECIAL EQUIPMENT

General Components .... Page #

MOBILITY AID LIFT AND SPECIAL EQUIPMENT

1. Purpose

The primary purpose of the power lift is to facilitate safe and efficient loading and unloading of mobility aid confined or special needs passengers by only one operator.

The lift shall be of sufficient capacity to lift the wheelchair, occupant and attendant. The controls shall be located so that the lift can be activated from inside or outside the bus. For more information, see also Section 3 – Colorado Minimum Standards in this manual.

2. Inspection Procedure

Lift Door
Check:

- Seal and weather-strip flange for cracking, leaking and age.
- Latches and hinges, interior and exterior, for looseness.
- Windows for cracks and visibility.
- Open door fastening device.
- Warning systems.

Power Lift
Check:

- Mounting to chassis and/or floor - for cracks, looseness, and deterioration of mounting hardware.
- Electrical operation and hand control.
- Operating and warning decals for proper usage.
- Manual operations and ramp safety stop.
- Hinge pin for wear, welds and framework.
- Non-skid material.
- Hydraulic system for leaks.
- Side rails and safety strap, if equipped.
- Load capacity check - refer to manufacturer's specifications.
- Check cables for condition; not broken, bent or stretched.
- Check spring condition.
- Check inner and outer roll stops operation.
- Check all adjustments.

Electrical
Check:

- Warning light or buzzer located in the driver’s area.
- Main power lines and circuit breakers.
- Door opening light (dome and exterior light).

- Safety shut-off switches, manual or door-operated.
- Condition of the hand control and cables (cords).
- Check warning lights

NOTE: See also Section 3 – Colorado Minimum Standards FMVSS 403, 404. Create link

Passenger Compartment Area
Check:

- Floor rails, floor mounts and wall mounts.
- Mobility aid securement straps.
- Occupant restraint straps and devices (seat belts).
- Stanchion chairs (if equipped) and elevator lift.
- Open holes in the floor.
- Aisle width for easy access for wheelchair movement.
- Seat barriers for looseness.

Accessories
Check:

- Special needs identification emblems.
- Securement strap and belt cutter.
- Bodily fluids clean-up kit.
- Evac aid is present and in good condition.

ADDITIONAL INFORMATION

1. Web Sites

www.braunability.com
www.ezlock.net
www.ezonpro.com
www.maxonmobility.com
www.nhtsa.dot.gov
www.qstraint.com
www.riconcorp.com

2. Lift Service Schedule

TABLE 3-1: MAINTENANCE SCHEDULE	
SERVICE POINT	**ACTION TO PERFORM**
DAILY SAFETY CHECK	
Overall Condition	Listen for any abnormal noises as lift operates (i.e., grinding or binding noises).
Control Pendant	Check that control pendant is not damaged and cable connectors are tight.
TWO-WEEK SAFETY CHECK	
Overall Condition	1. Listen for any abnormal noises as lift operates (i.e, grinding or binding noises). 2. Inspect underside of vehicle to be certain nothing is out of ordinary.
Control Pendant	Check that control pendant is not damaged and cable connectors are tight.
Electrical Wiring	Inspect electrical wiring for frayed wires, chaffed wires, loose connectors, etc.
Vehicle Interlock	Place vehicle in NON-INTERLOCK mode and attempt to operate lift.
Decals	Be certain that all lift decals are affixed properly, clearly visible and legible. Replace if necessary.
Handrails	Be certain that all handrail fasteners are properly tightened.
Lift Mountings and Support Points	1. Be certain that all lift mounting and support points are in proper order and free from damage. 2. Be certain that all mounting bolts are sufficiently tight.
Main Lifting Pivots	Be certain all traveling frame pins are installed properly, free from damage and locked in position.
Platform and Platform Attachment Points	Be certain platform operates properly during lift functions without obstruction(s).
Inner Rollstop	1. Be certain that inner rollstop operates properly during lift functions without obstruction(s). 2. Be certain that inner rollstop deploys fully as platform stops at the proper vehicle floor level.
Platform Rollstop	Be certain that rollstop operates properly without obstruction(s) when it contacts ground.
Hydraulic Power Unit	**⚠ CAUTION!** Do not add fluid until platform is lowered to ground level. Adding fluid while lift is stowed will cause the tank to overflow when platform is lowered.
	1. Check for visible hydraulic fluid leakage. 2. Be certain backup pump manual release valve is lightly-snug.

STEERING AND SUSPENSION

General Components .... **Page #**

STEERING

1. Purpose

Basically, there are two general types of steering systems: Manual and Power.

In the manual system, the driver's effort to turn the steering wheel is the primary force that causes the front wheels to turn to left or right on the steering knuckles.

With power steering, a hydraulic assist multiplies the driver's turning efforts.

2. Inspection Procedure

Inspect the steering knuckles, kingpins, steering arms, and tie rod arms. Replace if any indications of weakness, cracks, or excessive wear are found. Cracks can be located by die check, magnetic particle, or fluorescent particle inspection performed by a qualified mechanic.

Check spindle/wheel bearing diameters, size, and condition. Replace spindle if bearing diameters are under specification, discolored from heat, or severely scored.

If the tie rod end or steering arm has been removed, inspect tapers for fretting pits. Replace as needed.

Check condition of kingpin and bushing.

Check the condition of all steering linkage connections.

For units with sealed knuckle pins, check the seal for rips, tears, and excessive wear. Do not remove the seals from the steering knuckle unless replacement is necessary, or the knuckle is to be re-bushed.

Remove the thrust bearing seal from the thrust bearing case and inspect the seal for wear, rips, and tears.

NOTE: For aluminum axles with integral seals, **DO NOT REMOVE THE SEAL.**

Check the thrust bearing.

Check the knuckle pin bushings for wear, flaking, or scoring. Compare diameters with the correct specifications, if any diameter is 0.010" greater than the new bushing dimension, replace the bushings.

Check the axle center bore for condition and size. Replace center if bore is 0.001" greater than specification.

WARNING: Any indication of looseness in the total steering linkage under normal steering loads is sufficient cause to immediately check all pivot points for wear. Steering linkage pivots should be checked each time the axle assembly is lubricated.

NOTE: It is impossible to over stress the importance of careful and thorough inspection of the steering knuckle components prior to assembly. A thorough visual inspection for indications of wear or stress, and the replacement of such parts as are necessary, this will eliminate costly and avoidable front end difficulties.

3. **Tie Rod And Tie Rod End Inspection Procedure**

   Check the seals visually for any indication of damage. Check that the seal is securely seated on the socket. If the tie rod end has a grease fitting replace any damaged seals. Tie rod ends that do not have grease provisions, should be replaced if seals/boots are damaged or loose.

   No lateral or vertical movement should be found in any tie rod assembly when checked by hand. Leverage, or prying with a tool, can produce vertical movement in most tie rod ends, which is inherent in their design. Use of tools for checking free play is not recommended.

   Permanently lubricated, and extended tube end assemblies should be replaced if found below specifications. Serviceable models should be rebuilt.

   Any tie rod tubes found to be cracked, bent, or dented should be replaced.

4. **Steering Gear Maintenance Tips**

   Prevent internal bottoming of the steering gear. Carefully check axle stops to be sure that they meet the manufacturer's specifications.

CAUTION: Consult manufacturer’s specifications and procedures. Some gear boxes can be damaged if adjustment isn’t performed correctly.

Regularly check the fluid condition, filter and level in the power steering reservoir.

Keep the tires inflated to correct pressures.

Always use a puller to remove the pitman arms. Never use a hammer or a torch.

Investigate, and immediately correct the cause of any play, rattle, or shimmy in any part of the steering linkage or steering mechanism.

Do not attempt to weld any broken steering component. Replace the component(s) with original equipment or OEM approved products only.

Always clean around the reservoir filler cap before you remove it to prevent dirt and other foreign matter from entering the hydraulic system.

Investigate and correct any external leaks.

5. Troubleshooting guide for abnormal noises

If the power steering pump is belt driven, a squealing noise may indicate that the belt(s) should be tightened or replaced.

A thumping noise heard during a turn, or when changing directions, may indicate that some component is loose and shifting under load.

A change in the normal noise of the pump may indicate that air has been induced into the system, or that the fluid level is low.

6. Steering Troubleshooting Tables

ROAD WANDER	**Possible Cause**
	Tire pressure incorrect or unequal from left to right.
	Components in the steering linkage are loose or worn.
	Wheel bearings improperly adjusted or worn.
	Front end alignment out of specification.
	Steering gear mounting bolts loose.
	Pitman arm to output shaft bolt loose.
	Steering gear improperly adjusted.
	Looseness in the rear axle assemblies.
NO RECOVERY (Return to Center)	**Possible Cause**
	Tire pressure low.
	Front end components binding.
	Front end alignment out of specifications.
	Kingpins lack sufficient lubrication.
	Steering column binding.
	Pump flow insufficient.
	Steering gear improperly adjusted.

SHIMMY	Possible Cause
	Worn or unevenly worn tires.
	Improperly mounted tire or wheel.
	Wheel bearings improperly adjusted or worn.
	Steering linkage components loose or worn.
	Wheels or brake drums out of balance.
	Front end alignment out of specifications.
	Air in the hydraulic system.
OVERSTEERING or DARTING	**Possible Cause**
	Front end components binding or loose.
	Steering column binding.
	Steering gear improperly adjusted.
	Steering gear control valve spool or sleeve is tight or improperly adjusted.
	Rear axle mounts are loose or improperly positioned.
HIGH STEERING EFFORT in ONE DIRECTION	**Possible Cause**
	Unequal tire pressure.
	Vehicle overloaded.
	Hydraulic system pressure is low.
HIGH STEERING EFFORT in BOTH DIRECTIONS	**Possible Cause**
	Tire pressure too low.
	Vehicle overloaded.
	Hydraulic fluid level is low.
	Pump pressure is low.

	Steering system components binding.
	Restriction in, or too small of a return line.

LOST MOTION (lash) at STEERING WHEEL	**Possible Cause**
	Steering wheel loose on the shaft.
	Loose connection between the steering gear, intermediate column, and the steering column.
	Steering gear is loose on the frame.
	Pitman arm is loose on the output shaft.
	Steering components are loose or worn.
	Steering gear is improperly adjusted.
EXCESSIVE HEAT (150 degrees F. over ambient)	**Possible Cause**
	Excessive pump flow.
	Vehicle is overloaded.
	Hose or line is kinked, severely bent, restricted, or internally blocked.
	Replacement hose or line is too small.
	Limited return to center of the gear valve caused by column bind, or side load on the input shaft.
EXTERNAL OIL LEAKAGE	**Possible Cause**
	Finding the location of a leak may be difficult. Oil may run away from the leak source causing suspicion of the wrong part. A leak from the vent plug at the side cover indicates failure of the sector shaft oil seal inside the side cover.

7. Repair Procedure

Refer to the appropriate service manual for specific repair procedure.

SUSPENSION SYSTEMS

1. Purpose

Basically, suspension refers to the use of front and rear springs to suspend a vehicle's frame, body, engine, and power train above the wheels. These relatively heavy assemblies constitute what is known as “sprung” weight. “Unsprung” weight includes wheels and tires, brake assemblies, the rear axle assembly and any other structural member not supported by the springs.

Springs are engineered in a wide variety of types, shapes, sizes, rates and capacities. Types include leaf springs, coil springs, air springs, rubber springs, and torsion bars. They are used in sets of four per vehicle, or they are paired off in various combinations attaching to the vehicle by a number of different mounting techniques.

There are two types of front suspensions in general use: the independent systems and the solid axle system.

Independent suspension usually operates through heavy duty coil springs or torsion bars and direct, double-acting shock absorbers.

In solid axle construction, the axle beam and wheel assemblies are connected to the vehicle by leaf springs and direct or indirect-acting shock absorbers. With the solid axle setup, the steering knuckle and wheel spindle assemblies are connected to the axle beam by kingpins, or spindle bolts, which provide pivot points for each front wheel.

Modern independent front wheel suspension systems use ball joints, or spherical joints, to accomplish this purpose. The swiveling action of the ball joints allows the wheel and spindle assemblies to be turned left or right, and to move up and down with changes in road surface.

2. Leaf Springs

Front leaf (or plate) springs are used in conjunction with solid axle beams in most truck applications. Rear leaf springs are used on trucks and some passenger cars. Single leaf or multi-leaf springs are usually mounted longitudinally over the front axle beam and over the rear axle housing.

The spring center bolt fastens the leaves together, and its head locates the spring in the front axle beam or saddle on the rear axle housing. U-bolts clamp the spring firmly in place and keep it from shifting. Eyebolts, brackets and shackles attach it to the frame at each end. In many cases, leaf springs are used at the rear of the vehicle in combination with another type spring in front.

3. Coil Springs

Many independent front suspension systems incorporate compression type coil springs mounted between the lower control arms and the spring housing in the frame. Others have the coil springs mounted above the upper control arms, compressed between a pivoting spring seat bolted to the control arm and a spring tower formed in the front end sheet metal.

Generally, the upper control arm pivots on a bushing and shaft assembly, which is bolted to the frame. The lower arm pivots on a bushing and shaft assembly or on a bolt in the frame cross member. When the lower control arm is not the A-frame type, it is supported by a strut, which runs diagonally from the lower control arm to a bracket attached to the frame.

4. Air Ride

Technical Service Information

TSI–04–03–01

This TSI replaces 03–03–01R

Date: April, 2004

Subject File: SPRINGS

Subject: Air Suspension Adjustment Specifications for Air Spring Height Dimensions and Axle Travel Dimensions

Vendor: International

Vendor: Hendrickson

Vendor: Neway

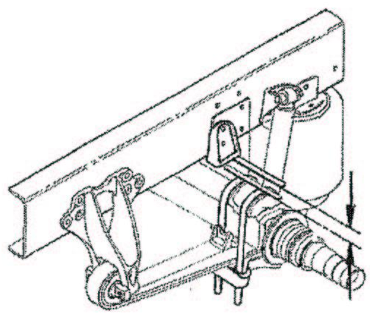
DESCRIPTION

RIDE HEIGHT (Reference Only)

Data book or lineset ride height on vehicles equipped with International, Neway, or Hendrickson air suspension is defined as the distance from the center line of the rear axle housing to the bottom flange of the frame as illustrated in Figure 2. Ride height is a reference only and should not be used as a dimension to adjust suspensions.

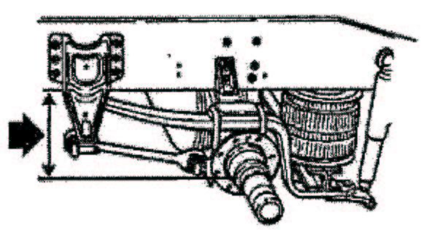
NOTE – Air spring height, axle travel and chassis ride height are not the same thing. Specifications for axle travel (Figure 1) or air spring height have been calculated to result in correct chassis ride height. When the axle travel or air spring height is adjusted to chart specifications, the chassis ride height is also correct.

DESCRIPTION (CONT.)

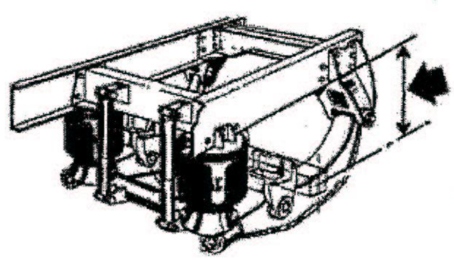


Post 2001 International Susp. (IROS)

Figure 1 Axle Travel



Pre 2001 International Air Susp.
Hendrickson Air Suspension



Neway Air Suspension

Figure 2 Ride Height

AIR SPRING HEIGHT

Air spring height on a vehicle equipped with Pre 2001 International, Hendrickson HAS, or Neway AD air suspension is measured from the bottom of a straight edge placed on the top metal plates of the air springs down to the top of the transverse crossmember that the air springs are mounted to (Figure 3).

Neway ARD air spring height is measured between mounting plates as illustrated in Figure 4.

DESCRIPTION (CONT.)

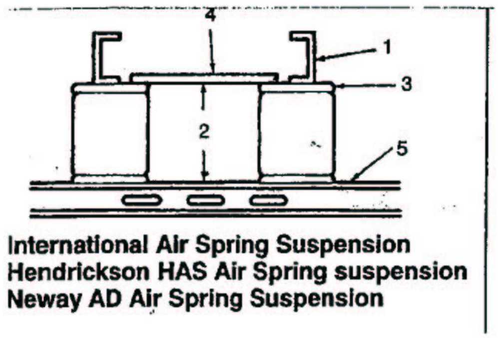


Figure 3 Air Spring Height Measurement (Viewed from Rear)

1. FRAME RAIL
2. AIR SPRING HEIGHT
3. AIR SPRING TOP METAL PLATE
4. STRAIGHT EDGE
5. TRANSVERSE CROSSMEMBER

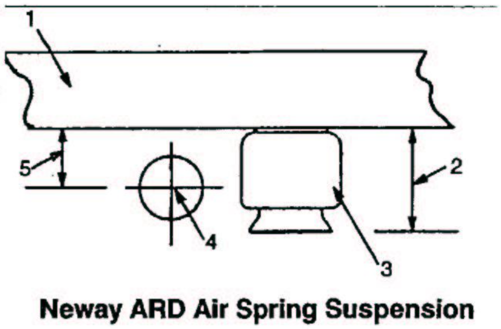


Figure 4 Neway ARD Air Spring Height Measurement (Side View)

1. FRAME RAIL
2. AIR SPRING HEIGHT
3. REAR REAR AIR SPRING
4. AXLE/WHEEL CENTER
5. RIDE HEIGHT

AXLE TRAVEL

IROS axle travel is measured from the bottom of the axle stop to the top of the U-bolt as illustrated in Figure 5.

DESCRIPTION (CONT.)

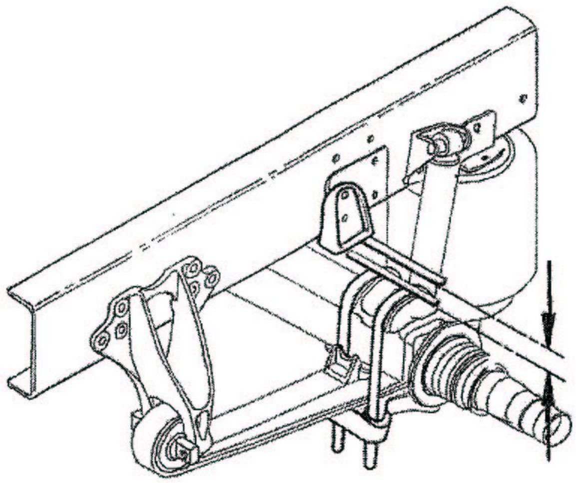


Figure 5 IROS Axle Travel Measurement

Air Suspension Specifications

The following tables list dimensions that control ride height. If resetting the suspension to obtain the proper settings, deflate the air system and then achieve the appropriate setting by inflating the air system. **DO NOT ACHIEVE SETTINGS BY LETTING AIR OUT OF THE SYSTEM.**

AIR SUSPENSION SPECIFICATIONS

IROS Air Suspension

NOTE – Refer to Service Section S03012 for detailed axle travel setting instructions.

Table 1 IROS Suspension Height Chart Adjustment Specification

IROS Suspension Feature Code	**Conf.**	**Model**	**Ride Height (Ref. Only)**	**Axle Travel in Inches** (measured from axle stop, see figure 5)
14UNN, 14UNM, 14UNL,	6x4	All	9.25	2.75 ± 0.125
14TBJ	4x2	7000, 8000, 9000	9.25	2.75 ± 0.125

AIR SUSPENSION SPECIFICATIONS (CONT.)

Table 1 IROS Suspension Height Chart Adjustment Specification (cont.)

IROS Suspension Feature Code	Conf.	Model	Ride Height (Ref. Only)	Axle Travel in Inches (measured from axle stop, see figure 5)
14TBJ, 14TBG, 14TBH, 14TBK, 14TBR, 14TBS, 14TBT	4x2	3200, 4000	9.25	3.0 ± 0.125
14TBL, 14TBM, 14TBN	4x2	4000	5.3	**4.6 ± 0.125** **Models built before 02/23/2004**
				3.2 ± 0.125 **Models built starting 02/23/2004**
14UNH	6x4	9000	5.3	1.55 ± 0.125
14WAW (Flat Floor)	4x2	3000	11.3	2.7 ± 0.125
All dimensions are in inches.				

Pre 2001 International Air Suspension

Table 2 International NAVAIR Suspension Height Adjustment Specification Chart (Not IROS)

Code	Ride Height (Ref. Only)	Air Spring Height (Figure 3)
03SAA , 03SAB	3.6	9.5 ± 0.25
03SAD, 03SAE, 03SAK, 03SAS, 03SAM, 03SAT, 14TAD, 14TAG, 14TAJ, 14TAK	5.1	12.0 ± 0.25
03SAP, 14TAH, 14UND	5.25	9.5 ± 0.25
03SAC, 14TAA, 14UNB	7	9.5 ± 0.25
14UNG	7.9	9.5 ± 0.25
14TAC, 14TAE, 14TAL, 14TAM, 14TAN, 14TAU, 14TBD, 14673, 14693, 14694	9.5	12.5 ± 0.25
All dimensions are in inches.		
NOTE – These settings will result in the frame being level to 1 degree lower at the front.		

AIR SUSPENSION SPECIFICATIONS (CONT.)

Table 5 Hendrickson Suspension Height Adjustment Specification Chart

HA Code	Ride Height (Ref. Only)	Shock Absorber Measurement (Figure 6)
14UJG, 14UJH, 14UJK, 14UJM	9.5	21.5
All dimensions are in inches.		

FIXED RIDE HEIGHT VERTICAL LINKAGE

Refer to Group 03, Springs, in the Master Service Manual for more detailed information on the air suspension system being serviced.

Suspension Height Adjustment

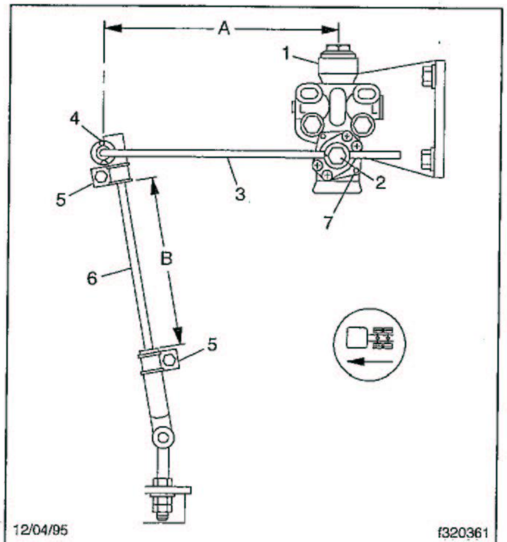
Adjustment, Vehicles Equipped with Adjustable Leveling Valve

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only to allow the slight movement needed for the drivetrain length change.
3. Check the length of the overtravel lever between its pivot points. See **Fig. 2.** The length should be 8 inches (203 mm). If needed, adjust the length of the overtravel lever.
   - 3.1 Loosen the adjustment locknut on the control shaft.
   - 3.2 Move the overtravel lever fore or aft until the length between the pivot points is 8 inches (203 mm).
   - 3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).
4. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad. See **Fig. 3.** If the distance is between 2-3/8 and 2-7/8 inches (60 to 73 mm) it is correct, and nothing more needs to be done. Apply the parking brakes and remove the chocks from the tires.

NOTE: If height adjustment is needed, use 2-3/8 inches (60 mm) as the target value.

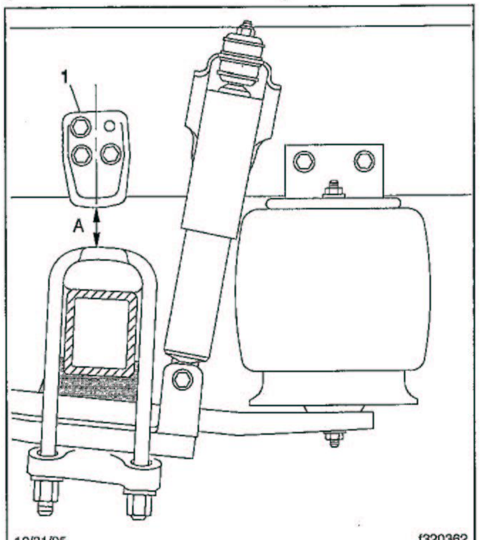
5. Loosen the two fasteners attaching the leveling valve to the mounting bracket.
6. Rotate the leveling valve clockwise (as you are facing it from the driver's side of the vehicle). Let the air exhaust from the valve until the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad is 2 inches (51 mm) or less.
7. Rotate the leveling valve counterclockwise, and raise the suspension height to 2-3/8 inches (60 mm). Stop the air flow to the air bag by rotating the leveling valve back clockwise.
8. Center the leveling valve.
   - 8.1 Rotate the valve very slightly clockwise and counterclockwise. You will notice a "dead" band where no air enters the valve or is exhausted from it. Don't rotate the valve too much, or you will change the suspension height.
   - 8.2 Rotate the valve so it's in the center of the "dead" band.
   - 8.3 Tighten the leveling valve mounting fasteners firmly.
9. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.



A. Measure the length of the overtravel lever between these two points.
B. Measure the length of the linkage rod between these two points.

1. Leveling Valve
2. Adjustment Locknut
3. Overtravel Lever
4. Cotter Pin
5. Linkage Adjustment Clamp
6. Linkage Rod

Fig. 2, Overtravel Lever and Linkage Rod Measurement



A. Measure height here.
1. Left Forwardmost Axle Stop

Fig. 3, Axle Stop Measurement

Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.

10. Check the adjusted distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt pad. See **Fig. 3**. The correct distance is between 2-3/8 and 2-7/8 inches (60 to 73 mm).
11. If the distance isn't right, repeat the adjustment procedure.
12. Apply the parking brakes; then remove the chocks from the tires.

Adjustment, Vehicles Equipped with Fixed Leveling Valve

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks are to be empty. In order to adjust the suspension height, you must change the length of the linkage rod using the following procedure. The previous method of centering the control valve and then adjusting the linkage no longer applies.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor; then chock the tires on one axle only.
3. Check the length of the suspension overtravel lever (see **Fig. 2**) between its pivot points. The overtravel lever should be from 5-3/4 inches to 6-1/4 inches (146 to 159 mm) long.

   If the length is acceptable, go to the step for measuring the suspension height.

   If the length is not acceptable, go to the next step.
4. Adjust the length of the overtravel lever.

   4.1 Loosen the adjustment locknut on the control shaft.

   4.2 Move the overtravel lever fore or aft until it is the correct length.

   4.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).
5. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt pad. See **Fig. 3**. The correct distance is between 2-3/8 and 2-7/8 inches (60 to 73 mm).

   If the distance is correct, nothing more needs to be done. Apply the parking brakes; then remove the chocks from the tires.

   If the distance isn't correct, go to the next step.

NOTE: If height adjustment is needed, use 2-3/8 inches (60 mm) as the target value.

6. Determine how much the suspension height needs to be changed so that the distance is 2-3/8 inches (60 mm). Then, using **Table 1**, find the amount the length of the linkage rod (see **Fig. 1** needs to be changed.

5. Inspection Procedure

Axle Parts/Members

Check all U-bolts, spring hangers, or any other axle positioning parts for cracks, breaks, loose or missing parts resulting in shifting of an axle from its normal position.

Spring Assembly

Check for:

- Any broken leaf(s) in the leaf spring assembly.
- Cracked or broken coil spring.
- Rubber spring missing or deteriorated.
- One or more leaves displaced in a manner that could result in contact with a tire, rim, brake drum or frame.
- Cracked, bent, or broken torsion bar spring in torsion bar suspension.
- Deflated air suspension system failure, leak, etc.

Torque, Radius or Tracking Components

Check for:

- Any part of a torque, radius or tracking component assembly or any part used for attaching same to the vehicle frame or axle that is cracked, loose, broken or missing (including missing or loose bushings in torque or track rods).

Frame

Check for:

- Any cracked, loose, sagging, or broken frame member permitting shifting of the body onto moving parts or other condition indicating an imminent collapse of the frame.
- Any cracked, loose, or broken frame member adversely affecting support of functional components such as the steering gear, engine, transmission, body parts, and suspension.

6. Suspension Troubleshooting Tables

FRONT END NOISE	Possible Cause
	Loose or worn wheel bearings.
	Worn shock absorbers or mounts.
	Worn struts or strut mountings.
	Loose or worn suspension components.

	Loose steering gear to frame bolts.
	Lack of ball joint lubrication.
FRONT WHEEL SHIMMY OR VIBRATION	**Possible Cause**
	Tires or wheel out of balance.
	Incorrect wheel alignment.
	Propeller shaft may be unbalanced.
	Loose or worn wheel bearings.
	Loose or worn tie rod ends.
	Wheel loose or uneven lug nut torque.
	Worn ball joints.
	Worn shock absorbers.
	Worn strut bushings.
VEHICLE LEANS OR SWAYS ON CORNERS	**Possible Cause**
	Loose stabilizer bar.
	Faulty shock absorbers.
	Broken or weak springs.
ABNORMAL SPRING NOISE	**Possible Cause**
	Loose U-bolts.
	Loose or worn suspension bushings.
ABNORMAL TIRE WEAR	**Possible Cause**
	Improper tire balance.
	Sagging or broken springs.
	Improper wheel alignment.
	Faulty shock absorbers.
	Improper suspension parts.

VEHICLE PULLS TO ONE	**Possible Cause**

SIDE	
	Mismatched or uneven tires.
	Broken or sagging springs.
	Loose or worn strut bushings.
	Improper wheel alignment.
	Power steering gear not centered.
	Improper steering gear adjustment.
	Brakes dragging.
	Improper wheel bearing adjustment.
SCUFFED TIRES	**Possible Cause**
	Improper wheel alignment.
	Bent suspension parts or frame.
CUPPED TIRES	**Possible Cause**
	Faulty shock absorbers.
	Worn ball joints.
	Loose or worn wheel bearings.
	Wheel and tire out of balance.
SPRINGS BOTTOM OR SAG	**Possible Cause**
	Bent or broken springs.
	Faulty shock absorbers.
"DOG" TRACKING	**Possible Cause**
	Broken spring or centering bolt.
	Bent rear axle housing.
	Frame bent or misaligned.
SHOCK ABSORBER NOISE	**Possible Cause**
	Loose shock absorber mounts.
	Worn shock absorber bushings.

SHOCK ABSORBERS

1. Purpose

The operating principal of a direct-acting hydraulic shock absorber consists of forcing fluid through restricting orifices in the valves. The restricted flow serves to slow down and control the rapid movement of the vehicle springs as they react to road irregularities. Generally, spring-loaded valves control fluid flow through the piston.

The hydraulic shock absorber automatically adapts itself to the severity of the shock. If the axle moves slowly, resistance to the flow of fluid will be light. If the axle movement is rapid or forceful, the resistance is much stronger. More time is then required to force fluid through the orifices causing more absorption of the shock.

By these hydraulic actions and reactions, the shock absorbers permit a soft ride over small bumps and provide firm control over spring action for cushioning large bumps. The double-acting units are made to operate efficiently in both directions, since spring rebound can be almost as violent as the original action that compressed the shock absorber.

2. Inspection Procedure

Check For:

- Bent or broken shock.
- Bent or broken shock mount.
- Oil leaking from shock

NOTE: Shock absorbers cannot be repaired and must be replaced. Qualified personnel can repair some struts, but extreme care must be taken, due to the spring tension.

I-BEAM TYPE FRONT AXLE

1. Axle Identification

For optimal tire wear on crowned road surfaces, the right and left kingpin bores in the beam are machined to slightly different kingpin angles. The front of the beam must be installed toward the front of the vehicle. The front of the beam may be marked by an identification tag and/or a white paint stripe on the left (driver's side end) of the beam. If the paint stripe or identification tag are missing, mark the front of the beam for correct installation.

NOTE: I-Beam axles should **NEVER** be welded. Re-sizing of kingpin bores by **qualified** personnel is acceptable.

2. Inspection Procedure

Any indication of looseness in the steering system, hard steering, unusual noise, or tire wear is sufficient cause to inspect all pivot points of the steering linkage.

Make sure all fasteners are tightened to the specified torque. Use a torque wrench to check the torque in a in a tightening direction. As soon as the fastener starts to move, record the torque. Correct if necessary. Replace any worn or damaged fasteners.

Inspect all parts of the axle for wear and damage. Look for bent or cracked parts. Replace all worn or damaged parts.

Make sure looseness does not exist at the pivot points. Make sure pivot points are lubricated.

Make sure all the parts move freely through the complete turning radius.

Inspect the tires for wear patterns that indicate suspension damage or misalignment.

Inspect steering knuckle bushings for wear and vertical end play. Also inspect the tie rod ends for looseness.

3. Maximum Limits For Front Axle Kingpins

This procedure is for determining if the front axle kingpin bushing wear (side play) and spindle vertical end play exceeds the maximum wear limits for normal service.

The following is one approved method of checking kingpin bushings for wear:

- Set the park brake or block the rear wheels to prevent the vehicle from moving. Position the front axle on floor stands with the wheels off the floor.

- Check the upper knuckle bushing for wear. Install a dial indicator so that the base is on the I-beam and the tip is against the side of the knuckle on top.
- Set the dial indicator on zero (0).
- Move the top of the tire side-to-side towards and away from the vehicle. If the dial indicator moves a total of 0.010 inch (0.254 mm), the upper bushing is worn or damaged. Replace both bushings.
- Check the lower knuckle bushing. Install the dial indicator so that the base is on the I-beam and the tip is against the side of the knuckle on the bottom.
- Set the dial indicator on zero (0).
- Move the bottom of the tire side-to-side towards and away from the vehicle. If the dial indicator moves a total of 0.010-inch (0.254 mm) the lower bushing is worn or damaged. Replace both bushings.

NOTE: Some of the newer vehicles have a higher tolerance; check manufacturer specifications.

4. **Measuring Spindle Vertical End Play**

Raise and support the axle.

Lift the wheel and tire (spindle only if wheel is removed) so that all clearance is taken up between the steering knuckle and the axle kingpin boss.

Using a feeler gauge, measure the clearance. If the measurement is more than 0.060 (1.5 mm) add shims as needed to reduce the clearance to 0.005 - 0.010-inch (0.1270 - 0.2540 mm)

NOTE: Refer to the appropriate service manual for additional methods to measure for kingpin wear. When replacement of any axle or suspension part has been made, it is recommended that an alignment be done.

TIRES

1. Purpose

Tires provide traction for moving and stopping the vehicle. Properly inflated, tires will absorb irregularities in the road surface, give a safe and comfortable ride, and provide a reassuring grip to the road at all speeds.

2. Inspection Procedure

Tire Service
Excessive or uneven tread wear results from under inflation, rapid stops, fast acceleration, misalignment, and unbalanced conditions. Road surface condition will also affect tire life. Gravel roads and rough-finished concrete will wear tires quickly. Smooth concrete and asphalt surfaces aid in promoting maximum tire life. Normal wear causes the tire tread to be reduced evenly and smoothly.

3. Tire Wear Patterns Due To Misalignment

- **Toe Wear**
  The typical wear pattern that develops from excessive toe is a feather edged scuff across the crown. Excessive toe is usually seen on both steer tires.

- **Camber Wear**
  ..If the spindle has excessive positive camber, the tire will scrub off the outside shoulder. If the spindle has excessive negative camber, the tire will scrub off the inside shoulder. Camber wear is usually seen on just one tire.

- **Cupping Wear**
  ....Any loose or worn component in the steering or suspension systems can cause odd wear, cupping, and flat spots. Check for loose wheel bearings, excessive steering gear lash, worn tie rod ends, and worn kingpins. Check for worn shock absorbers. Check for improper tire inflation or balancing.

- **Flat Spotting Wear**
  Localized wear across the tread width. Causes include brake lockup, brake imbalance, out of round brake drums, axle hop or skip. This type of wear pattern can also be caused by a tire being parked on a surface containing hydrocarbon oils, chemicals, and solvents. The affected area of the tread will wear more rapidly, leaving a flat spot.

- **Diagonal Wear**
  Localized wear diagonally across the tread width. Side forces imposed by a combination of toe and camber create diagonal stress in the footprint of the tire. Localized wear patterns tend to follow this same direction creating diagonal wear. Causes include excessive toe setting, axle misalignment, excessive steering system elasticity, incorrect steering angle in turns, and excessive camber setting.

4. Rim And Wheel Maintenance During Tire Inspections

Check all metal surfaces thoroughly while making tire inspections, including the areas between the duals and on the inboard side of the wheel. Watch for:

- Excessive rust or corrosion build-up.
- Cracks in metal.
- Bent flanges, resulting from road obstructions.
- On bud type wheels check for damage/wear to mounting holes.

Pull damaged rims or wheels.

Replace damaged parts.

NOTE: Insure that replacements are made with the proper size and types of rims.

Inflate tires only to recommended air pressure. If manufacturer provides recommended tire pressure range for a specific vehicle type, guidelines should be followed.

5. Rim And Wheel Maintenance During Tire Changes

Check for cracks in the rim base, in the back flange, and in the gutter areas. These are caused by deep rim tool marks, overloading, over inflating tires, and using larger than recommended tire sizes.

Check for cracks in the wheel disc, between the stud holes or hand holes. These are caused by loose wheel nuts, improper installation procedures, and the use of incorrect sizes or types of attaching parts.

Check for cracks through the side ring, spreading laterally through the entire section. These are caused by improper mounting and dismounting techniques, and impact with road obstructions.

Paint the rim by brush or spray with fast-drying metal primer. Surfaces should be clean and dry prior to painting. Insure that any bare metal areas on the outside or the tire side of the rim are covered.

Lubricate the tire side of the rim base just prior to mounting the tire. Avoid the use of any lubricant, which contains water, or solvent that is injurious to rubber. A combination lubricant and rust-preventive compound is preferable.

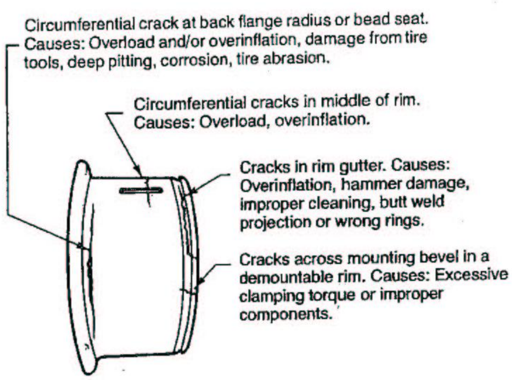
Inflate tires only to recommended air pressure.

6. Wheels/Rims

HOW TO IDENTIFY DAMAGED RIMS/WHEELS

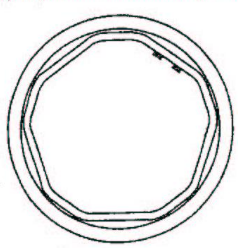
Rim/wheel components can become damaged. Check all metal surfaces for rust or corrosion buildup, cracks in metal, bent flanges and side rings, deep rim tool marks on rings or in gutter areas. Watch for the problems illustrated in the following 3 pages and take the corrective actions to prevent further problems. Remember, it is dangerous to assemble cracked, bent, severely corroded or sprung rim/wheel components. Such items should be destroyed and discarded.

RIM BASE CRACKS

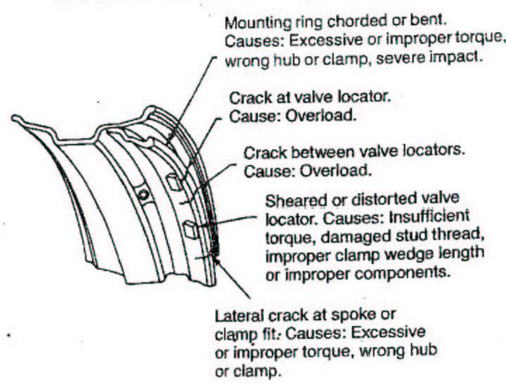


RIM BASE DISTORTION

Flange or rim gutter chorded or bent. Causes: Excessive or improper torque, wrong hub or clamp, severe impact, run flat or hammering on rim gutter.



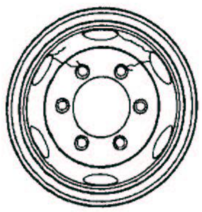
MOUNTING RING PROBLEMS



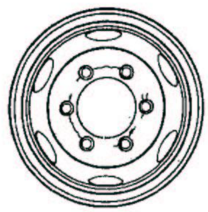
ACCURIDE AC-20 NOTE: Page number references pertain to Accuride's "AC" section only.

VI

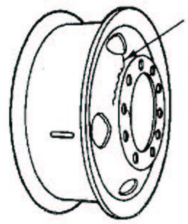
DISC WHEEL CRACKS/BOLT HOLE DISTORTION



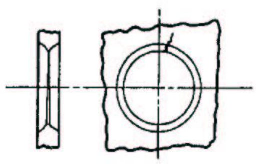
Handhole to handhole.
Handhole to bolt hole.
Handhole to rim.
Cause: Overloading.



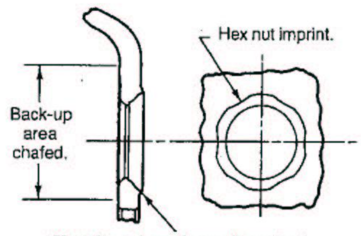
Bolt hole to bolt hole.
Causes: Loose cap nuts, small hub backup (also see bolt hole cracks/distortions).



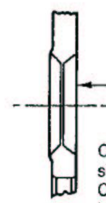
Cracks at disc nave and/or handhole. Causes: Bad fit-up, damaged hub, overload or sharp edge at handhole.



Crack originating from thin edge of stud hole. Cause: Damaged or worn-out at chamfers.



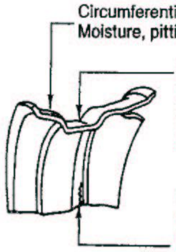
Chamfer enlarged or wallowed out by nut. Causes: Loose cap nuts or insufficient nut torque due to damaged threads, improper torquing or by worn-out nut.



Chamfer extruded on side opposite nut. Causes: Too much torque or improper nut.

TUBELESS RIM LEAKS

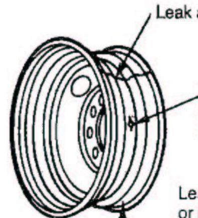
Circumferential cracks at bead seat. Causes: Moisture, pitting and erosion by the tire bead.



Circumferential cracks in well radius. Causes: Overload or overinflation. Corrosion due to water from the air lines, improper mounting lubricant, balance or sealer.

Circumferential cracks at attachment weld. Causes: Overload, overinflation or loose mounting on vehicle. **Note:** Wheel with well welded discs may not be approved for use with radial tires.

Leak at butt weld. Cause: Overload.



Leak at valve hole. Causes: Damage or severe corrosion.

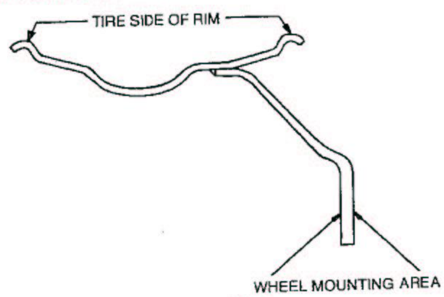
Leak under tire bead, groove or ridge across bead seat. Causes: Corrosion, tire tool marks, bent flange or other damage.

PROCEDURES FOR INSPECTING AND INSTALLING ACCURIDE RIMS/WHEELS ON VEHICLES

INSPECTION AND PREPARATION INSTRUCTIONS FOR HEAVY TRUCK STEEL DISC WHEELS

A. During Tire Inspections or Periodic Vehicle Maintenance Checks:

1. Check all metal surfaces thoroughly including both sides of the wheels and areas between duals. Watch for excessive rust or corrosion buildup; cracks in metal; bent, broken flanges or components; loose, missing or damaged nuts; bent or stripped studs; and incorrectly matched rim parts. (See pages 20 through 22.)
2. Replace an assembly that is damaged or has damaged components. Caution: Excessively corroded or cracked rims are dangerous, particularly during the removal of the assembly. Deflate tire (both tires or a dual assembly) before removing the wheel. Insert a wire through the valve to assure that debris has not prevented deflation. (See page 10.)
3. Look for rust streaks which are an indication of loose nuts or improper nut fit. After tightening the nuts t' the proper recommended torque level or replacing them, remove the rust streaks.
4. Replace broken studs and each unbroken stud next to the broken stud.
5. Determine the cause of the damage before installing another wheel. (See pages 20 through 22.)
6. Inflate tires to only the recommended air pressure, being sure not to exceed the wheel's maximum inflation rating. Use precautions outlined on pages 8 and 15 through 18.



B. During Tire Changes: (See tire demounting procedures on pages 10 and 28 through 33).

1. After the tire is removed, check all metal surfaces, especially the tire side of the rim and the mounting area of the disc. Watch for the conditions outlined in A-1 above.
2. Replace damaged wheels, components, nuts, studs, and valves. Inspect and replace valve grommet as needed.
3. Thoroughly remove rust, dirt and other foreign materials from all surfaces. The areas used for mounting the wheel to the vehicle and the rim area where the tire seats are especially important to clean. Hand or electric wire brushes, light sand blasting, or solvent baths may be used. Wheel mounting areas must be kept flat. Remove any metal projections, burrs at the bolt hole chamfers and/or paint buildup. The hub or drum where the wheel contacts, must also be cleaned and kept flat. Wire brush at the base of each stud. The rim bead seat must be clean and free of rust, corrosion and rubber deposits to insure proper tire seating. The gutter of the rim and the rings must be clean to ensure proper seating of these components. (See page 23.)
4. Paint or spray all bare metal surfaces of the rim and wheel using a fast-drying metal primer. Surfaces should be clean and dry prior to painting. Ensure that bare metal areas on the tire side of rim are painted. This is especially important for tubeless rims, since moisture in the air chamber can cause corrosion. The wheel mounting areas must be kept free of paint runs and paint buildup. The disc wheel mounting area and the bolt hole chamfers should not have excessive paint building. (See page 23.)
5. Use the proper tire and rim combination. (See page 25.)
6. Lubricate tire side of rim base and tire beads just prior to mounting tire. Avoid the use of any lubricant or solvent that is injurious to rubber, steel or paint. A combination lubricant and rust-preventative compound is preferable. (See page 14.) The air supply should incorporate moisture traps to prevent water or moisture inside the tire. Follow the tire-mounting instructions for type of rim being used. These are on pages 28 through 33.

HEAVY TRUCK STEEL DISC WHEEL INSTALLATION PROCEDURE

I. STUD-PILOTED MOUNTING

Wheels with the stud-piloted mounting system are called stud mount wheels. Stud mount wheels are designed to be centered by the nuts on the studs. The seating action of the chamfered nuts in the chamfered bolt holes centers the wheels. (See Figure 1).

A. 10 Hole, 11¼" Bolt Circle DCN Mounting.

1. Inflate Tire Prior to Installing on Vehicle.

   —See inflation procedure on page 8 and 15 through 18.

2. Inspect Parts Before Installing. (See page 34.)

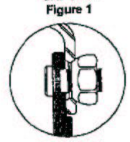
   —Check all parts for damage, including rims/wheels and rings. Ensure that studs, nuts and mounting faces of hub drum and wheels are flat, clean and free from grease. Clean hub surface with wire brush if scale is present. Install wheels only on hubs or drums that have the proper back-up diameter. (See SAE J694.)

   —Replace any damaged parts. Do not bend, weld, heat or braze components. Do not use tubes to stop rim air leakage.

> ⚠ **WARNING:** Not all nuts and studs can be used with all types of wheels. The use of improper nuts and studs can cause nut loosening, stud failure, or premature wheel failure, which could cause an accident or injury.

—Use correct nuts. Inspect nuts to ensure they are not worn and function properly. The nuts listed below are recommended for use with ACCURIDE and EXTRA SERVICE WHEELS with .875" spherical bolt hole chamfers. (The manufacturer's part numbers are listed with each figure.)

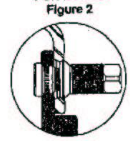
TYPICAL FRONT CAP NUT
Figure 1



¾"-16 Thread

Right	Left
X-1803	X-1804
E-5652R	E-5652L

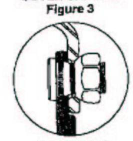
TYPICAL INNER CAP NUT FOR DUALS
Figure 2



¾"-16 Thread

Right	Left
X-1828	X-1829
E-5549R	E-5549L

TYPICAL FRONT OR OUTER CAP NUT
Figure 3



1⅛"-16 Thread

Right	Left
X-1831	X-1832
E-5552R	E-5552L

IMPROPER ASSEMBLIES

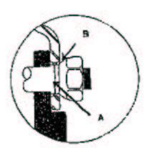


Figure 4

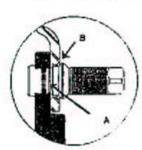


Figure 5

The nuts shown above or their equivalent are special for aluminum wheels only and must not be used to install steel wheels since bottoming may occur (Arrow A) before nuts are seated (Arrow B).

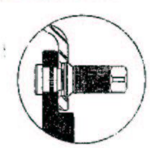


Figure 6

The inner cap nuts above or their equivalent must not be used for wheels in single applications due to limited nut to disc contact.

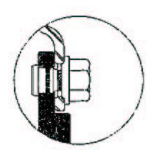


Figure 7

Flanged cap nuts shown above or their equivalent, are not recommended to be used since the nut will not contact the bolt hole chamfer and slippage may occur.

Key to Nut Sources: X —National Wheel and Rim Association, Jacksonville, FL

E —Euclid Industries, Inc., Cleveland, OH

NOTE: Page number references pertain to Accuride's "AC" section only.

PROCEDURES FOR INSPECTING AND INSTALLING ACCURIDE RIMS/WHEELS ON VEHICLES (continued)

HEAVY TRUCK STEEL DISC WHEELS (continued)

3. Install Wheel on Vehicle.

a. Front Wheels

—Slide front wheel over studs, being careful not to damage the stud threads. Snug up nuts in the sequence shown in Figure 8. Do **not** tighten them fully until all have been seated. This procedure will permit the uniform seating of nuts and ensure the even, face-to-face contact of wheels, hub and drum. Tighten nuts to **450—500 ft.-lbs.** (dry) using the same criss-cross sequence.

NUT TIGHTENING SEQUENCE FOR FRONT OR INNER DUAL

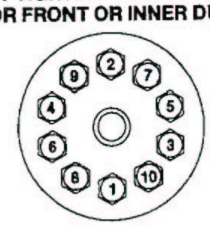


Figure 8

b. Dual Rear Wheels

—Slide the inner dual wheel over studs, being careful not to damage the stud threads. Snug up the inner cap nuts in sequence shown in Figure 8. Do **not** tighten them fully until all have been seated. This procedure will permit the uniform seating of nuts and ensure the even, face-to-face contact of wheels, hub and drum. Tighten to **450—500 ft.-lbs.** (dry) using the same criss-cross pattern.

—Align the hand holes to allow access to the air valves.

—Slide the outer dual wheel over the inner cap nuts and repeat the entire procedure except using the nut tightening sequence in Figure 9. Tighten the outer cap nut to 450—500 ft.-lbs.

NUT TIGHTENING SEQUENCE FOR OUTER DUAL

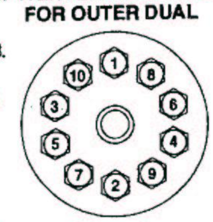


Figure 9

4. Torque Nuts Properly.

—Be sure to tighten wheel nuts to the recommended nut torque. Do **not** overtighten. Do not lubricate the nuts or studs.
—After the first 50 to 100 miles of operation, recheck the torque level and retighten nuts to the proper torque level. When inner cap nuts are retightened be sure to loosen the outer cap nuts first, tighten inner cap nuts and retighten outer cap nuts to proper torque level.
—Maintain nut torque at the recommended level through planned, periodic checks.
—If air wrenches are used, they must be periodically calibrated for proper torque output. Use a torque wrench to check the air wrench output and adjust the line pressure to give correct torque.

⚠ **WARNING:** Nuts must be kept tight by retorquing nuts on a routine basis and using the proper nut torque and tightening sequence. Loose nuts could result in loose wheels or premature wheel failure. This can result in an accident or injury.

B. 10 Hole, 335 mm Bolt Circle European Mounting.

1. The same general installation guidelines are followed as for a 10 Hole, 11¼" DCN mounting except a different type of nut is used. These special nuts are composed of a split washer and flanged nut which are two separate pieces.

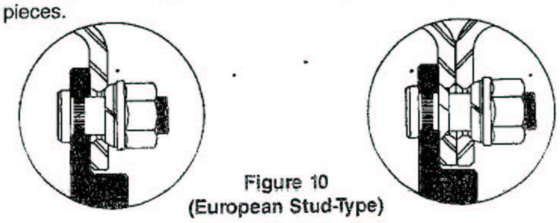


Figure 10
(European Stud-Type)

2. The inner real dual wheel is positioned by a spherical washer that slides over the stud before the wheel. The stud size is M22 × 1.5 and the recommended torque is 258-278 ft. lbs.

C Other Mounting Patterns.

1. Other stud-piloted mounting patterns may use different nuts and stud sizes which require different nut tightening sequences and different recommended torque levels. Consult with the wheel manufacturer. Also refer to page 47 for additional information.

II. HUB-PILOTED MOUNTING

Hub mount wheels are designed to center on the hub at the center hole or bore of the wheel. Because of this feature, they need a close tolerance in the center hole. Hub mount wheels are used with two-piece flange nuts (see Figure 11) which contact the disc face around the bolt hole and do not rely on contacting the bolt hole chamfer to function properly. Hub mount wheels generally have straight through bolt holes with no chamfers which provides a visual way of identifying hub mount wheels. It is important to note that some hub mount wheels and stud mount wheels may have the same bolt circle pattern. Therefore, they could mistakenly be interchanged. (Examples: 10 H-11¼″ BC, 10 H-8¾″ BC, 10 H-335mm BC, 8 H-6½″ BC.) Each mounting system requires its correct mating parts. It is important that the proper components are used for each type of mounting and the wheels are fitted to the proper hubs.

You must never use the hub mount wheels which have straight holes with ball seat or spherical chamfer nuts. These parts are not engineered to work together and can cause premature wheel failure. On heavy truck dual wheels, this condition would not allow the inner cap nut to fit into the inner wheel causing the inner cap nut to interfere with the outer wheel (see Figure 12). This could cause premature cracking and failure of the outer dual wheel.

Stud mount wheels should not be used with hub mount hubs, wheels or flange nuts (see Figure 13). Chamfered stud mount wheels do not have sufficient surface area near the bolt hole to support the flange nut. This type of misassembly may lead to loss of torque, broken studs and cracked wheels. Information concerning mounting types and sizes is found in ACCURIDE's wheel and rim catalog.

⚠**WARNING: ALWAYS USE HUB MOUNT WHEELS AND FLANGE NUTS ON HUB MOUNT HUBS AND STUD MOUNT WHEELS AND CHAMFERED NUTS ON STUD MOUNT HUBS.** If different designs are mixed or improperly matched, premature wheel failure will result which could cause an accident or injury.

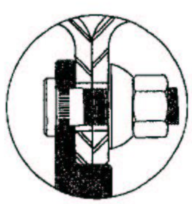


Figure 11
(Proper Mounting)

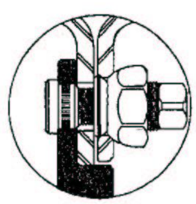


Figure 12
(Improper Mounting)

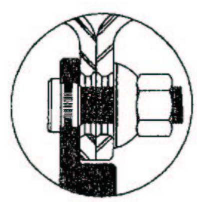


Figure 13
(Improper Mounting)

A. 10 Hole, 11¼″; 10 Hole, 285.75mm and 10 Hole, 335mm Bolt Circle Mountings.

1. Inflate Tire Prior to Installing on Vehicle.

—See inflation procedure on page 8 and 15 through 18.

HEAVY TRUCK STEEL DISC WHEELS (continued)

2. Inspect Parts Before Installing.

—Check all parts for damage, including rims/wheels and rings. Ensure that studs, nuts and mounting faces of hubs, drums and wheels are flat, clean and free from grease. Clean hub surface with wire brush if scale is present. Install wheels only on hubs or drums that have the proper backup diameter. (See SAE J694.)

—Replace any damaged parts. Do not bend, weld, heat or braze components. Do not use tubes or stop rim air leakage.

> ⚠**WARNING:** Not all nuts and studs can be used with all types of wheels. The use of improper nuts and studs can cause nut loosening, stud failure, or premature wheel failure, which could cause an accident or injury.

—Use correct nuts. Inspect nuts to ensure they are not worn and function properly. The nuts listed below are recommended for use with ACCURIDE and EXTRA SERVICE WHEELS. (The manufacturer's part numbers are listed with each figure.)

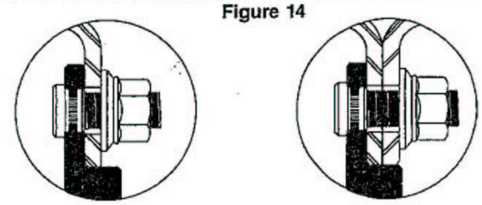
TYPICAL 2-PIECE FLANGE NUTS FOR FRONTS AND DUALS

Figure 14

M22 x 1.5 Thread

33mm Hex
MF 39627 (1) 27mm hgt.
MF 39628 (1) 31mm hgt.
MF 39701 (2) 27mm hgt.
MF 39702 (2) 31mm hgt.

1½ Inch Hex
MF 39604 (1)
MF 39955 (2)



M20 x 1.5 Thread

30 mm Hex
MF 39724 (1)
MF 39708 (2)

7/8"-14 Thread

1½ Inch Hex
X-1687
E-5710 .88" hgt.
X-1818
E-5711 1.4" hgt.

(1) Phosphate Oil Finish (2) 2 Coat Teflon Finish

Key to Nut Sources: MF—Metform, Savanna, IL
E—Euclid Industries, Inc. Cleveland, OH

—Before reusing flange nuts that have already been used in service, apply 2 drops of oil at one point between the flange and the hex. This will allow the parts to rotate freely and provide the proper clamping force when tightened. See Figure 15. Use any common lubricant typically used for fasteners. Examples are motor oil, and general purpose lubricating oils. Excessive lubricant is not desirable; it will not improve nut performance, it makes the nuts hard to handle, it attracts dirt to the nuts, and it may cause unsightly appearance to the wheel. Only **used** nuts should be lubricated.

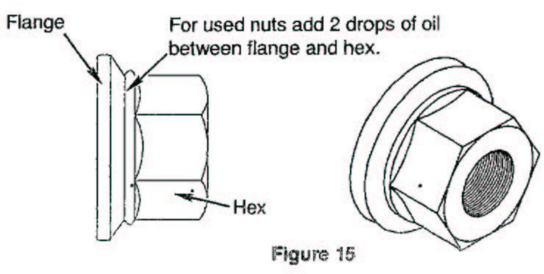


Figure 15

—Since flange nuts generate higher clamping force always use grade eight studs with hub mount wheels.

3. Intall Wheel on Vehicle.

—Before installing wheels, lubricate the hub pilot pads to prevent galling. Do not lubricate any other wheel or hub surfaces.

—For a hub with intermittent pilot pads, position a pad at twelve o'clock to center the wheel and reduce runout.

a. Front Wheels

—Slide the front wheel over studs being careful not to damage the stud threads. Snug up nuts in the sequence shown in Figure 8 on page 36. Do **not** tighten them fully until all have been seated. Tighten nuts to hold **390 to 500 ft.-lbs.** using the same criss-cross sequence.

b. Dual Rear Wheels

—Slide the inner dual wheel over the studs being careful not to date the stud threads. Align the hand holes for valve access and slide the outer dual wheel over the studs again being careful not to damage the stud threads. Snug up nuts in the sequence shown for outer duals in Figure 9 on page 36. Do **not** tighten them fully until all have been seated. Tighten nuts to **390 to 500 ft.-lbs.** using the same sequence. Hub mount wheels use two-piece flange cap nuts for both the front and rear applications. No inner cap nuts are required.

4. Torque Nuts Properly.

—Be sure to tighten wheel nuts to the recommended nut torque. Do **not** overtighten.

—After the first 50 to 100 miles of operation, recheck the torque level and retighten nuts to the proper level.

—Maintain nut torque at the recommended level through planned, periodic checks.

—If air wrenches are used, they must be periodically calibrated for proper torque output. Use a torque wrench to check the air wrench output and adjust the line pressure to give correct torque.

⚠**WARNING:** Nuts must be kept tight by retorquing nuts on a routine basis and using the proper nut torque and tightening sequence. Loose nuts could result in loose wheels or premature wheel failure. This can result in an accident or injury.

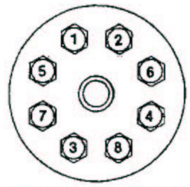
B. 8 Hole, 275mm Bolt Circle Mounting.

1. The same general installation guidelines are followed as for the 10 Hole, 285.75mm bolt circle mounting except use the nut tightening sequence shown in Figure 16. Tighten the nuts to the recommended nut torque values on page 47.

C. Other Mounting Patterns.

1. Other hub-piloted mounting patterns may use different nuts and stud sizes which may require a different nut tightening sequence and different recommended torque values. Consult with the wheel manufacturer. Also refer to page 47 for additional information.

Figure 16



NUT TIGHTENING SEQUENCE

XII

B. 8 Hole, 6½" Bolt Circle Mounting. Use nut tightening sequence shown in Figure 27 on page 46. Three nut types can be used with this mounting (see figures below). Each nut type and size requires a different recommended torque level. Refer to the stud size and nut type in the recommended nut torque table below.

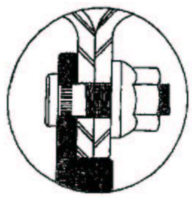


Figure 28 (Hub-Type)

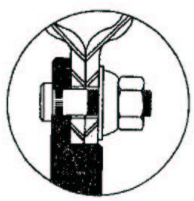


Figure 29 (Hub-Type)

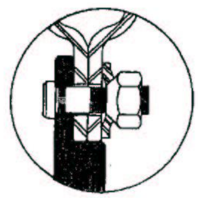


Figure 30 (Hub-Type with Clamping Plate)

C. 10 Hole, 11¼"; 10 Hole, 285.75mm and 10 Hole, 335mm Bolt Circle Mounting. See information on pages 37 through 39.

D. Other mounting patterns may use different nuts and stud sizes which require different nut tightening sequence and different recommended torque levels. Consult the wheel manufacturer.

RECOMMENDED NUT TORQUE

MOUNTING	THREAD SIZE	TORQUE FT.—LBS.	NUT TYPE
LIGHT TRUCK			
10 Hole, 7.25" Hub Piloted (Ford) (5.47" Bore)	9/16-18	125-165	two piece flange
10 Hole, 7.25" Hub Piloted (Chevy) (5.25" Bore) with Clamping Plate	5/8-18	130-170	90° cone (1)
8 Hole, 6.50" I.O.C. (Ford)	9/16-8 5/8-18	175-200 175-200	90° cone 90° cone
8 Hole, 6.50" (Chrysler)	5/8-18	275-325	one piece flanged
8 Hole, 6.50" Hub Piloted (Ford) (4.88" Bore)	9/16-18 5/8-18	125-165 130-170	two piece flange two piece flange
8 Hole, 6.50" Stud Piloted (Ford) (4.88" Bore)—Single Wheel	9/16-18	130-150	60° cone
8 Hole, 6.50" Hub Piloted (Chevy) (4.56" Bore) with Clamping Plate	9/16-18 M14 x 1.5	110-120 110-120	90° cone (1) 90° cone (1)
6 Hole, 8.75" Stud Piloted	3/4-16 1 1/8-16	450-500 450-500	.875" sph. rad. .875" sph. rad.
MEDIUM/HEAVY TRUCK, TRAILER AND BUS			
10 Hole, 13 3/16" HD Stud Piloted	15/16-12 1 5/16-12	750-800 750-800	1.187" sph. rad. 1.187" sph. rad.
10 Hole, 335mm Hub Piloted	M22 x 1.5	390-500	two piece flange
10 Hole, 11¼" Stud Piloted	3/4-16 1 1/8-16	450-500 450-500	.875" sph. rad. .875" sph. rad.
10 Hole, 11¼" Hub Piloted (Bus Mount)	3/4-16 7/8-14	300-350 350-400	two piece flange two piece flange
10 Hole, 285.75mm Hub Piloted	M22 x 1.5	390-500	two piece flange
10 Hole, 8.75" Hub Piloted	11/16-16	300-350	one piece flanged
10 Hole, 8.75" Stud Piloted	3/4-16 1 1/8-16	450-500 450-500	.875" sph. rad. .875" sph. rad.
8 Hole, 275mm Hub Piloted	M20 x 1.5 M22 x 1.5	280-310 390-500	two piece flange two piece flange
Demountable Rims	5/8-11 3/4-10	150-175 210-260	flat nut flat nut

(1) These nuts can only be used with a clamping plate. Do not use 90° cone nuts against the disc face.

NOTE: Hub, stud, and spoke wheel manufacturers may have different torquing requirements. Please consult ACCURIDE's field service representatives if torquing recommendations conflict.

ADDITIONAL INFORMATION

1. Web Sites

www.babsteering.com

2. APPENDIX G

A vehicle does not pass an inspection if it has one of the following defects or deficiencies:

7. Steering Mechanism

a. Steering wheel free play (on vehicles equipped with power steering the engine must be running).

Steering Wheel diameter	Manual steering	Power steering system
16"	2"	4 1/2"
18"	2 1/4"	4 3/4"
20"	2 1/2"	5 1/4"
22"	2 3/4"	5 3/4"

b. Steering Columns

(1) Any absence or looseness of U-bolt(s) or positioning part(s).
(2) Worn, faulty or obviously repair welded universal joint(s).
(3) Steering wheel not properly secured.

c. Front Axle Beam and All Steering Components Other Than Steering Column.

(1) Any crack(s) in gear box or mounting brackets.

d. Pitman Arm. Any looseness of the pitman arm on the steering gear output shaft.

e. Power Steering. Auxiliary power assist cylinder loose.

f. Ball and Socket Joints.

(1) Any movement under steering load of a stud nut.
(2) Any motion, other than rotational between any linkage member and its attachment point of more than 1/4 inch.

g. Tie Rods and Drag Links.

(1) Loose clamp(s) or clamp bolt(s) on tie rods or drag links.
(2) Any looseness in any threaded joint.

h. Nuts. Nut(s) loose or missing on tie rods, pitman arm, drag link, steering arm or tie rod arm.

i. Steering System. Any modification or other condition that interferes with free movement of any steering component.

8. Suspension.

a. Any U-bolt(s), spring hanger(s), or other axle positioning part(s) cracked, broken, loose or missing resulting in shifting of an axle from its normal position. (After a turn, lateral axle displacement is normal with some suspensions. Forward or rearward operation in a straight line will cause the axle to return to alignment.)

b. Spring Assembly

(1) Any leaves in a leaf spring assembly broken or missing.
(2) Any broken main leaf in a leaf spring assembly, (include assembly with more than one main spring).
(3) Coil spring broken.
(4) Rubber spring missing.
(5) One or more leaves displaced in a manner that could result in contact with a tire, rim, brake drum or frame.
(6) Broken torsion bar spring in a torsion bar suspension.
(7) Deflated air suspension, i.e., system failure, leak, etc.

c. Torque, Radius, or Tracking Components. Any part of a torque, radius or tracking component assembly or any art used for attaching the same to the vehicle frame or axle that is cracked, loose, broken or missing. (Does not apply to loose bushings in torque or track rods).

9. Frame.

a. Frame Members.

(1) Any cracked, broken, loose, or sagging frame member.
(2) Any loose or missing fasteners including fasteners attaching functional component such as engine, transmission, steering gear, suspension, body parts, and fifth wheel.

b. Tire and Wheel Clearance. Any condition, including loading that causes the body or frame to be in contact with a tire or any part of the wheel assemblies.

c. (1) Adjustable axle assemblies (Sliding Subframes). Adjustable axle assembly with lockingpins missing or not engaged.

10. Tires.

a. Any tire on any steering axle of a power unit.

(1) With less than 4/32 inch tread when measured at any point on a major tread groove.
(2) Has body ply or belt material exposed through the tread or sidewall.
(3) Has any tread or sidewall separation.
(4) Has a cut where the ply or belt material is exposed.
(5) Labeled "Not for Highway Use" or displaying other marking , which would exclude use on steering axle.
(6) A tube-type radial tire without radial tube stem markings. These markings include a red band around the tube stem, the word "radial"

embossed in metal stems, or the word "radial" molded in rubber stems.
(7) Mixing bias and radial tires on the same axle.
(8) Tire flap protrudes through valve slot in rim and touches stem.
(9) Regrooved tire except motor vehicles used solely in urban or suburban service (see exception in 393.75(e)).
(10) Boot, blowout patch or other ply repair.
(11) Weight carried exceeds tire load limit. This includes overloaded tire resulting from low air pressure.
(12) Tire is flat or has noticeable (e.g., can be heard or felt) leak.
(13) Any bus equipped with recapped or retreaded tire(s).
(14) So mounted or inflated that it comes in contact with any part of the vehicle.

b. All tires other than those found on the steering axle of a power unit:
(1) Weight carried exceeds tire load limit. This includes overloaded tire resulting from low air pressure.
(2) Tire flat or has noticeable (e.g. can be heard or felt) leak.
(3) Has body ply or belt material exposed through the tread or sidewall.
(4) Has any tread or sidewall separation.
(5) Has a cut where ply or belt material is exposed.
(6) So mounted or inflated that it comes in contact with any part of the vehicle. (This includes a tire that contacts its mate.)
(7) Is marked "Not for highway use" or otherwise marked and having like meaning.
(8) With less than 2/32 inch tread when measured at any point on a major tread groove.

11. Wheels and Rims

a. Lock or Side Ring. Bent, broken, cracked, improperly seated, sprung or mismatched ring(s).

b. Wheels and rims. Cracked or broken or has elongated bolt holes.

c. Fasteners (both spoke and disc wheels). Any loose, missing, broken, cracked, stripped or otherwise ineffective fasteners.

d. Welds.
(1) Any cracks in welds attaching disc wheel disc to rim.
(2) Any crack in welds attaching tubeless demountable rim to adapter.
(3) Any welded repair on aluminum wheel(s) on a steering axle.
(4) Any welded repair other than disc to rim attachment on steel disc wheel(s) mounted on the steering axle.

AUTOMATIC TRANSMISSIONS

General Components .... Page #

AUTOMATIC TRANSMISSIONS

1. **Purpose**

   Automatic transmissions transfer engine torque to the driveline.

2. **Inspection Procedure**

   Inspect external transmission filters, and lines for visible leakage, mounting, and fluid level.

NOTE: Filter changes should be in accordance with manufacturer's specifications.

Maintaining proper fluid level is very important. Transmission fluid is used to apply the various clutch packs and to lubricate and cool the transmission. A fluid level that is too low or too high can cause damage.

NOTE: Two types of fluid level checks are possible - a hot check and a cold check. Use of the hot check is recommended. Transmission fluid level is checked at normal operating temperatures with the engine at idle and on level ground. For cold checks, refer to manufacturer's recommendations.

Inspect for proper shift cable adjustment.

Check mounting for loose or missing bolts and brackets.

Inspect mechanical actuator adjustment or vacuum modulator operation.

If any of the following problems are found, it is recommended that they be repaired before the unit is put back into service:

- Shift problems or clutch slippage.
- Visible leakage.
- Improper fluid level.
- Loose or missing bolts and brackets.
- Improper converter lock-up (if equipped).
- Current transmission fault codes.
- Check all wiring and electrical connections.

3. **Repair Procedure Tips**

   Start with the simplest checks first (such as improper fluid levels and plugged filters). Next, refer to the manufacturer's manual or the troubleshooting section on the following page.

PREVENTATIVE MAINTENANCE AND TROUBLESHOOTING TIPS

1. Fluid Level Checks

Maintaining the proper fluid level is very important. Transmission fluid is used to apply the various clutch packs and to lubricate and cool the transmission. A fluid level that is too low can cause damage. If the fluid level is too high, aeration and overheating will occur. Always check the transmission fluid level at least twice to ensure a proper reading.

- **Hot Check**
  Check fluid level at operating temperature with the engine at idle, the transmission in neutral, and the vehicle on level ground. This is the preferred method.

- **Cold Check**
  A cold check is to be done only when there is a need to determine that sufficient fluid is in the transmission to operate the vehicle.

NOTE: Clean debris and dirt from the dipstick area before checking the fluid level. Check that the dust cap is secure to the dipstick, and sealing properly. If Inconsistent readings occur, check for proper venting of the transmission.

2. Filter Changes

Fluid must be handled in clean containers, funnels, etc. This prevents contamination. Keep all filters and replacement parts in their original cartons until ready for use. Filter change intervals depend on a variety of factors, such as driving conditions, and can vary from district to district. A good place to start is with the manufacturer’s guidelines.

- **Internal Filter Change**
  When changing the internal filter, be sure to remove the old o-ring from the oil filter intake tube. Lubricate and install the new o-ring with the proper ATF or the manufacturer's recommended lubricant. Install the filter using care not to introduce dirt, or foreign material into the fluid area. Tighten the retaining screw, or bolt, to the manufacturer’s specification.

NOTE: When changing the internal filter, this is a good time to check for loose mounting bolts, leaking oil lines, the condition of the cables and/or linkage, and the vacuum modulator hose and line. Check the pan for any unusual material. Clean the pan, and straighten the mounting (gasket) surface on a flat surface. Install the oil pan by hand, taking care not to disturb the gasket, then torque the pan bolts to the manufacturer's specification.

- **Auxiliary Filter Change**
  These service intervals depend on a variety of factors, such as driving conditions, and can vary from district to district. Whenever possible, change the filters during a major PM, or follow the manufacturer's guidelines.

- **Breather Filter**
  Keep the breather clean. Follow the manufacturer's guidelines or clean the breather during a major PM.

3. Shift Linkage

For best performance, proper adjustment of the shift linkage is essential. Failure to obtain the proper detent in drive, neutral, and reverse will result in improper clutch application, thus causing premature failure.

- **Visual Check**
  Check the linkage for bent, loose, or worn parts. Check for accumulation of grease and dirt. Moving parts should be clean and slightly lubricated.

- **Adjustment**
  The manual selector lever is adjusted to move freely, and give a crisp detent feeling in each gear selection. If the linkage is adjusted properly, the stops in the manual selector will match the detents in the transmission. After proper adjustment, the pin, which engages the shift linkage at the transmission, can be moved freely in each range.

4. Throttle Modulation

For efficient performance, it is very important that the mechanical actuator or vacuum modulator is operating properly.

- **Mechanical Actuator Adjustment**
  With the engine off, the throttle is placed in the full throttle position. The mechanical actuator cable will also be in the full throttle position. Check that the clevis pin fits freely through the hole in the clevis. For additional specifications, check the manufacturer's service manual.

- **Vacuum Modulator**
  Inspect the vacuum line/hose for leaks, proper routing, and overall condition. If any transmission fluid is present in the line/hose, the modulator is defective. A modulator can be tested with a vacuum

pump, or using slight air pressure. Refer to the manufacturer's service manual for testing procedures.

- **Electronic Controls**
  Refer to the manufacturer's service manual for testing procedures.

TEST PROCEDURES

1. Road Test

Perform a road-test by simulating the conditions reported by the driver. In addition, do a full throttle test checking up shift points. Generally shift points are as follows:

- 1 to 2 will be within 400 rpm's of the engine governed speed
- 2 to 3 will be within 300 rpm's of the engine governed speed
- 3 to 4 will be within 200 rpm's of the engine governed speed.

NOTE: Check the manufacturer's manual for exact specs. On some transmissions, if the shift does not occur within the parameters, the shift signal valves can be adjusted up or down.

2. Stall Test

A stall test is performed, in a forward gear, to determine when a power package (engine/transmission) is performing inadequately. The stall test will determine whether the problem lies with the engine or the transmission.

Apply the service brakes fully, block the vehicle securely, shift the selector into a forward range, and accelerate the engine to full throttle. After the engine RPM's stabilize, record your reading, release the throttle, shift the transmission into neutral, and then maintain 1000 RPM's for at least two minutes to cool the transmission.

Compare your test results to the established norm for that unit. If the engine RPM was below the specifications, the problem is associated with the engine. If the engine RPM was above specifications, the problem lies with the transmission.

ADDITIONAL INFORMATION

Web Sites

www.allisontransmission.com
www.eaton.com
www.meritor.com
www.roadranger.com

MANUAL TRANSMISSIONS

MANUAL TRANSMISSIONS

1. Purpose

The manual transmission transfers engine torque from the engine to the driveline in different forward and reverse gears.

2. Inspection Procedure

Inspect rear yoke, yoke retention nut, and flange for looseness.

Remove the inspection plate.

- Check for excessive clutch material.
- Lubricate the throw out bearing (if equipped).
- Inspect for signs of leakage in the clutch housing area.

Check the fluid level and condition.

Lubricate the linkage at the pivot points, or cross shaft ball.

Ensure that the return spring(s) are in place and in good condition.

Check for any external leakage.

Check for loose or missing mounts and mounting hardware.

Check the shift tower and shift lever condition.

Road test to ensure proper shift action and that each gear stays in place without popping out of gear.

NOTE: Repair as to meet or exceed standards and recommendations as outlined by the manufacturer. For additional troubleshooting, refer to the clutch section.

ADDITIONAL INFORMATION

Web Sites

www.allisontransmission.com
www.drivetrain.com
www.edmunds.com/car-technology/manual-transmission-basics.html

RECCOMMENDED TOOLS AND EQUIPMENT FOR COMPLETING ANNUAL INSPECTIONS

*Required by CDE

NOTE: All equipment should be commensurate in size & capacity to the vehicle being inspected.

Equipment

Hoist or a Bumper Jack
Rolling Floor Jack*
Jack Stands or Supports*
Headlight Testing Equipment

Measuring Tools

Brake Drum Micrometer*
Brake Disc Rotor Micrometer*
Dial Indicator
Tire Tread Depth Gauge*
Tire Inflation Gauge*
Tape Measure/Ruler*

Miscellaneous Tools

Tire Inflation Tool*
Pry Bars
Spanner Sockets
Seal Removal Tools
Seal Installation Tools
Brake Shoe Removal Tools
Brake Shoe Installation Tools
Wheel Removal/Installation Tools
Torque Wrenches

This list is very brief, and should be adequate for doing inspections. We hope that all districts and outside facilities are far beyond this minimum.

The Colorado Department of Education does not have a required tool list, but does require that the inspecting site have adequate tools and measuring tools to perform the inspection. The adequate tools will still be checked during CDE inspections.

APPENDIX G

General Components .... Page #

Minimal formatting has occurred in Section 24 – Appendix G in order to preserve the integrity of the U.S. DOT Federal Motor Carrier Safety Administration's original document.

For more information, see also the Federal Motor Carrier Safety Administration's web site: www.fmcsa.dot.gov

Appendix G to Subchapter B—Minimum periodic inspection standards

A vehicle does not pass an inspection if it has one of the following defects or deficiencies:

1. Brake System.
a. Service brakes.

(1) Absence of braking action on any axle required to have brakes upon application of the service brakes (such as missing brakes or brake shoe(s) failing to move upon application of a wedge, S-cam, cam, or disc brake).
(2) Missing or broken mechanical components including: shoes, lining, pads, springs, anchor pins, spiders, cam rollers, push-rods, and air chamber mounting bolts.
(3) Loose brake components including air chambers, spiders, and cam shaft support brackets.
(4) Audible air leak at brake chamber (Example-ruptured diaphragm, loose chamber clamp, etc.).
(5) Readjustment limits. (a) The maximum pushrod stroke must not be greater than the values given in the tables below and at §393.47(e). Any brake stroke exceeding the readjustment limit will be rejected. Stroke must be measured with engine off and reservoir pressure of 80 to 90 psi with brakes fully applied.

Clamp-Type Brake Chambers

Type	**Outside Diameter**	**Brake Readjustment Limit (Standard Stroke)**	**Brake Readjustment Limit (Long Stroke)**
6	4 1/2 in.	1 1/4 in.	
9	5 1/4 in.	1 3/8 in.	
12	5 11/16 in.	1 3/8 in.	1 3/4 in.
16	6 3/8 in	1 3/4 in.	2 in.
20	6 25/32 in.	1 3/4 in.	2 in. (50.8 mm). 2 1/2 in. (63.5 mm)*
24	7 7/32 in.	1 3/4 in.	2 in. (50.8 mm). 2 1/2 in. (63.5 mm)**
30	8 3/32 in.	2 in.	2 1/2 in.
36	9 in.	2 1/4 in.	

* For type 20 chambers with a 3-inch (76 mm) rated stroke.
** For type 24 chambers with a 3-inch (76 mm) rated stroke.

Bendix DD–3 Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit
30	8 1/8 in.	2 1/4 in.

Bolt-Type Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit
A	6 15/16 in.	1 3/8 in.
B	9 3/16 in.	1 3/4 in.
C	8 1/6 in.	1 3/4 in.
D	5 1/4 in.	1 1/4 in.
E	6 3/16 in.	1 3/8 in.
F	11 in.	2 1/4 in.
G	9 7/8 in.	2 in.

Rotochamber-Type Brake Chambers

Type	Outside Diameter	Brake Readjustment Limit
9	4 9/32 in.	1 1/2 in.
12	4 13/16 in.	1 1/2 in.
16	5 13/32 in.	2 in.
20	5 15/16 in.	2 in.
24	6 13/32 in.	2 in.
30	7 1/6 in.	2 1/4 in.
36	7 5/8 in.	2 3/4 in.
50	8 7/8 in.	3 in.

(b) For actuator types not listed in these tables, the pushrod stroke must not be greater than 80 percent of the rated stroke marked on the actuator by the actuator manufacturer, or greater than the readjustment limit marked on the actuator by the actuator manufacturer.

(6) Brake linings or pads.(a) Lining or pad is not firmly attached to the shoe;(b) Saturated with oil, grease, or brake fluid; or(c) Non-steering axles: Lining with a thickness less than 1/4 inch at the shoe center for air drum brakes, 1/16 inch or less at the shoe center for hydraulic and electric drum brakes, and less than1/8inch for air disc brakes.(d) Steering axles: Lining with a thickness less than 1/4 inch at the shoe center for drum brakes, less than 1/8 inch for air disc brakes and 1/16 inch or less for hydraulic disc and electric brakes.

(7) Missing brake on any axle required to have brakes.

(8) Mismatch across any power unit steering axle of:(a) Air chamber sizes.(b) Slack adjuster length.

Wedge Brake Data—Movement of the scribe mark on the lining shall not exceed 1/16 inch.

b. Parking Brake System. No brakes on the vehicle or combination are applied upon actuation of the parking brake control, including driveline hand controlled parking brakes.

c. Brake Drums or Rotors.

(1) With any external crack or cracks that open upon brake application (do not confuse short hairline heat check cracks with flexural cracks).
(2) Any portion of the drum or rotor missing or in danger of falling away.

d. Brake Hose.

(1) Hose with any damage extending through the outer reinforcement ply. (Rubber impregnated fabric cover is not a reinforcement ply). (Thermoplastic nylon may have braid reinforcement or color difference between cover and inner tube. Exposure of second color is cause for rejection.
(2) Bulge or swelling when air pressure is applied.
(3) Any audible leaks.
(4) Two hoses improperly joined (such as a splice made by sliding the hose ends over a piece of tubing and clamping the hose to the tube).
(5) Air hose cracked, broken or crimped.

e. Brake Tubing.

(1) Any audible leak.
(2) Tubing cracked, damaged by heat, broken or crimped.

f. Low Pressure Warning Device missing, inoperative, or does not operate at 55 psi and below, or 1/2 the governor cut-out pressure, whichever is less.

g. Tractor Protection Valve. Inoperable or missing tractor protection valve(s) on power unit.

h. Air Compressor.

(1) Compressor drive belts in condition of impending or probable failure.
(2) Loose compressor mounting bolts.
(3) Cracked, broken or loose pulley.
(4) Cracked or broken mounting brackets, braces or adapters.

i. Electric Brakes.

(1) Absence of braking action on any wheel required to have brakes.
(2) Missing or inoperable breakaway braking device.

j. Hydraulic Brakes. (Including Power Assist Over Hydraulic and Engine Drive Hydraulic Booster).

(1) Master cylinder less than 1/4 full.

(2) No pedal reserve with engine running except by pumping pedal.
(3) Power assist unit fails to operate.
(4) Seeping or swelling brake hose(s) under application of pressure.
(5) Missing or inoperative check valve.
(6) Has any visually observed leaking hydraulic fluid in the brake system.
(7) Has hydraulic hose(s) abraded (chafed) through outer cover-to-fabric layer.
(8) Fluid lines or connections leaking, restricted, crimped, cracked or broken.
(9) Brake failure or low fluid warning light on and/or inoperative.

k. Vacuum Systems. Any vacuum system which:
(1) Has insufficient vacuum reserve to permit one full brake application after engine is shut off.
(2) Has vacuum hose(s) or line(s) restricted, abraded (chafed) through outer cover to cord ply, crimped, cracked, broken or has collapse of vacuum hose(s) when vacuum is applied.
(3) Lacks an operative low-vacuum warning device as required.

2. Coupling Devices.
a. Fifth Wheels.
(1) Mounting to frame.
(a) Any fasteners missing or ineffective.
(b) Any movement between mounting components.
(c) Any mounting angle iron cracked or broken.
(2) Mounting plates and pivot brackets.
(a) Any fasteners missing or ineffective.
(b) Any welds or parent metal cracked.
(c) More than 3/8 inch horizontal movement between pivot bracket pin and bracket.
(d) Pivot bracket pin missing or not secured.
(3) Sliders.
(a) Any latching fasteners missing or ineffective.
(b) Any fore or aft stop missing or not securely attached.
(c) Movement more than 3/8 inch between slider bracket and slider base.
(d) Any slider component cracked in parent metal or weld.
(4) Lower coupler.
(a) Horizontal movement between the upper and lower fifth wheel halves exceeds 1/2 inch.
(b) Operating handle not in closed or locked position.
(c) Kingpin not properly engaged.
(d) Separation between upper and lower coupler allowing light to show through from side to side.
(e) Cracks in the fifth wheel plate. Exceptions: Cracks in fifth wheel approach ramps and casting shrinkage cracks in the ribs of the body of a cast fifth wheel.
(f) Locking mechanism parts missing, broken, or deformed to the extent the kingpin is not securely held.

b. Pintle Hooks.

(1) Mounting to frame.

(a) Any missing or ineffective fasteners (a fastener is not considered missing if there is an empty hole in the device but no corresponding hole in the frame or vice versa).

(b) Mounting surface cracks extending from point of attachment (e.g., cracks in the frame at mounting bolt holes).

(c) Loose mounting.

(d) Frame cross member providing pintle hook attachment cracked.

(2) Integrity.

(a) Cracks anywhere in pintle hook assembly.

(b) Any welded repairs to the pintle hook.

(c) Any part of the horn section reduced by more than 20%.

(d) Latch insecure.

c. Drawbar/Towbar Eye.

(1) Mounting.

(a) Any cracks in attachment welds.

(b) Any missing or ineffective fasteners.

(2) Integrity.

(a) Any cracks.

(b) Any part of the eye reduced by more than 20%.

d. Drawbar/Towbar Tongue.

(1) Slider (power or manual).

(a) Ineffective latching mechanism

(b) Missing or ineffective stop.

(c) Movement of more than 1/4 inch between slider and housing.

(d) Any leaking, air or hydraulic cylinders, hoses, or chambers (other than slight oil weeping normal with hydraulic seals).

(2) Integrity.

(a) Any cracks.

(b) Movement of 1/4 inch between subframe and drawbar at point of attachment.

e. Safety Devices.

(1) Safety devices missing.

(2) Unattached or incapable of secure attachment.

(3) Chains and hooks.

(a) Worn to the extent of a measurable reduction in link cross section.

(b) Improper repairs including welding, wire, small bolts, rope and tape.

(4) Cable.

(a) Kinked or broken cable strands.

(b) Improper clamps or clamping.

f. Saddle-Mounts.

(1) Method of attachment.
  (a) Any missing or ineffective fasteners.
  (b) Loose mountings.
  (c) Any cracks or breaks in a stress or load bearing member.
  (d) Horizontal movement between upper and lower saddle-mount halves exceeds 1/4 inch.

3. Exhaust System.
a. Any exhaust system determined to be leaking at a point forward of or directly below the driver/sleeper compartment.

b. A bus exhaust system leaking or discharging to the atmosphere:
(1) Gasoline powered—excess of 6 inches forward of the rearmost part of the bus.
(2) Other than gasoline powered—in excess of 15 inches forward of the rearmost part of the bus.
(3) Other than gasoline powered—forward of a door or window designed to be opened. (exception: Emergency exits).

c. No part of the exhaust system of any motor vehicle shall be so located as would be likely to result in burning, charring, or damaging the electrical wiring, the fuel supply, or any combustible part of the motor vehicle.

4. Fuel System.
a. A fuel system with a visible leak at any point.

b. A fuel tank filler cap missing.

c. A fuel tank not securely attached to the motor vehicle by reason of loose, broken or missing mounting bolts or brackets (some fuel tanks use springs or rubber bushings to permit movement).

5. Lighting Devices.
All lighting devices and reflectors required by Section 393 shall be operable.

6. Safe Loading.
a. Part(s) of vehicle or condition of loading such that the spare tire or any part of the load or dunnage can fall onto the roadway.

b. Protection Against Shifting Cargo—Any vehicle without a front-end structure or equivalent device as required.

c. Container securement devices on intermodal equipment—All devices used to secure an intermodal container to a chassis, including rails or support frames, tiedown bolsters, locking pins, clevises, clamps, and hooks that are cracked, broken, loose, or missing.

7. Steering Mechanism.
a. Steering Wheel Free Play (on vehicles equipped with power steering the engine must be running).

Steering Wheel Free Play

Steering Wheel Diameter	Manual Steering System	Power Steering System
16 in.	2 in.	4 1/2 in.
18 in.	2 1/4 in.	4 3/4 in.
20 in.	2 1/2 in.	5 1/4 in.
22 in.	2 3/4 in.	5 3/4 in.

b. Steering Column.
(1) Any absence or looseness of U-bolt(s) or positioning part(s).
(2) Worn, faulty or obviously repair welded universal joint(s).
(3) Steering wheel not properly secured.

c. Front Axle Beam and All Steering Components Other Than Steering Column.
(1) Any crack(s).
(2) Any obvious welded repair(s).

d. Steering Gear Box.
(1) Any mounting bolt(s) loose or missing.
(2) Any crack(s) in gear box or mounting brackets.

e. Pitman Arm. Any looseness of the pitman arm on the steering gear output shaft.

f. Power Steering. Auxiliary power assist cylinder loose.

g. Ball and Socket Joints.
(1) Any movement under steering load of a stud nut.
(2) Any motion, other than rotational, between any linkage member and its attachment point of more than 1/4 inch.

h. Tie Rods and Drag Links.
(1) Loose clamp(s) or clamp bolt(s) on tie rods or drag links.
(2) Any looseness in any threaded joint.

i. Nuts. Nut(s) loose or missing on tie rods, pitman arm, drag link, steering arm or tie rod arm.

j. Steering System. Any modification or other condition that interferes with free movement of any steering component.

8. Suspension.

a. Any U-bolt(s), spring hanger(s), or other axle positioning part(s) cracked, broken, loose or missing resulting in shifting of an axle from its normal position. (After a turn, lateral axle displacement is normal with some suspensions. Forward or rearward operation in a straight line will cause the axle to return to alignment).

b. Spring Assembly.

(1) Any leaves in a leaf spring assembly broken or missing.
(2) Any broken main leaf in a leaf spring assembly. (Includes assembly with more than one main spring).
(3) Coil spring broken.
(4) Rubber spring missing.
(5) One or more leaves displaced in a manner that could result in contact with a tire, rim, brake drum or frame.
(6) Broken torsion bar spring in a torsion bar suspension.
(7) Deflated air suspension, i.e., system failure, leak, etc.

c. Torque, Radius or Tracking Components. Any part of a torque, radius or tracking component assembly or any part used for attaching the same to the vehicle frame or axle that is cracked, loose, broken or missing. (Does not apply to loose bushings in torque or track rods.)

9. Frame.

a. Frame Members.

(1) Any cracked, broken, loose, or sagging frame member.
(2) Any loose or missing fasteners including fasteners attaching functional component such as engine, transmission, steering gear, suspension, body parts, and fifth wheel.

b. Tire and Wheel Clearance. Any condition, including loading, that causes the body or frame to be in contact with a tire or any part of the wheel assemblies.

c. (1) Adjustable Axle Assemblies (Sliding Subframes). Adjustable axle assembly with locking pins missing or not engaged.

10. Tires.

a. Any tire on any steering axle of a power unit.

(1) With less than 4/32 inch tread when measured at any point on a major tread groove.
(2) Has body ply or belt material exposed through the tread or sidewall.
(3) Has any tread or sidewall separation.
(4) Has a cut where the ply or belt material is exposed.
(5) Labeled “Not for Highway Use” or displaying other marking which would exclude use on steering axle.
(6) A tube-type radial tire without radial tube stem markings. These markings include a red band around the tube stem, the word “radial” embossed in metal stems, or the word “radial” molded in rubber stems.

(7) Mixing bias and radial tires on the same axle.
(8) Tire flap protrudes through valve slot in rim and touches stem.
(9) Regrooved tire except motor vehicles used solely in urban or suburban service (see exception in 393.75(e).
(10) Boot, blowout patch or other ply repair.
(11) Weight carried exceeds tire load limit. This includes overloaded tire resulting from low air pressure.
(12) Tire is flat or has noticeable (e.g., can be heard or felt) leak.
(13) Any bus equipped with recapped or retreaded tire(s).
(14) So mounted or inflated that it comes in contact with any part of the vehicle.

b. All tires other than those found on the steering axle of a power unit:
(1) Weight carried exceeds tire load limit. This includes overloaded tire resulting from low air pressure.
(2) Tire is flat or has noticeable (e.g., can be heard or felt) leak.
(3) Has body ply or belt material exposed through the tread or sidewall.
(4) Has any tread or sidewall separation.
(5) Has a cut where ply or belt material is exposed.
(6) So mounted or inflated that it comes in contact with any part of the vehicle. (This includes a tire that contacts its mate.)
(7) Is marked “Not for highway use” or otherwise marked and having like meaning.
(8) With less than 2/32 inch tread when measured at any point on a major tread groove.

11. Wheels and Rims.
a. Lock or Side Ring. Bent, broken, cracked, improperly seated, sprung or mismatched ring(s).

b. Wheels and rims. Cracked or broken or has elongated bolt holes.

c. Fasteners (both spoke and disc wheels). Any loose, missing, broken, cracked, stripped or otherwise ineffective fasteners.

d. Welds.
(1) Any cracks in welds attaching disc wheel disc to rim.
(2) Any crack in welds attaching tubeless demountable rim to adapter.
(3) Any welded repair on aluminum wheel(s) on a steering axle.
(4) Any welded repair other than disc to rim attachment on steel disc wheel(s) mounted on the steering axle.

12. Windshield Glazing.
(Not including a 2 inch border at the top, a 1 inch border at each side and the area below the topmost portion of the steering wheel.) Any crack, discoloration or vision reducing matter except:
(1) coloring or tinting applied at time of manufacture;

(2) any crack not over 1/4 inch wide, if not intersected by any other crack;
(3) any damaged area not more than 3/4 inch in diameter, if not closer than 3 inches to any other such damaged area;
(4) labels, stickers, decalcomania, etc. (see 393.60 for exceptions).

13. Windshield Wipers.
Any power unit that has an inoperative wiper, or missing or damaged parts that render it ineffective.

[53 FR 49411, Dec. 7, 1988; 53 FR 49968, Dec. 12, 1988, as amended at 73 FR 76827, Dec. 17, 2008; 77 FR 46639, Aug. 8, 2012; 77 FR 59829, Oct. 1, 2012]

ACCESSORIES

Webasto Heaters

1. Heater Maintenance

Inspect heater for functionality and complete possible tune-up before winter.

Run heater monthly for at least 10 minutes during off-season.

Inspect mounting hardware for loose or missing items. Remove accumulated debris from around the heater. Pay close attention to the air intake and exhaust outlet.

Check exhaust tubing for cracks, blockages, missing sections and loose clamps.

Repair corroded or damaged wiring and connections. Inspect fuses and switches. Clean battery connections and check condition of the vehicle's batteries.

NOTE: All Webasto heaters should operate at +12 Volts to optimize performance.

Inspect the system for leaking or damaged coolant lines, clamps and connections. Check for proper routing and attachment to vehicle. Inspect the coolant circulation pump for damage or seal leakage.

Run the unit. Make sure all coolant valves are open for proper coolant flow throughout the entire system.

NOTE: Be sure to keep the manufacturer's service manuals for heater-specific inspection information or repairs.

2. Heater Lockout Reset Procedure – TSL17

Find the main weather-pack fuse holder (usually located behind the heater).

Remove Fuse F1 (15 amp) and wait 10 seconds before reinserting. This prepares the control unit for resetting.

Reinsert Fuse F1 and wait an additional 10 seconds. Now turn the heater on using the on/off switch.

Wait 10 seconds after turning the heater on and remove fuse F1 again.

Wait 30 seconds and then turn the heater off at the switch.

Reinsert fuse F1 after waiting 3-10 seconds of shutting off the heater.

Wait a further 10 seconds and turn the heater back on again.

The lockout mode should now be canceled and the heater operating normally.

3. Setting the Timer – ISS

The ISS time is a 7-day NOI (No Operator Interface) timer. This means you can set the timer to specific needs and the timer will do the rest. This timer has battery backup and will hold its memory if the vehicle battery is disconnected and it will recharge when 12 volt power is restored.

To set the timer clock:

- Press and hold the “Clock” button and by pressing the “hour” and “min” buttons set the clock appropriately.
- In the upper left corner you will see the “am” or “pm” sign.

Setting the timer on/off functions:

- Press the “timer” button one time. You will see the screen now says “1” “on” using the day button select the appropriate day or days.
- Look in the upper left hand corner for the “am” or “pm” sign. Using the day button you can select one or multiple days.
- After you have selected the proper day/days and set the appropriate on time, push the “timer” button once again.
- You should now see “1” “off” using the day button select the appropriate days again.

NOTE: Be sure the days selected match the same days you selected for Timer “1” “On.”

- Now set the timer to the appropriate “off” time.
- After you have set the timer functions needed, push the “clock” this will save your settings and return to the clock.

NOTE: These steps can be repeated six more times giving you multiple on and off settings. It is very important that you set this timer to the specific needs of each vehicle to optimize the heater’s efficiency.

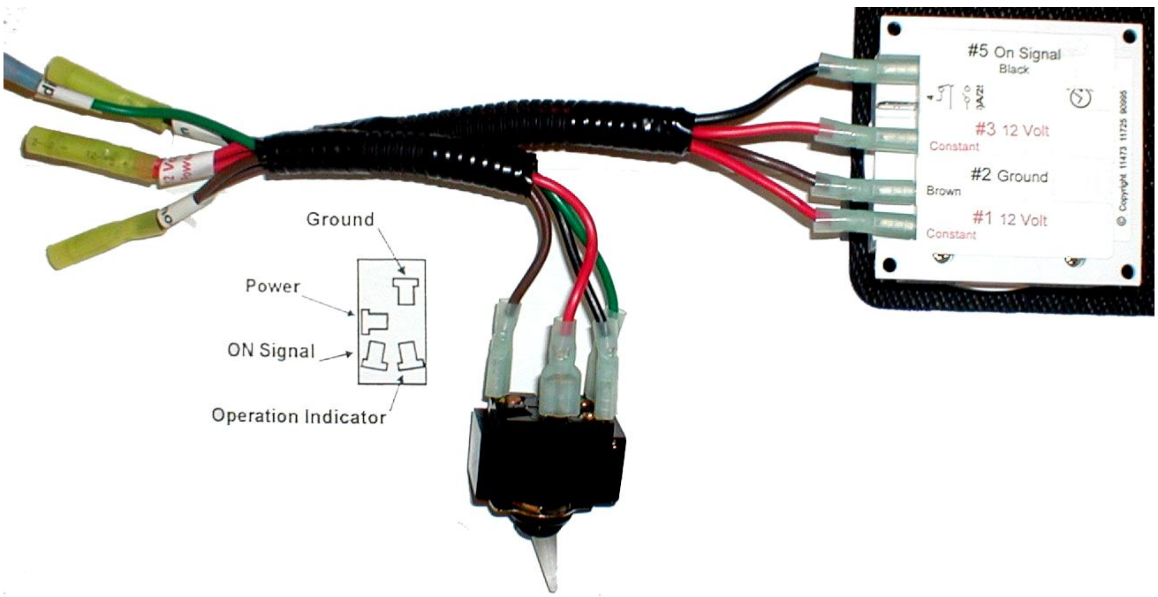
The largest button on the timer is the “manual” button. At the bottom of the “LCD” screen you will see a small line that moves as you push this button. Underneath the small line you will see the corresponding function “on” “auto” “off”.

The manual button can be used as a toggle switch to operate the heater or after you have programmed the timer for automatic service, push the manual button until the line is over “auto” on the timer. The timer will now turn the heater on and off at the times preset earlier.

The toggle switch will illuminate green when the heater has an “on” signal. If the toggle switch is in the “off” position and the timer has turned the heater on the toggle will illuminate green.

This is an easy way to identify the heater is in operation. While the timer is “on” the toggle switch will NOT operate the heater. The toggle switch is a master switch while the timer is not in operation.

4. Timer Wiring Diagram



5. Troubleshooting Tables

When troubleshooting any Webasto heater eliminate the following possible causes first:

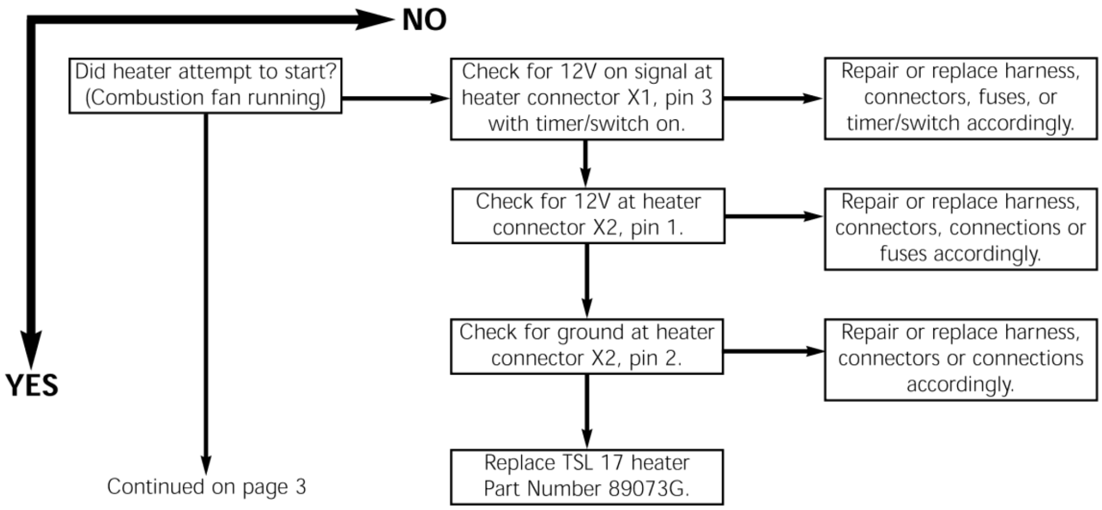
- Power supply to the heater is less than 10.5 volts at the main power connections located at the vehicle battery. (Charge batteries and perform a load test) Proper battery voltage is important. Use no less than 12 volts at the main power leads.
- Blown fuses. Always check the main power supply fuses located at the 12-volt positive connection.
- Corrosion on the battery terminals for heater, electrical wiring, connections and fuses.
- Loose contacts or connectors, wrong crimping on connectors.
- Ensure that the 7-day timer has been set properly and is in the automatic mode.
- If equipped, check and re-set the inertia switch.

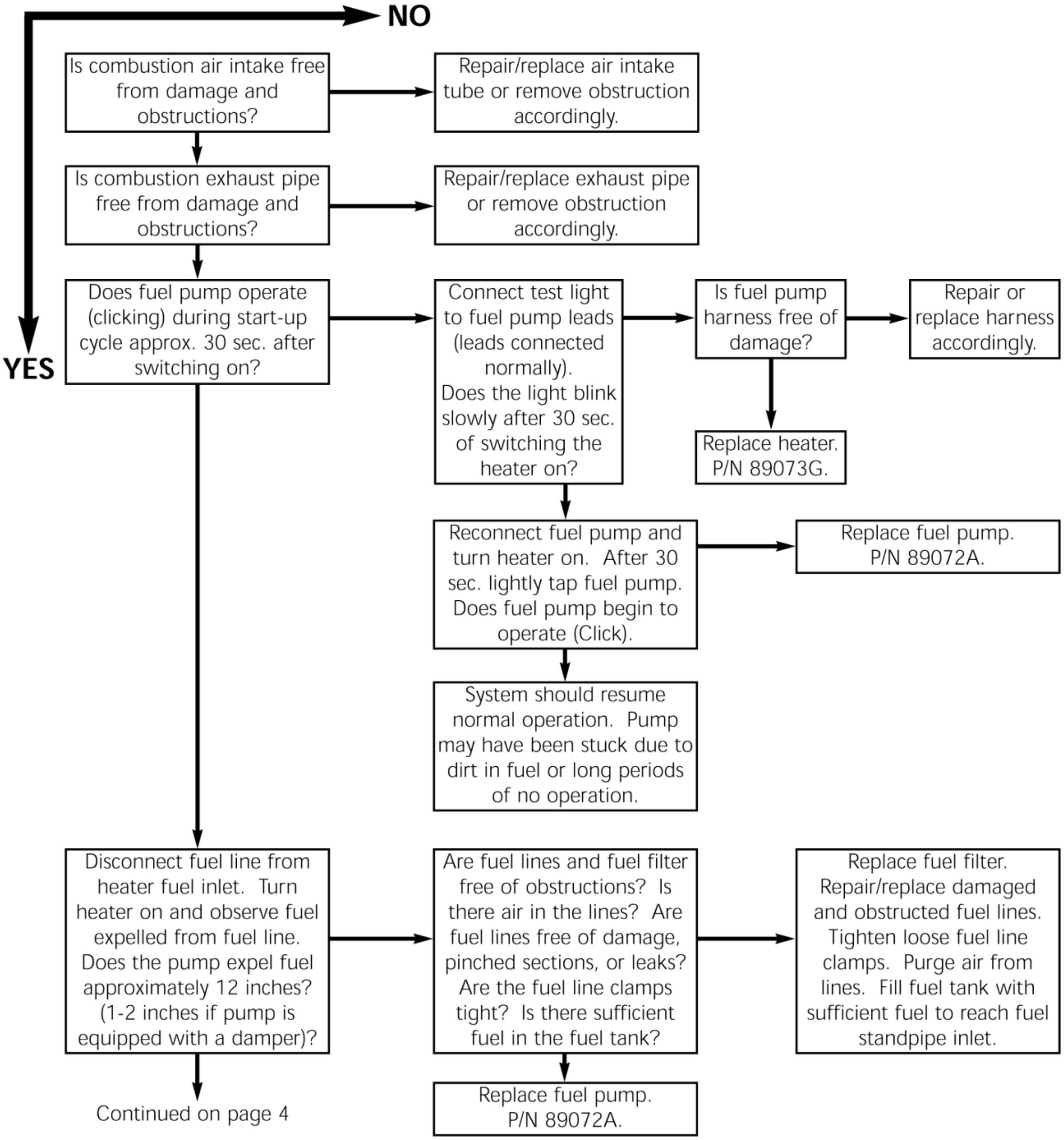
ATTENTION!

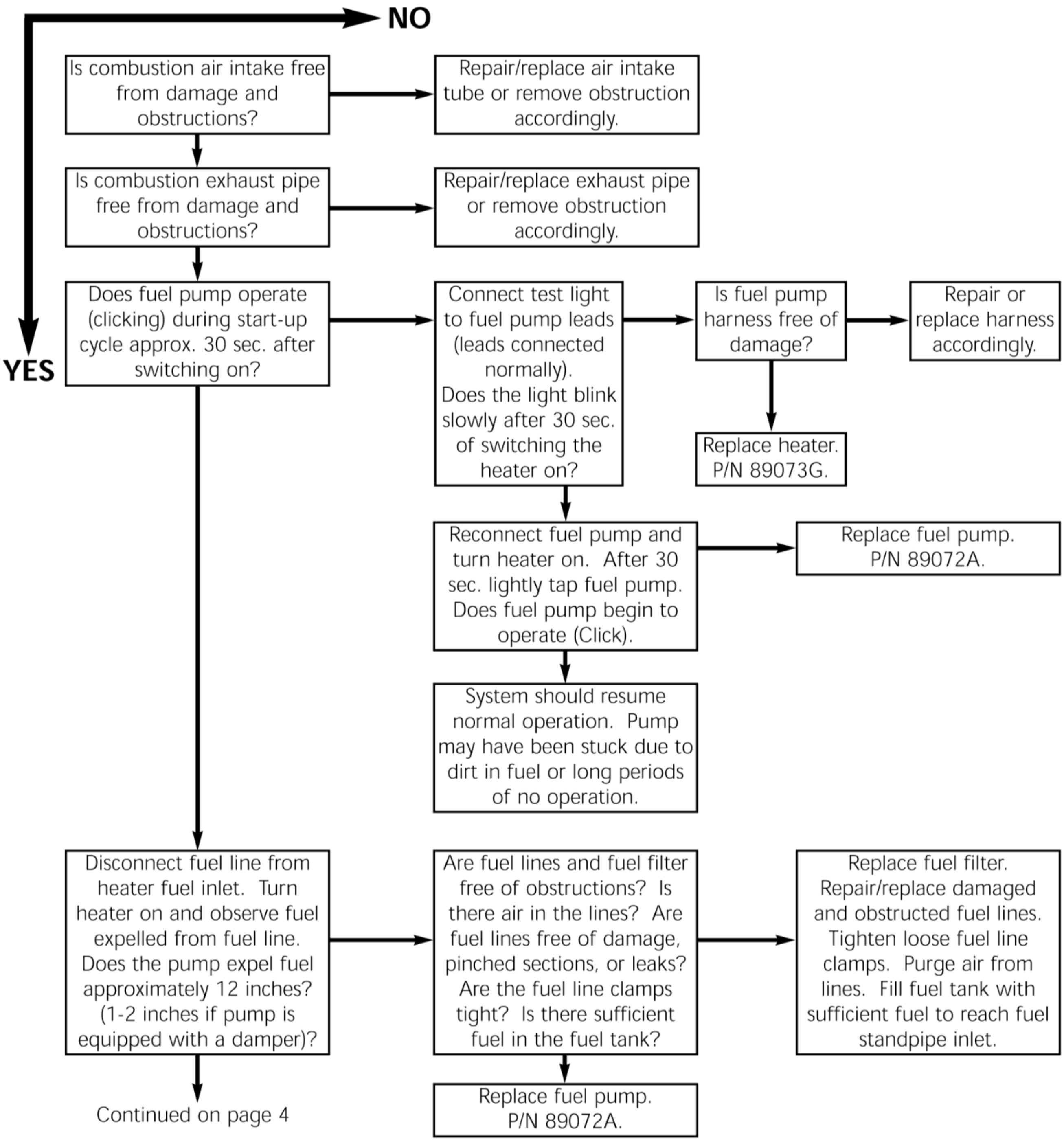
Troubleshooting is normally limited to the isolation of defective components and provides information on defective wiring and connections.

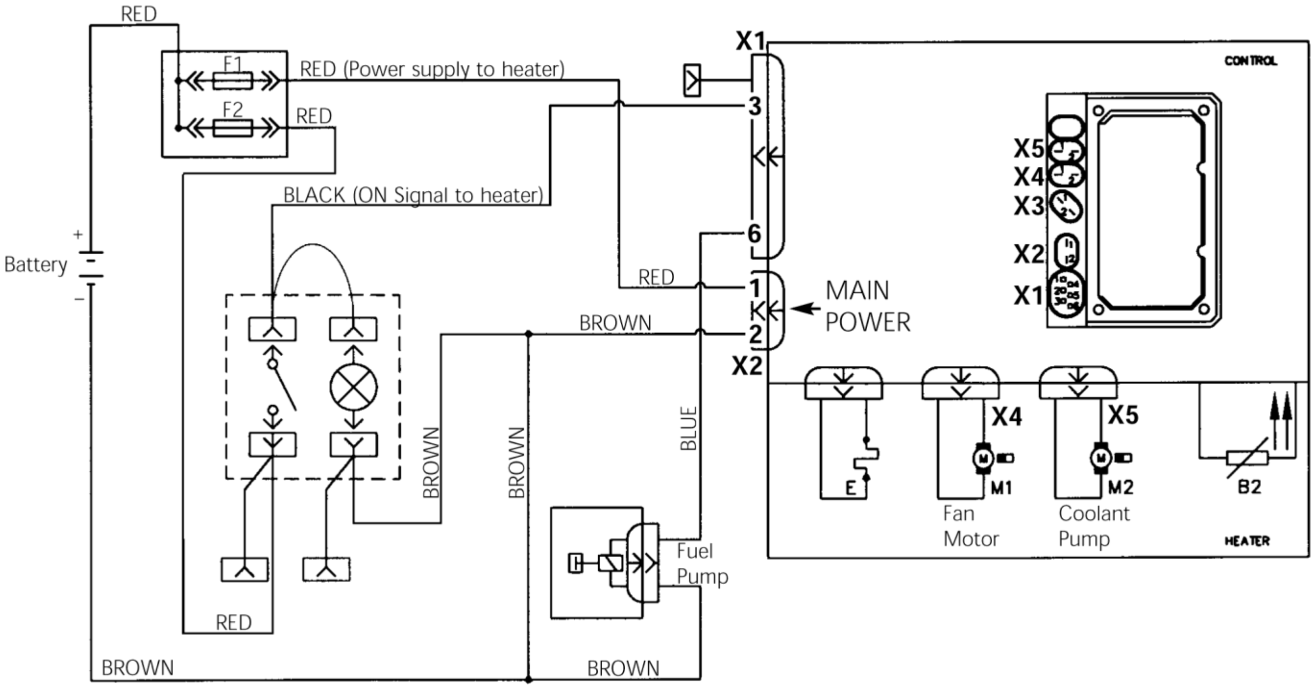
The following possible causes for trouble have not been taken into consideration and must always be excluded as a possible cause for malfunctions:

- *power supply to heater is less than 10.5 volts at main power connections (charge batteries and perform load test). See wiring diagram on page 5 for reference to power connections.*
- *blown fuses.*
- *corrosion on battery terminals for heater, electrical wiring, connections and fuses.*
- *loose contacts or connectors, wrong crimping on connectors.*
- *ensure heater and components have been correctly installed following all pertaining installation instructions.*




NO
YES
Is combustion air intake free from damage and obstructions?
Repair/replace air intake tube or remove obstruction accordingly.
Is combustion exhaust pipe free from damage and obstructions?
Repair/replace exhaust pipe or remove obstruction accordingly.
Does fuel pump operate (clicking) during start-up cycle approx. 30 sec. after switching on?
Connect test light to fuel pump leads (leads connected normally). Does the light blink slowly after 30 sec. of switching the heater on?
Is fuel pump harness free of damage?
Repair or replace harness accordingly.
Replace heater. P/N 89073G.
Reconnect fuel pump and turn heater on. After 30 sec. lightly tap fuel pump. Does fuel pump begin to operate (Click).
Replace fuel pump. P/N 89072A.
System should resume normal operation. Pump may have been stuck due to dirt in fuel or long periods of no operation.
Disconnect fuel line from heater fuel inlet. Turn heater on and observe fuel expelled from fuel line. Does the pump expel fuel approximately 12 inches? (1-2 inches if pump is equipped with a damper)?
Are fuel lines and fuel filter free of obstructions? Is there air in the lines? Are fuel lines free of damage, pinched sections, or leaks? Are the fuel line clamps tight? Is there sufficient fuel in the fuel tank?
Replace fuel filter. Repair/replace damaged and obstructed fuel lines. Tighten loose fuel line clamps. Purge air from lines. Fill fuel tank with sufficient fuel to reach fuel standpipe inlet.
Replace fuel pump. P/N 89072A.
Continued on page 4


NO
YES
Is combustion air intake free from damage and obstructions?
Repair/replace air intake tube or remove obstruction accordingly.
Is combustion exhaust pipe free from damage and obstructions?
Repair/replace exhaust pipe or remove obstruction accordingly.
Does fuel pump operate (clicking) during start-up cycle approx. 30 sec. after switching on?
Connect test light to fuel pump leads (leads connected normally). Does the light blink slowly after 30 sec. of switching the heater on?
Is fuel pump harness free of damage?
Repair or replace harness accordingly.
Replace heater. P/N 89073G.
Reconnect fuel pump and turn heater on. After 30 sec. lightly tap fuel pump. Does fuel pump begin to operate (Click).
Replace fuel pump. P/N 89072A.
System should resume normal operation. Pump may have been stuck due to dirt in fuel or long periods of no operation.
Disconnect fuel line from heater fuel inlet. Turn heater on and observe fuel expelled from fuel line. Does the pump expel fuel approximately 12 inches? (1-2 inches if pump is equipped with a damper)?
Are fuel lines and fuel filter free of obstructions? Is there air in the lines? Are fuel lines free of damage, pinched sections, or leaks? Are the fuel line clamps tight? Is there sufficient fuel in the fuel tank?
Replace fuel filter. Repair/replace damaged and obstructed fuel lines. Tighten loose fuel line clamps. Purge air from lines. Fill fuel tank with sufficient fuel to reach fuel standpipe inlet.
Replace fuel pump. P/N 89072A.
Continued on page 4



Additional wiring diagrams are available. Refer to the TSL 17 Operation/Installation manual (P/N 907512). This manual is available free for printing or downloading from our Web site at: www.webasto-thermo.com.

6. Operating Specifications

Engine Only Preheater

Variable Heat Rating:

Input:

Full:	20,960 Btu/h (6.1 kW)
Reduced:	10,480 Btu/h (3.0 kW)

Output:

Full:	17,200 Btu/h (5.0 kW)
Reduced:	8,600 Btu/h (2.5 kW)
Fuel type:	Diesel #1, #2,Arctic, ULSD, Alternative Bio Diesel Fuels

Fuel consumption:

Full:	0.16 gal/h (0.61 l/h)
Reduced:	0.08 gal/h (0.30 l/h)
Rated voltage:	12V

Power consumption @ 12V

Full:	3.8 Amps (46 W)
Reduced:	2.6 Amps (32 W)
Water Flow:	2 gal/minute @ 1.9 PSI (450 l/h @ 0.13 bar)
Dimensions:	L 9.1” x W 4.1” x H 6.4” L 232mm x W 105mm x H 163mm
Weight:	7.0 lbs (3.2 kg)

NOTE: Technical data is subject to +/- 10% variance.

Engine/Passenger Compartment Preheater

Variable Heat Rating:

Input:	52,400 Btu/h (15.2 kW)
Output:	45,000 Btu/h (13.1 kW)
Fuel type:	Diesel #1, #2,Arctic, ULS, Alternative Bio Diesel Fuels
Fuel consumption:	0.4 gal/h @ full operating cycles
Rated voltage:	12V
Power consumption:	9.5 amps @ 12V (114 W) w/ high capacity coolant pump
Dimensions:	L 23” x W 8.1” x H 10” L 584mm x W 205mm x H 228mm
Weight:	Approx 65 lbs (29.5 kg)

NOTE: Technical data is subject to +/- 10% variance.

DROP CHAINS

1. Onspot Automatic Tire Chains

Operation

The Onspot Automatic Tire chain offers the traction of a single set of conventional snow chains at the flip of a switch, without having to stop the vehicle.

An electric switch mounted in the cab provides 12 volts to an air solenoid mounted on the vehicle's frame rail. Compressed air to the solenoid is supplied from either the vehicle's onboard air system or a 12-volt compressed air kit.

When the dashboard switch is activated, the solenoid opens allowing compressed air to enter the air chamber and lower the chainwheel so it contacts the inside of the tire. The friction between the tire and the rubber-covered chainwheel causes the chainwheel to rotate, creating enough centrifugal force to flail the chains out in front of the tire.

Six lengths of chain spaced at 60-degree intervals on the chainwheel ensure that there are always two chains between the tire and road surface whether you are accelerating, braking or are in a wheel lockup condition. The traction from the chainwheel is obtained in forward OR reverse.

When the dashboard switch is turned off, the solenoid exhausts the air provided to the chain units and return springs in the air chambers bring the chainwheels back to their resting position.

Inspection Procedure
(as recommended by Onspot)

- Start the vehicle.
- Move forward at 3 to 5 MPH and turn on the Onspot Chains.
- Count to five and turn the chains off.
- The chains should lower and pass between the tire and the road surface. On a dry surface the operator should be able to feel the chains under the tire.
- The chains should retract up and out of the way when turned off and the chains should **NOT** be dragging on the ground in the resting position.

NOTE: This procedure can be done in dry weather conditions. Snow or ice need not be present to verify drop chain operation.

Bulletin # 3130027

ONSPOT
Automatic Tire Chains

Keep your Onspots in tune
General Guidelines

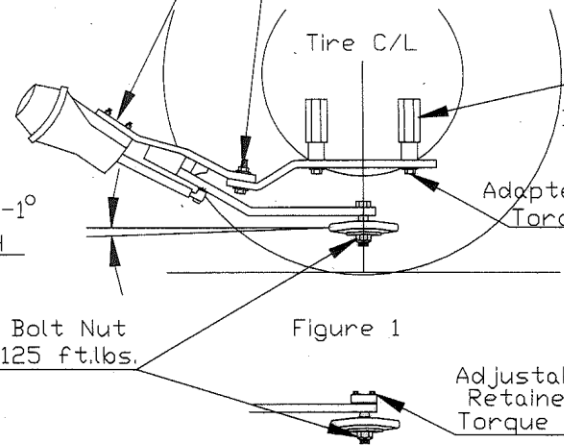


Figure 1

Grease Arm Bearings

Check Play In:
- Ball Joint
- Chainwheel Bearings
- Arm Bearings

Check Tire Sidewall Pressure
(minimum 20 Lbs)

Check Chainwheel Contact
- Operating Angle
- Pitch
- Contact Height

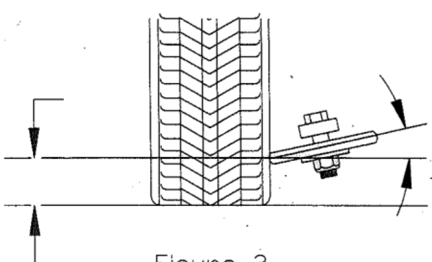


Figure 2

2 3/4" contact on loaded vehicle
with 16" wheels and 170mm chainwheel

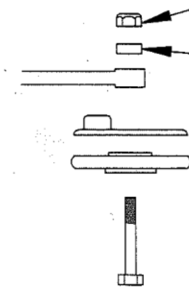


Figure 4

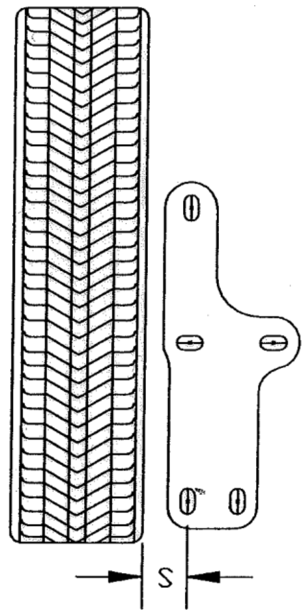
Red Chainwheel Driver Side
Blue Chainwheel Passenger Side

1-800-224-2467

Automatic Tire Chains

Top View

Model 04 Shown

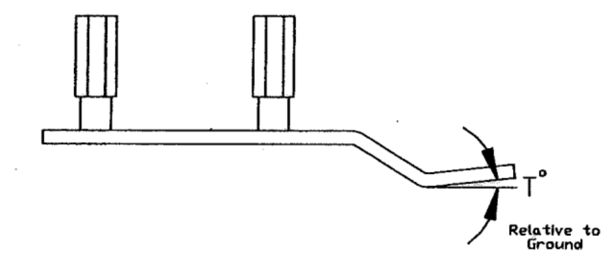


'S' Dimension

01 = 2 3/4"
03 = 1 1/2"
04 = 1 1/2"
05 = 4"

(Plus/Minus 1/4")

Side View



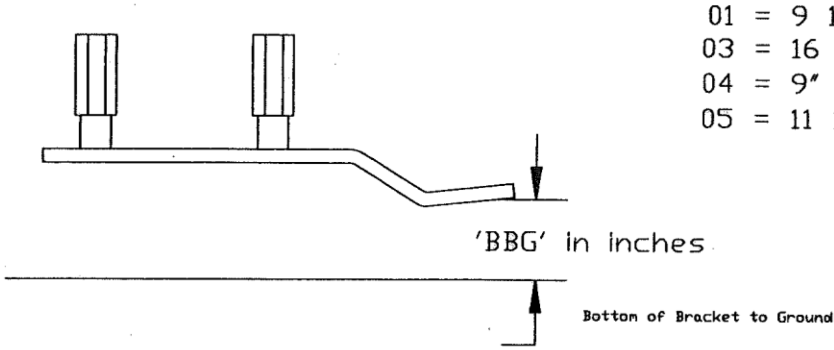
'T' Angle

01 = 6°
03 = 0°
04 = 8°
05 = 0°

(Plus/Minus 2°)

'BBG' Dimension

01 = 9 1/2"
03 = 16 1/4"
04 = 9"
05 = 11 1/4"



The above are general guidelines for 190mm wheels at 4" tire contact.

FUTURE REVISIONS

Future revisions of this manual will include greater information on other accessory systems such as Camera Systems, GPS units, and the Air Top Scholastic auxiliary heaters.

In the meantime, the best course of action for a technician would be to visit the unit manufacturers' web sites for their district's specific brand.

A list of web sites is available in the Additional Information part of this section.

ADDITIONAL INFORMATION

1. Web Sites

www.busvision.com
www.instrumentsales.com
www.onspot.com
www.rudchain.com
www.webasto.us
www.zonarsystems.com

2. TSL 17 Diagram

The Webasto TSL 17 (Thermo Top C) Coolant Heater - Overview

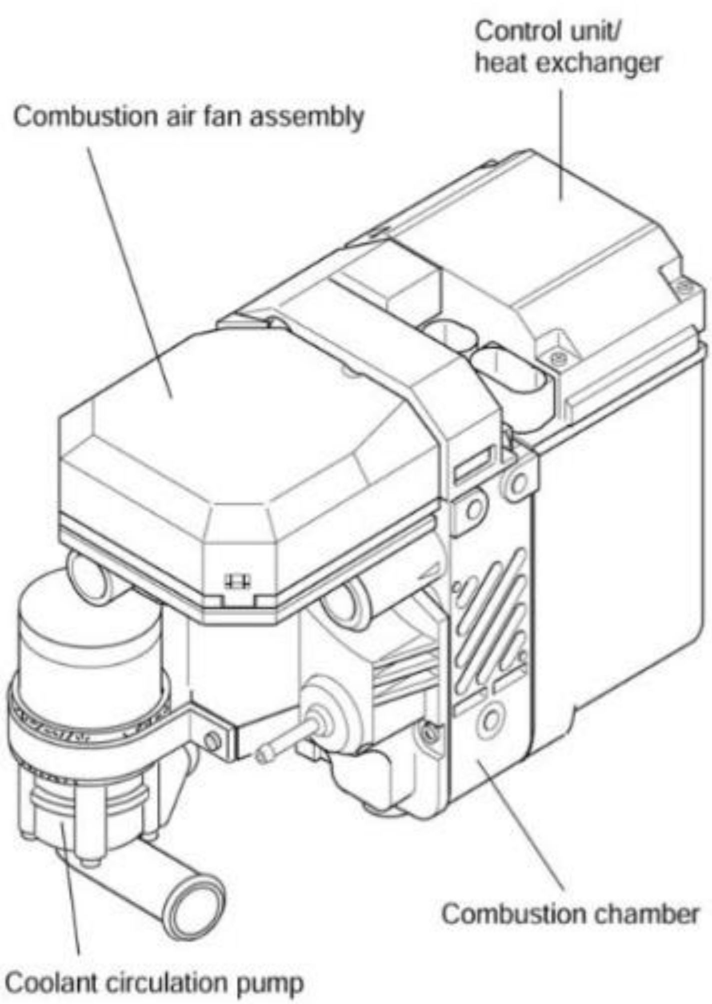
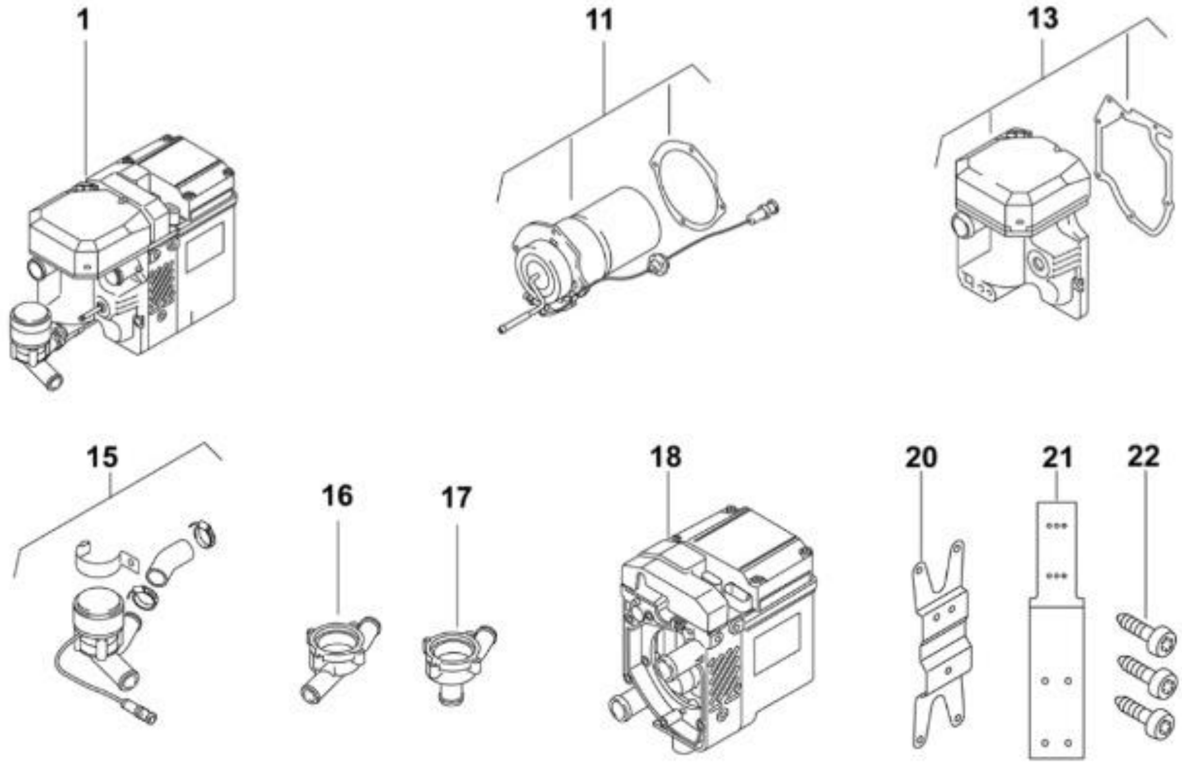


Figure 1. TSL 17 (Thermo Top C) Coolant Heater

TSL 17 (12 Volt, Diesel) - fig. 1



Item Repère	Quantity Nombre TSL 17	Part No. Référence	A/N	Description Désignation		Remarks Remarques
TSL 17 - 12 Volt, Diesel Heaters / Réchauffeur						
1	1	89073K		TSL 17 - 12 V, Diesel	replacement heater réchauffeur de rechange	
2-10						
Parts for heater / Pièces pour le réchauffeur						
11	1	92995C		burner (Diesel) brûleur (Gas-oil)	12 V 12 V	with screws and gaskets / avec vis et joints
12						
13	1	9001383A		combustion air fan turbine d'air	12 V 12 V	
14						
15	1	93008A		circulation pump pompe de circulation	U 4847 - 12 V U 4847 - 12 V	with seals and screws / avec pièces d'étanchéité et vis
16	1	93011C		pump housing Corps de pompe	193° 193°	for / pour U 4847
17	1	93012C		pump housing Corps de pompe	axial axial	for / pour U 4847
18	1	92998E		burner head + heat exchanger + control unit tête de brûleur + échangeur de chaleur + boîtier de commande		
19						
20	1	87394B		universal mounting plate plat de support universel		
21	1	901088		mounting plate - heavy duty truck applications plat de support - applications résistantes de camion		
22	3	86889B		screw - EJOT PT 10 DG 60 x 18 vis - EJOT PT 10 DG 60 x 18		for fastening bracket to heater / pour le support d'attache au réchauffeur