Wayne Walter

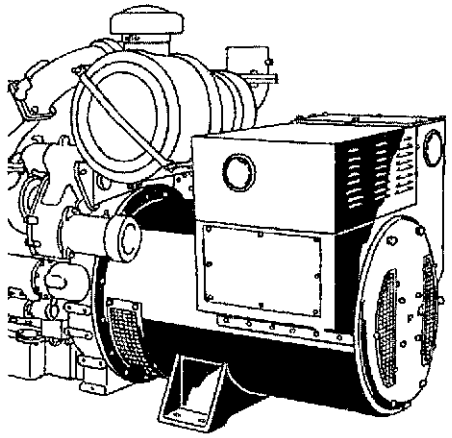
FORM 34072

OPERATION AND MAINTENANCE INSTRUCTIONS

CATERPILLAR

ELECTRIC SET GENERATORS

Self-Regulated—Statically Excited



Caterpillar Tractor Co., General Offices, Peoria, Illinois. • Caterpillar Americas Co., Peoria, Illinois. • Caterpillar Overseas S.A., Geneva. • Caterpillar of Australia Pty. Ltd., Melbourne. • Caterpillar Brasil S.A., São Paulo. • Caterpillar Tractor Co., Ltd., Glasgow. • Caterpillar of Canada Ltd., Toronto.

Warranty

The Manufacturer warrants its products for six (6) months after the date of delivery to the initial user. This warranty is limited to the repair or replacement, as the Manufacturer may elect, at one of its factories designated by it, of such parts as shall appear to the Manufacturer upon inspection to have been defective in material or workmanship but does not include any installation or transportation costs. No warranty is made with respect to items made by others when such items are warranted by their respective makers or when they are supplied by the Manufacturer on special order. This warranty is in lieu of all other warranties, express or implied, and no other warranty of any kind is made or authorized by the Manufacturer. No recommendation by the Manufacturer of items made by others shall imply or constitute any warranty with respect to such items.

T25495

Foreword

Caterpillar products are a result of advanced engineering, skilled manufacturing, and the finest materials metallurgical science can select. Thousands of satisfying, economical working hours are built into each machine.

Whether or not the owner derives the maximum service from his machine depends largely on the care exercised in its operation and maintenance. This book is written to give the operator essential information regarding the day-to-day operation, lubrication and adjustment of the machine. Careful adherence to these instructions will result in assured economy.

More and more Caterpillar owners are depending upon their dealer for service other than the care and adjustments described in this book. This practice is recommended because Caterpillar dealers have stocks of genuine Caterpillar parts and are equipped with tools designed and built by Caterpillar. Their servicemen are factory-trained and are kept closely informed by the factory regarding advanced methods of servicing Caterpillar products — thus, in all ways they are equipped to render the best of service.

T20841

Avoid Accidents

Most accidents, whether they occur in the air, in industry, on the farm, at home, on the highways, or at sea, are caused by someone's failure to follow simple and fundamental safety rules or precautions. For this reason most accidents can be prevented by recognizing the real cause and doing something about it before the accident occurs.

Regardless of the care used in the design and construction of any type of equipment, there are many conditions that cannot be completely safeguarded against without interfering with reasonable accessibility and efficient operation.

A careful operator is the best insurance against an accident.

The complete observance of one simple rule would prevent many thousands of serious injuries each year. That rule is: "Never attempt to clean, oil or adjust a machine while it is in motion."

T24352

WARNING

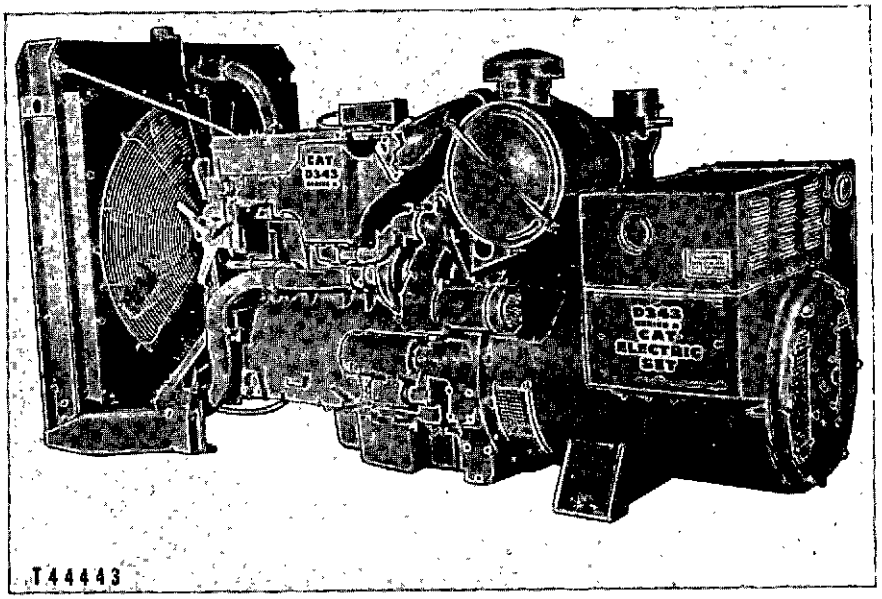
DO NOT REMOVE OR INSTALL COVER WITH GENERATOR OPERATING

WHEN THE ENGINE IS RUNNING THE ALUMINUM RECTIFIER PLATE IS ELECTRICALLY CHARGED. SERIOUS INJURY MAY RESULT FROM PERSONAL CONTACT WITH THE ALUMINUM RECTIFIER PLATE. THE RECTIFIER MAY BE DAMAGED IF A METAL CONTACT IS MADE BETWEEN THE ALUMINUM RECTIFIER PLATE AND THE GENERATOR FRAME.

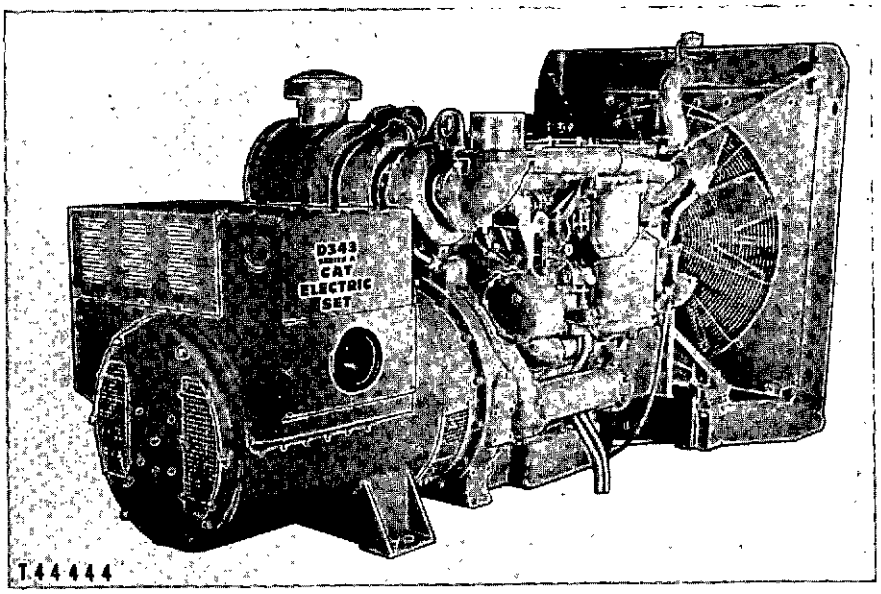
T44509

WARNING PLATE LOCATED ON THE SIDE OF THE GENERATOR EXCITER AND REGULATOR

Table of Contents



CATERPILLAR D343 ELECTRIC SET — LEFT SIDE VIEW



CATERPILLAR D343 ELECTRIC SET — RIGHT SIDE VIEW

Lubrication Instructions

GENERAL LUBRICATING INFORMATION

Detailed instructions regarding the lubrication of the generator bearing is in a following topic. The established interval for lubricating the generator is designated in service hours. Service hours are to be interpreted as those recorded on the engine Service Meter. The selection of the proper lubricant will add much to the performance, economy and long life of the generator. The lubricant recommended for the generator is described in the topic that follows. Take particular care to prevent dirt from entering the bearing when the lubricant is being applied.

BALL AND ROLLER BEARING LUBRICANT (Abbreviated BR)

(BR) This lubricant is a mixture of mineral oil and metallic soaps. Use No. 2 grade for most temperatures. For extremely low temperatures use No. 0 or No. 1 grade.

This lubricant can be applied to all bearing points — plain bearings, ball bearings and roller bearings — where equipped with hydraulic pressure fittings or when bearings are hand packed.

Use only a high grade Ball and Roller Bearing Grease of short fiber. This grease must be satisfactory in anti-friction bearings at speeds up to 3000 RPM at a maximum temperature of 300°F. It is a grease with sufficient adhesive qualities to cling to the bearings in all extremes of high and low operating temperatures.

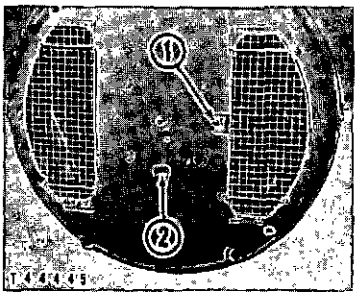
BR Ball and Roller Bearing Lubricant

GENERATOR BEARING

The generator bearing should be lubricated every 2000 service hours of operation.

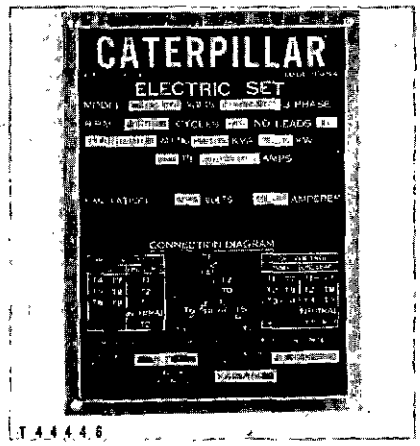
To lubricate, remove the generator rear cover, wash cover and bearing, hand pack bearing and reinstall cover.

If for some reason the bearing cannot be washed and lubricated in this manner, it may be lubricated as follows. Remove the plug (1) from the filler opening and the plug (2) from the drain opening. Install a 1/8 inch pipe thread, grease fitting in the filler opening and apply lubricant until fresh clean grease appears from the drain opening. Remove the fitting and replace the drain opening plug. Operate the generator until the temperature of the bearing has caused the grease to completely expand and run out of the filler opening. Stop the generator, install the plug in the filler opening and wipe off any excess grease.



Installation Instructions

The following information applies to Caterpillar Self-Regulated Statically-Excited generators. If additional information is necessary on Caterpillar generators after shipment from the factory, the engine serial number, the generator part number, and the generator serial number should be furnished when inquiring at your Caterpillar dealer. The part number and serial number of the generator is stamped on the generator nameplate. The generator part number and serial number is also stamped on the generator frame.



GENERATOR NAMEPLATE

◆

NOMENCLATURE

The generator serial number is composed of a group of numbers, two letters, and another group of numbers. For example, 205SS101, 204SH306, etc. This serial numbers denotes four things:

1. The first group of numbers indicate the approximate nominal KW rating of the 60 cycle generator. For a 50 cycle generator the number is usually one less than that for 60 cycle generators.

2. The letter S is the symbol for Caterpillar Self-Regulated Statically-Excited generators.

3. The next letter indicates the voltage rating of the generator as follows:

   a. L — 120-240 volts ..... 60 cycle

      K — 120-240 volts ..... 50 cycle

   b. H — 240-480 volts ..... 60 cycle or

      200-400 volts ..... 50 cycle

G — 240-480 volts ..... 50 cycle

c. S — 120/208 volts ..... 60 cycle

d. X — 600 volts ..... 60 cycle

e. N — 2400 volts ..... 60 cycle

P — 2400/4160 volts ..... 60 cycle

See the topic, CONNECTIONS, for additional information on generator voltages.

4. The last numbers are the actual serial numbers of the generator in its KW and voltage class.

GENERATOR LOADING

When a generator is installed or reconnected, it is of the utmost importance to make certain that the total current (amperes) of any one phase of the generator does not exceed the rated current capacity of the generator. The desired condition exists when each phase is loaded equally and within the generator current rating. Thus a balanced load condition exists and overheating, due to overloading, will not be encountered.

Where three-phase current only is used the load is usually balanced and the generator three-phase rating needs only to be checked against the three-phase load to be sure the load is within the capacity of the generator.

When single-phase current is taken from a generator connected for three-phase operation the phase loading will be unbalanced unless equal single-phase current is taken from each phase of the generator. The advantage of balancing a single-phase load on all three phases of a three-phase generator is that the full capacity of the generator can be utilized as well as affording protection against phase overloading.

When additional current is desired the total load and generator capacity should be checked because overloading the generator or any one phase of the generator will result in overheating, thus causing shorter generator life.

CONNECTIONS
(Shipped Connected As Ordered)

Caterpillar generators are of the three-phase, AC, single and dual voltage types. The first are described as four-wire type (208 or 2400) because in three-phase operation, their four generator lead wires cannot be readily reconnected for any other three-phase voltage; and the second are described as 10-wire dual voltage types (120-240 and 240-480) be-

cause in three-phase operation the ten generator lead wires can be connected for either one or the other (not both at the same time) of the specified voltages.

In the following instructions high voltage refers to 480 volts and low voltage refers to 240 volts in the 240-480 volt generators and correspondingly in the 120-240 volt generators.

As a safety measure, the frame of the generator should always be well grounded electrically. If the type of foundation or piping used with the electric set does not in itself provide adequate grounding, the frame of the generator should always be connected to a suitable ground, such as a convenient water pipe.

Voltage Regulator Connections

The following information gives and explains connections used to match generators properly to the load.

1. Determine the required operating voltage.
2. Connect the generator leads to give the proper nominal voltage *(high or low) for multiple voltage machines.*
3. Electric sets are shipped with the regulator connected for nameplate rated voltage. For information on regulator connections and changes in generator ratings when operated at other than nameplate rated volts, see your Caterpillar dealer.

Three-Phase Neutral Connections

Single Units

Three-Wire: The generator neutral may be grounded in a three-phase, three-wire system.

Four-Wire: In a three-phase, four-wire system, the neutral wire may be grounded at the generator, or at other places in the line depending on existing codes. If the neutral is grounded at places other than the generator, there should never be any disconnect device in the neutral line.

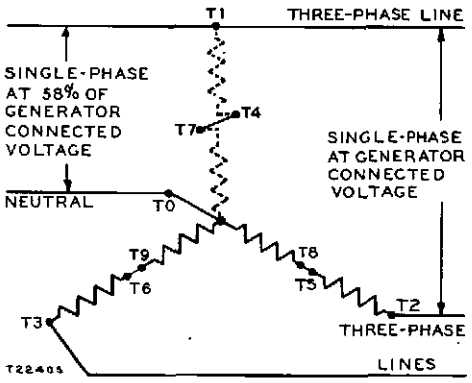
Multiple Units

In some cases operation of generators in parallel with the neutrals grounded may result in current circulating in the neutral connection. The current is not considered harmful until it approaches the nameplate ampere rating. It can be controlled by grounding the neutral of only one generator. If alternate units are to be operated individually with one neutral solidly grounded, knife switches in the neutral grounding circuits will permit selection of the generator neutral to be grounded.

Connections For Taking Single-Phase Current From A Three-Phase Connected Generator

Three-phase and single-phase current may be taken simultaneously from a generator connected for three-phase service. This is done by connecting the line leads to the generator leads for three-phase service; then

DIAGRAM OF CONNECTIONS FOR TAKING SINGLE-PHASE CURRENT FROM A THREE-PHASE GENERATOR CONNECTED FOR HIGH VOLTAGE



LINE-TO-LINE AND CORRESPONDING LINE-TO-NEUTRAL VOLTAGES

Generator	Line-To-Line Volts	Line-To-Neutral Volts
120/208	208	120
120-240	120	69
	240	139
	220	127
240-480	240	139
	220	127
	480	278
	440	254
2400	2400	1390

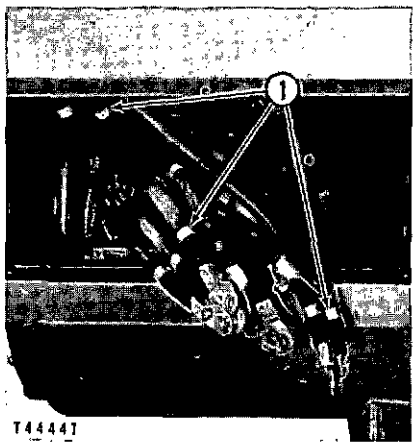
from any two of the three-phase line leads single-phase service can be obtained. Single-phase current between any one of the three-phase lines and the neutral, can also be taken from the same three-phase generator. However, different voltages will result between two three-phase lines and between one line and the neutral. See the preceding diagram and chart.

Connecting from any three-phase line lead to any other three-phase line lead will produce single-phase current at the voltage for which the generator is connected. Connecting from neutral to any three-phase line lead will produce single-phase current at approximately 58% of the voltage for which the generator is connected. In some cases transformers may

be necessary to provide the desired single-phase voltage. When single-phase loads are applied to a three-phase connected generator, they *should be balanced as closely as possible between the three-phase coils* in order to protect against phase overloading. See the topics, GENERATOR TEMPERATURE and GENERATOR LOADING.

RECONNECTION

Reconnection is simple as all generator leads have the terminals and metal bands (1), stamped with the terminal marking, in accordance with the diagram of generator coils and lead wire markings.



METAL BANDS ON GENERATOR LEAD WIRES

1–Stamped metal bands.

◆

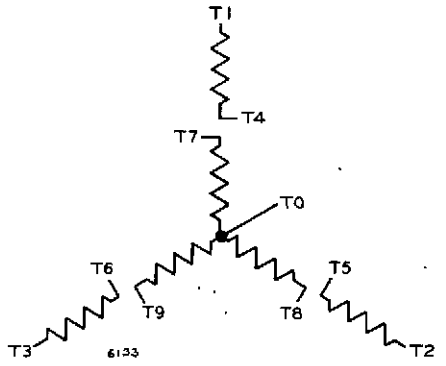
If the generator is reconnected from three-phase to single-phase or from single-phase to three-phase it is recommended that a new name plate be secured, the new rating stamped thereon and placed on the generator to indicate revised voltage, phase and capacity so only the proper electrical equipment will be used. New nameplates can be secured from your Caterpillar dealer.

The generator lead wire marked TO is always neutral in three-phase high voltage operation. In three-phase low voltage operation T4, T5, T6, and TO are connected together. This group of wires make the neutral for the generator when three-phase low voltage is desired.

If a dual voltage generator should be connected for one voltage and is to be installed in a system requiring the other voltage, the generator leads must be reconnected. For example; if a generator connected for 480 volts is to power a 240 volt system it must be connected for low voltage.

The standard system for labeling generator leads is shown in the following diagram. Note that the leads are numbered starting with T1 on the

DIAGRAM OF GENERATOR COILS AND LEAD WIRE MARKINGS



outside ends of the outer phase windings proceeding clockwise for T2 and T3. The inner ends of the outer phase windings are labeled T4, T5, and T6 again moving in a clockwise direction. The outer ends of the inner phase windings are labeled T7, T8 and T9 moving in a clockwise direction. The inner ends of the inner phase windings are joined together to form T0 or the generator neutral. This forms a ten-wire machine. In a four-wire machine there are only three-phase windings, so the outer phase windings the labeled T1, T2 and T3 moving in a clockwise direction, and the inner ends of these windings are joined to form the generator neutral T0.

Nameplates on Caterpillar generators include a table showing how generator phase leads should be connected together so the generator will deliver either low or high voltage as required. The table also shows which phase leads become the generator terminal leads to which the line leads are to be connected.

Three-Phase

To reconnect for the required three-phase voltage, follow the chart carefully. Scrape and securely bolt the terminals of the generator lead wires together with the line leads. Then the connections should be

THREE-PHASE CONNECTIONS ON THREE-PHASE GENERATOR

REQUIRED VOLTAGE	CONNECT LINE LEADS TO			NEUTRAL	CONNECT
3 Phase High Voltage	T1	T2	T3	T0	T4 to T7 T5 to T8 T6 to T9
3 Phase Low Voltage	T1 & T7	T2 & T8	T3 & T9	T4, T5, T6 & T0	T4, T5, T6 & T0 For Neutral

thoroughly insulated with a wrapping of varnished cambric or rubber composition tape, followed by a wrapping of black friction tape. As directed in the chart, securely bolt the correct terminals of the remaining generator lead wires. Insulate and tape.

Single-Phase

Single-phase operation may be obtained by reconnecting a three-phase generator for either two or three-wire output. When a three-phase generator is connected for single-phase operation, do not exceed the generator nameplate current (amperes); this will prevent the generator from being overloaded. When a three-phase generator is connected for single-phase operation it cannot be expected to produce more than 58% of its three-phase KVA and KW ratings.

The three-phase 240-480 dual voltage generators can be reconnected for single-phase 240 or 480 volt two-wire service, or single-phase 240/480 volt three-wire service. Also the 120-240 dual voltage generators can be reconnected for single-phase 120 or 240 volt two-wire service, or single-phase 120/240 volt three-wire service. Note that the nomenclature for the three-wire connection is 120/240 volts or 240/480 volts since both voltages can be obtained simultaneously without reconnecting the generator. The low voltage is the line-to-electrical neutral value and the high voltage is the line-to-line value of this connection. The neutral of a single-phase three-wire generator is *the electrical midpoint between T9 and T2. It is not* the generator neutral T0.

Nameplates on Caterpillar single-phase generators contain a table showing how generator phase leads should be connected together so the generator will deliver either low or high voltage or three-wire dual voltage. The table also shows which phase leads become the generator terminal leads to which the line leads are connected.

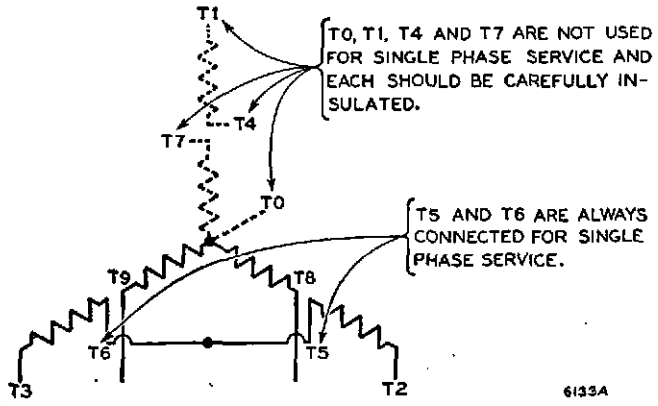


DIAGRAM OF GENERATOR COILS AND LEAD WIRE MARKINGS
(Single-Phase Connections Shown)

SINGLE-PHASE CONNECTIONS FOR THREE-PHASE GENERATORS

REQUIRED VOLTAGE	CONNECT LINE LEADS TO			CONNECT	TAPE INDIVIDUALLY
Single-Phase 2 Wire Low Voltage	T2 & T8		T3 & T9	T5 & T6	T1 T4 T7 T0
Single-Phase 3 Wire Low/High Voltage	T3	T2 & T9 Neutral	T8	T5 & T6	T1 T4 T7 T0
Single-Phase 2 Wire High Voltage	T3		T8	T2 & T9 T5 & T6	T1 T4 T7 T0

To reconnect for the required single-phase voltage, follow the chart carefully. Scrape and securely bolt the terminals of the generator lead wires together with the line leads. Then the connections and line leads should be thoroughly insulated with a wrapping of varnished cambric or rubber composition tape, followed by a wrapping of black friction tape.

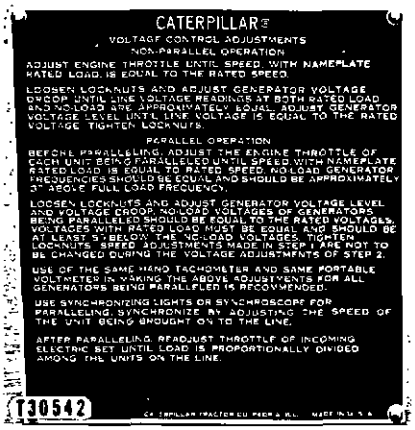
Insulate the terminals to be taped individually and wrap them with black friction tape. As described in the chart, securely bolt together the correct combinations of terminals of the remaining generator lead wires. Insulate and tape them.

VOLTAGE SETTING

Generators will be set for standard nameplate voltages and for single unit operation when leaving the factory unless otherwise specificed. The adjustments may have to be changed for particular applications such as parallel operation or operation at special voltages. If adjustments are necessary see the topics, SINGLE UNIT OPERATION or PARALLEL UNIT

VOLTAGE SETTING INSTRUCTION PLATE

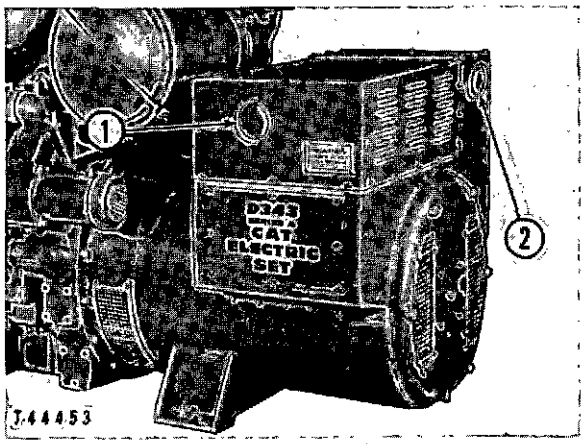
◆



OPERATION and if operation at a special voltage is required, see your Caterpillar dealer.

When a Self-Regulated Statically-Excited generator is to be paralleled with "N" or "K" series or Self-Regulated Constant Voltage generators the voltage level and voltage droop controls of the Self-Regulated Statically-Excited generator must be adjusted so that open circuit and full load voltages of the Self-Regulated Statically-Excited generator match those of the other generators. See Steps 5 and 6 under the topic, OPEN CIRCUIT AND FULL LOAD VOLTAGE ADJUSTMENT.

The voltage controls, voltage level and voltage droop, are located behind cover **(1)** at the side and cover **(2)** at the rear of the regulator housing respectively. Adjustment of these controls for parallel operation is covered under the topic, OPEN CIRCUIT AND FULL LOAD VOLTAGE ADJUSTMENT.



VOLTAGE SETTING CONTROL COVERS
1–Voltage level control cover. 2–Voltage droop control cover.

FINAL INSTALLATION ADJUSTMENTS

Adjustments outlined in this topic are for single and multiple unit operation and are required when any one or any combination of the following exist.

1. To complete an initial installation after recommended procedures in the preceding topics have been followed.
2. When the unit or units have been reconnected.
3. When the unit or units have been relocated.
4. Whenever, during operation, periodic observation of the electrical measuring instruments indicate that operating conditions have changed to the extent that adjustments are required.

When the units are to be operated in parallel these adjustments are made to give two or more units in the system the same voltage, voltage droop and speed (frequency) characteristics. Adjustments are made by

the use of the engine governor control, governor control stops, generator regulator controls and checked by use of the switchgear meters.

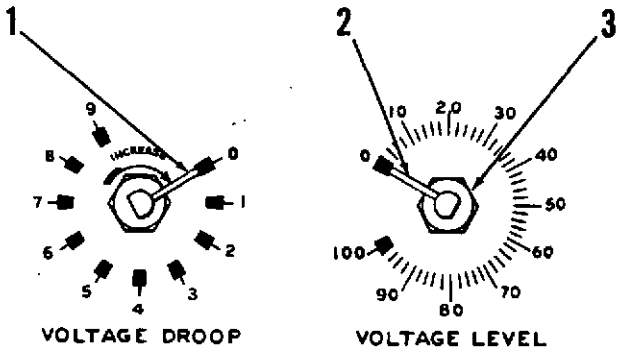
No special tools or instrument are required once the final installation adjustments are made. However, a voltmeter, ammeter and tachometer are necessary items in making these adjustments. Such switchgear items as wattmeters, field ammeters, power factor meters and varmeters are quite useful, but the decision to include them in original equipment is a matter of individual choice.

SINGLE UNIT OPERATION

Operation of a single unit, when a single unit installation is made, is covered in this topic. When a unit in a multiple unit installation is to be operated individually, no changes should be made to the adjustments required for parallel operation. See the topic, PARALLEL UNIT OPERATION.

Starting: To make the necessary adjustments for single unit installation, adjust the unit as given in the following steps:

1. Remove the covers from the voltage level and the voltage droop controls.
2. Start the engine as described in the OPERATION AND MAINTENANCE INSTRUCTIONS for the engine.
3. Run the engine at full governed speed.
4. Set the voltage droop control **(1)** on ZERO. Loosen the locknut **(3)** and set the voltage level control **(2)** to give the required open circuit voltage.



VOLTAGE SETTING CONTROLS

1–Voltage droop control. 2–Voltage level control. 3–Locknut.

5. Install the voltage level and voltage droop control covers on the regulator housing.

The unit is now properly adjusted for single unit operation.

Stopping: Stop the electric set as given in the following steps.

1. Remove as many indivdual loads as possible before removing the generator from the line to reduce arcing and damage to the line switch or circuit breaker.

2. Open the circuit breaker or the line switch to disconnect the generator from the line.
3. Move the governor control lever to the half engine speed position. See the topic, STOPPING THE DIESEL ENGINE, in the OPERATION AND MAINTENANCE INSTRUCTIONS book for the engine.

PARALLEL UNIT OPERATION

When connecting electric sets in parallel, in an initial installation, or when reconnecting generators that have been disconnected for any reason, the information in this section should be followed carefully and accurately. If the units have been properly paralleled previously and operated successfully then the operator will be concerned only with the topic, MULTIPLE UNIT OPERATION.

Starting: Start the engines as described in the OPERATION AND MAINTENANCE INSTRUCTIONS for the engines.

Adjusting: Preliminary checks are necessary to give each incoming unit the same operating characteristics as the units on the line. The results of these adjustments will generally reflect the care with which they are made, as well as the operating condition of the equipment itself. Some variation in the division of watts and amperes should be expected as the system load changes. The intent of these adjustments is to make the electric sets operate together without serious reduction of their combined output capacities.

1. Check phase rotation. Make proper phase connections.
2. Check open circuit and full load engine speed or frequency adjustment. Use the governor control lever for adjustments.
3. Check no load and full load voltages.

Phase Rotation

The phase rotation (sequence of rotation of the phases) of the generators to be paralleled must be the same. To determine whether the units have like phase rotation synchronizing lights can be used.

Connect the three-phase terminals of the line to the line side of the generator circuit breakers.

It is good practice to connect corresponding lines to corresponding terminals of the circuit breakers. The three terminals of the generators should be connected to the trip element sides of the circuit breakers with phase two of each generator connected to corresponding terminals of the circuit breakers. Phase rotation can then be matched as described below.

1. Connect lamp bulbs across the open circuit breaker contacts from the generator side to the line side. Either a set of three lamps, one across each pole of the circuit breaker, or a set of two lamps with one connected across each of the outside sections of the circuit breaker, may be used. Each lamp must have a voltage rating of twice the value of

the generator line voltage. If lamps of this rating cannot be obtained, several lamps in series, dropping resistors, or step down transformers must be used.

2. Adjust the engine speed until the frequency of the unit to be paralleled approaches the line frequency and adjust the voltage to the same value as the line voltage. The lamps will start blinking.
   a. If they blink in unison, the phase rotation of the unit to be paralleled is the same as the phase rotation of the line.
   b. If the lamps blink in sequence it indicates that the phase rotation of one of the power sources is backward with respect to the other. To correct this, disconnect phase leads 1 and 3 from the generator side of one circuit breaker and reverse them. For example, if the generator terminal leads were connected 1-2-3 starting from the

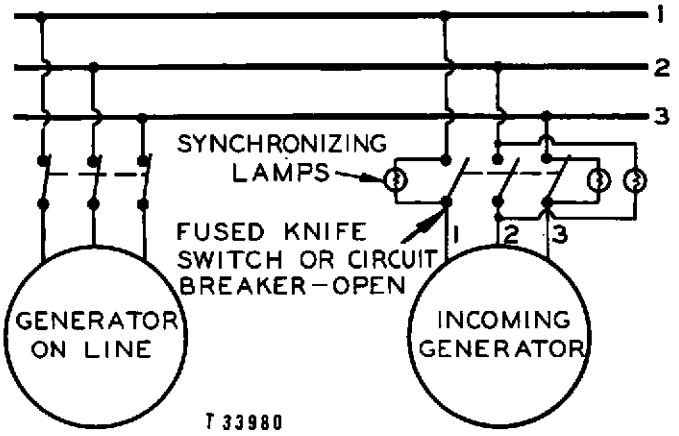


ILLUSTRATION I
DIAGRAM SHOWING LAMP CONNECTIONS ACROSS CIRCUIT BREAKER POLES TO CHECK PHASE ROTATION

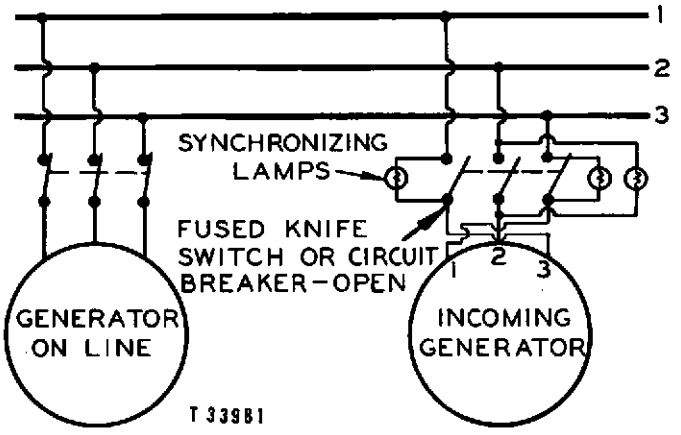


ILLUSTRATION II
DIAGRAM SHOWING LAMP CONNECTIONS ACROSS CIRCUIT BREAKER POLES TO CHECK PHASE ROTATION

left, see illustration I, reversing 1 and 3 so they will read 3-2-1, see illustration II, will reverse the phase rotation of the generator with respect to its previous connection. When the frequency and voltage are again adjusted near the line values the lamps will blink on and off in unison, indicating like phase rotation.

WARNING

Full line voltage is present at the circuit breaker or knife switch. Therefore, if temporary synchronizing lamps without switches are used, extreme caution should be observed when connecting temporary synchronizing lamps across the circuit breaker or knife switch.

Open Circuit And Full Load Speed Or Frequency Adjustment

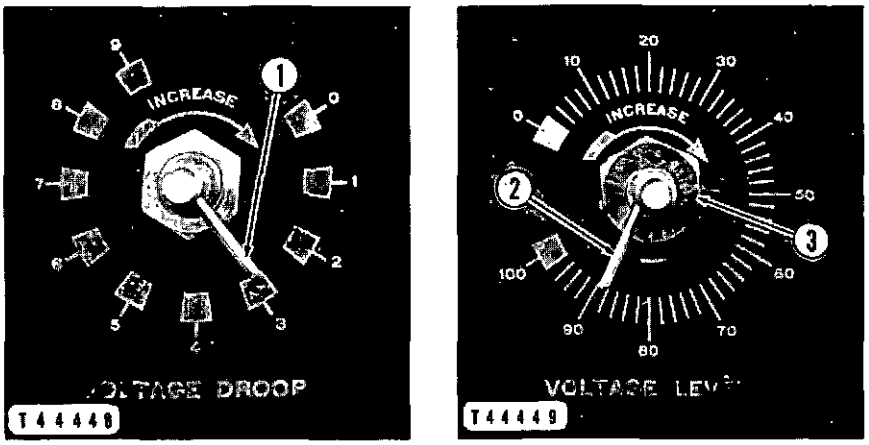
Governor adjustment should be made with care to obtain proportional load division. Proportional division of KW load in parallel operation requires carefully matched governor characteristics.

1. Allow each electric set to run one hour with some load to reach operating temperatures before making adjustments.
2. Adjust the governor control to give rated frequency or nameplate rated generator speed at full rated KW load.
3. Remove the load and determine the no load frequency or speed. No load frequency should be at least 3% above rated and should be equal within plus or minus ½% for two or three units or plus or minus ⅓% for more than three units. If these frequency tolerances cannot be obtained by use of the governor controls see your Caterpillar Dealer. If full load is not available for this test then the speed droop should be the same fraction of 3% as the load applied is of full load.
4. Repeat Steps 2 and 3 several times to be sure that the readings will repeat themselves. Note full and no load speeds.

Open Circuit And Full Load Voltage Adjustment

The following voltage adjustment procedure for parallel operation of self-regulated constant-voltage and statically excited generators gives the settings for the generators. Adjustments should be made to give a voltage droop of 5 to 8% with unity power factor loads (lighting) or 8 to 10% with 0.8 power factor loads (motor) when full load is applied. Voltage droop of 10 to 15% at unity of .8 power factor will be required when paralleling with a saturated field self-regulated generator of the "N" or "K" series.

1. Remove the covers from the voltage level, the voltage droop controls and loosen the voltage level control locknut **(3)**.



VOLTAGE SETTING CONTROLS
1–Voltage droop control. 2–Voltage level control. 3–Locknut.

2. Move the voltage droop control **(1)** to 3.

3. Move the voltage level control **(2)** to obtain the desired open circuit voltage. If full load is not available for this test then the voltage droop should be the same fraction of 5 to 8% as the load applied is of full load.

4. Apply and remove load and record the open circuit and full load voltages and speeds.

5. Repeat Steps 2, 3 and 4 at other control settings until the required voltage droop values are obtained.

Each time the voltage droop setting is changed the generator voltage will change slightly so the voltage level control setting will require adjustment to obtain the desired voltage. The steps will probably have to be repeated several times before a satisfactory voltage droop and voltage level setting are obtained.

6. Lock the voltage level control in position by tightening the locknut **(3)**. If the required voltage droop valve occurs at several settings, use the highest setting toward 9.

7. Follow the above procedure for each unit that is to be paralleled.

8. Install the voltage level and voltage droop control covers on the regulator housing.

The units are now properly adjusted for parallel operation.

Operation Instructions

The foregoing topics have been devoted to installation and final adjustments which are permanent in nature. The following topics give instructions for the adjustments and manipulation of controls necessary for day-to-day operation.

Caterpillar Electric Sets may supply power as individual units or when connected in parallel with other self-regulated sets or externally-regulated sets. A thorough knowledge of the controls, instruments, and their operation is essential to obtain maximum performance. During operation, continuous observation should be the operator's responsibility. By doing so, or by use of safety devices which are available as attachments, extensive damage of the electric set may be avoided if unusual operation conditions occur.

OPERATING ELECTRIC SETS

After initial installation or after changes have been made to the system, instructions in the topic INSTALLATION ADJUSTMENT should be followed before beginning the day-to-day operation of the electric set covered in this topic.

Single Unit Operation

Starting: When starting the diesel engine care should be taken to see that the line switch is open.

Start the engines as described in the OPERATION AND MAINTENANCE INSTRUCTIONS for the engines.

When the diesel engine is warm and is running at full speed, close the line switch and apply the load.

Stopping: Stop the electric set as given in the following steps:

1. Remove some individual loads, before removing the generator from the line to reduce arcing and damage to the line switch.
2. Open the line switch to disconnect the generator from the line.
3. Move the governor control lever to the half engine speed position. See the topic, STOPPING THE DIESEL ENGINE, in the OPERATION AND MAINTENANCE INSTRUCTIONS for the engine.

Multiple Unit Operation

Starting: When starting the diesel engine care should be taken to see that the line switch is open.

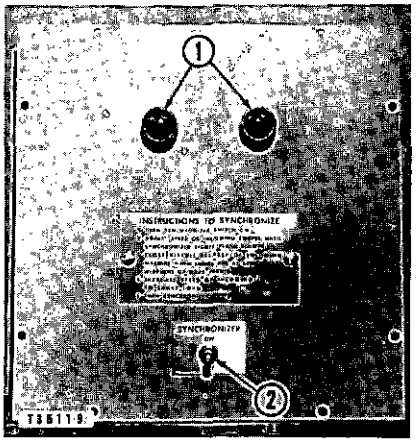
Start the engines as described in the OPERATION AND MAINTENANCE INSTRUCTIONS for the engines.

Paralleling: To parallel one electric set with another with a minimum of disturbance, the frequency of the incoming unit should be the same as the unit or units already operating, and the voltages should be equal and in phase at the instant the line switch is closed. If there is a difference between the frequencies or voltages of the generators being paralleled, there will be an undesirable disturbance of the line voltage.

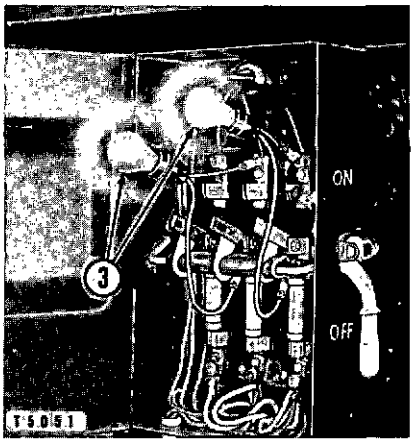
CAUTION

Extensive damage to the electric set may result if generators are paralleled while the voltages are out of phase. Always use synchronizing lamps or a synchroscope and exercise care in the paralleling operation.

By use of synchronizing lamps **(1)** or **(3)** as shown, an idle unit can be put in service with no disturbance. To synchronize an idle unit, proceed according to the following instructions.



SYNCHRONIZER CABINET
1–Synchronizing lamps. 2–Synchronizing lamps switch.



TEMPORARY SYNCHRONIZING LAMPS
3–Lamps fastened across switch to check synchronism if the synchronizer cabinet is not available.

With the idle unit governor control lever in the full governed speed position, turn on the synchronizing lamps switch **(2)**, observe the lamps for the frequency with which they flash ON or OFF. By means of the governor control vary the incoming engine speed until the synchronizing lamps come on and fade out very slowly; about ten times a minute or less. Always have the incoming engine initially slightly higher in speed. Then reduce its speed slowly. Doing this will assure that the incoming engine will absorb a small amount of load instead of consuming power from the system.

To put the electric set on the line at the proper time, wait until the lamps are dark; then very quickly, while the lamps are still dark, close the line switch. The incoming generator is now in parallel with the line. Turn off the synchronizing lamps.

Loading: After the unit is paralleled, but carrying very little or no load, one of the following two conditions will exist.

a. First condition — when the unit on the line was at no load. In this condition both units are in parallel at high idle and are ready to receive the load.

   Note that if the units are cold, any ammeter indications show circulating current which may disappear when the units are warmed up. If, after the units are warm the ammeter indications are greater than 25% of the generator rated amperes, readjust the unit as instructed in the topic, FINAL INSTALLATION ADJUSTMENTS.
   The load can now be added.

b. Second condition — when the unit on the line is carrying load. In this event both the governor and the voltage regulator of this unit were operating some place on their droop characteristics below high idle and open circuit voltage points. The incoming governor in this condition was not advanced to high idle speed setting at the time of paralleling. The incoming generator voltage will be slightly below the hi-idle open circuit value. After paralleling, the governor control on the incoming unit should be advanced to the full governed speed position. This causes the incoming unit to pick up its proportional share of the kilowatt loading. If kilowatt meters are installed the readings will be proportional to the ratings of the units paralleled. The regulator of the incoming unit will control the incoming generator so that it will deliver its share of the load amperes.

   Note that units in parallel at operating temperature may have some current unbalance. This current unbalance can range from 10% at full load to 25% at no load of nameplate current rating. Additional load can now be added.

Stopping: Remove an electric set from the line as given in the following steps:

1. Before removing a generator from the line, check that the load is equal to or less than the rated capacity of the units to remain on the line.

2. See that the neutral of one of the generators remaining on the line is satisfactorily grounded.

3. Slowly reduce the speed setting by moving the governor control enough to remove the load from the generator. If the line switch is

opened when a heavy load is on the line, arcing and possible burning of the line switch may result. Circuit breakers are generally designed so they can safely be opened while carrying a current up to ampere rating of the circuit breaker.

4. Open the line switch.

5. After the line switch is open, move the governor control lever to the half engine speed position. See the topic, STOPPING THE ENGINE in the OPERATION AND MAINTENANCE INSTRUCTIONS.

GENERATOR TEMPERATURE

The measurement of the actual temperature of a generator in operation is a laboratory project. The temperature is normally high enough to be uncomfortable to the touch of the hand. However, generator overheating can be controlled by observing the following rule.

The maximum surrounding air temperature should not exceed 104° F. (40° C.). If the air temperature entering the generator exceeds 104° F. (40° C.) while the generator is operating at rated full load, either the load must be reduced or the room temperature reduced or both to prevent reduction of service life of the generator coils.

CAUTION

The generator should not be operated with a continued excessive overload, improperly connected loads or improper type of loads which will cause overheating. In no case should the generator be allowed to produce sustained current above that indicated on the generator nameplate.

GENERATOR STORAGE

If the generator is to be stored or out of operation for any length of time it should be thoroughly covered to prevent dirt or moisture collecting on the generator parts. Any accumulation of dust or moisture during storage periods may reduce insulation efficiency and cause arcing and rapid brush wear. Therefore store the generator in a clean dry place and before starting after storage, wipe the collector rings with a cloth dampened with carbon tetrachloride.

Where condensation from moisture will prevail, a light coating of petroleum jelly on the collector rings will protect against corrosion. This coating will greatly reduce corrosion where salt air and acid fumes are present.

During long storage periods in certain atmospheric conditions it is impossible to provide storage conditions which will prevent condensation. When these conditions exist the generator should be gradually

dried when putting the generator into service by slowly heating it to prevent damage to the insulation. This can be done by one of the following methods:

1. Place the generator in an oven and bake at a temperature not exceeding 185° F. (85° C.) for at least four hours. (Preferred method.)
2. Enclose the generator with canvas or other covering and insert heating units or lamps to raise the temperature. Leave a hole in the top of the enclosure for the moisture to escape.
3. Pass a current at low voltage through the field windings with the generator at rest to raise the temperature of the field windings gradually to 185° F. (85° C.).

However, there is a possibility that the insulation has deteriorated to the extent that its resistance has been reduced to a dangerously low value. If this condition is suspected see your Caterpillar dealer.

Maintenance Instructions

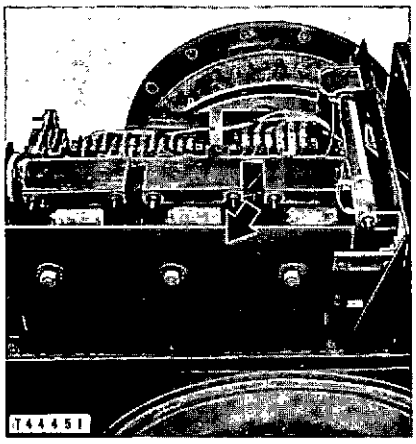
The previous topics have been instructions pertaining to operating the electric set. The following topics give detailed information regarding the care and various adjustments of the generator.

GENERATOR EXCITER AND REGULATOR

The generator exciter and regulator are so constructed that there are no moving parts, therefore, no periodic maintenance is required. If malfunctions do occur, as for example, loose wire connections, loose component mounting screws or burned out wires or insulation, the engine must be stopped before removing the cover from the exciter and regulator components.

WARNING

When the engine is running, the aluminum rectifier plate is electrically charged. When the cover is removed, an electrical shock and serious injury may result from personal contact with the aluminum rectifier plate. The rectifiers may be damaged if a metal connection is accidentally made between the aluminum rectifier plate and the generator frame.



ALUMINUM RECTIFIER PLATE

(200 KW set, exciter and regulator cover removed.)

◆

WINDINGS

Generators are often located where dust accumulates on windings and in ventilating ducts. Oily vapor and paper or textile dusts build up and block ventilation, thus leading to overheating of the generator. Dusts from conductor type metals shorten creepage distances and penetrate windings causing short circuits and grounds. Hard, sharp, abrasive dusts wear insulation, and shorten its life as they are driven past exposed surfaces by ventilation air. Cast-iron dust is agitated by magnetic fields and can very easily cause short circuits over insulation. When removing

dusts from the generator windings, brushes, and all other internal parts, suction should be the method of removing them. Very low air pressure may be used to remove light harmless dusts if a convenient means of sucking out the dust is not available. Hose tips for either pressure or suction should not be of metal.

Grease and oil can be removed by the conservative use of carbon tetrachloride, which is non-inflammable and evaporates quickly. Never use gasoline to clean generator parts. After cleaning, dirt can be sucked or blown out. This process must be repeated until grease, oil and dirt are removed. Avoid excessive applications of cleaning solution as it will soak into inaccessible places, where it may soften and harm insulation. Good ventilation is essential where a large quantity of carbon tetrachloride is used because its vapor has disagreeable toxic effects.

It is good maintenance practice to check the rotor coils for looseness periodically. As a general rule, overheating of the generator is responsible and in these cases the generator load should be either reduced or more adequate ventilation provided. Continued operation with loose rotor coils may result in damage to the generator windings. See your Caterpillar dealer.

COLLECTOR RING CARE

Collector rings are usually bronze, endless rings, fastened at the rear of the rotor spider concentric with the rotor assembly shaft.

Under normal operation the collector rings need no particular attention but weekly precautions should be taken to prevent enforced shut downs due to unexpected failures. During these weekly checks it should be noted that the brushes are contacting properly. If the load on the generator is not excessive and arcing of the brushes is noticed, the brushes should be adjusted or the collector rings cleaned, or both, to eliminate the arcing.

To clean the collector rings wipe them with a piece of lint free cloth (canvas is a good material for this) fastened to a wooden stick. If a dry cloth does not satisfactorily remove the dirt apply carbon tetrachloride to the cloth and clean the rings again. If it is found that the rings are rough, pitted, worn or eccentric they can be machined in a lathe or on the machine using a portable tool after which they should be dressed and polished with "0000" sandpaper to obtain a smooth, bright brush bearing surface. If this needs to be done see your Caterpillar dealer.

The collector rings, under certain atmospheric conditions, become discolored. This is not always undesirable because normal collector ring coloring may vary from copper to straw, chocolate to black and should be left on the collector rings. The undesirable colors of green, blue or spotted blotches are caused by chlorine vapor, sulphuric fumes and oils respectively which should be eliminated for satisfactory performance.

GENERATOR BRUSHES

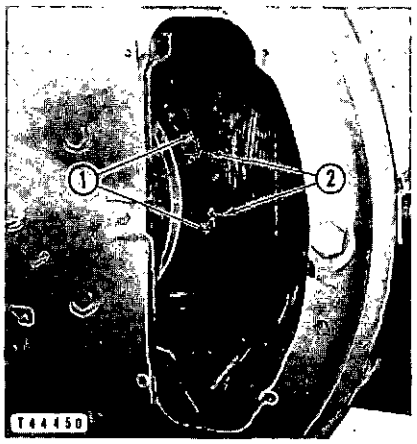
Correct brush contact is important to assure satisfactory generator performance and brush life. The following conditions contribute to correct brush contact: 1 — The collector rings should be clean, polished smooth and concentric with the shaft. 2 — The brushes should be free to move in the holders. 3 — Correct brush pressure should be maintained. See the topic, BRUSH SPRING TENSION ADJUSTMENT.

A brush which is contacting properly during operation may show a line of pin point sparks at the trailing edge of the brush contact surface, or none at all, between the collector rings and brushes. Excessive sparking indicates poor contact which can usually be corrected by making a systematic check and necessary adjustments.

1. The generator load should be within the rated capacity of the generator.
2. Replace short brushes, fit poorly seating brushes to the collector rings and see that the brushes move freely in the holders.
3. Check to see that there is sufficient spring tension and that there are no broken brush springs.
4. Clean the collector rings if they are rough or dirty.

Brush Spring Tension Adjustment: The spring tension on brushes contacting the generator collector rings is gradually reduced as the brushes wear and should be adjusted to eliminate excessive arcing of the brushes. Extreme spring tension shortens the life of brushes, therefore, care should be taken when adjusting the spring tension to assure correct contact without excessive spring tension. See the brush spring tension chart.

To adjust the spring tension, lift the spring end **(2)** from the notched plate, move the spring end against the tension and insert it in the next notch **(1)**.



BRUSH TENSION ADJUSTMENT
1–Notch in plate. 2–Spring end.

◆

These spring tensions have been calculated on the basis that 1½ pounds pressure per square inch are required for generator brushes.

BRUSH SPRING TENSION CHART

Brush Size	*Spring Tension*
⅝ x 5/16	5 Ounces
1⅛ x ½	14 Ounces

To install new brushes care must be used in fitting them to the collector rings to insure a maximum of brush contact surface. After each new brush is installed place a piece of "00" sandpaper between the brush and the collector ring with the abrasive surface next to the brush. Slowly *pull the sandpaper from under the brush so that the brush will fit the* collector ring surface and form a good contact. After the brushes have been seated, remove all abrasive and conductive dusts.

The standard brushes supplied with Caterpillar Electric Set generators are designed to give satisfactory service under most conditions. In some cases different brushes may be necessary. Consult your Caterpillar dealer if brush life is unsatisfactory.

Index

CATERPILLAR

Diesel Engines - - - - Tractors - - - - Motor Graders
- - - - - - Earthmoving Equipment - - - - - - -

THERE IS A CATERPILLAR DEALER NEAR YOU

FORM 34072

PRINTED IN U.S.A.