



Technical Manual

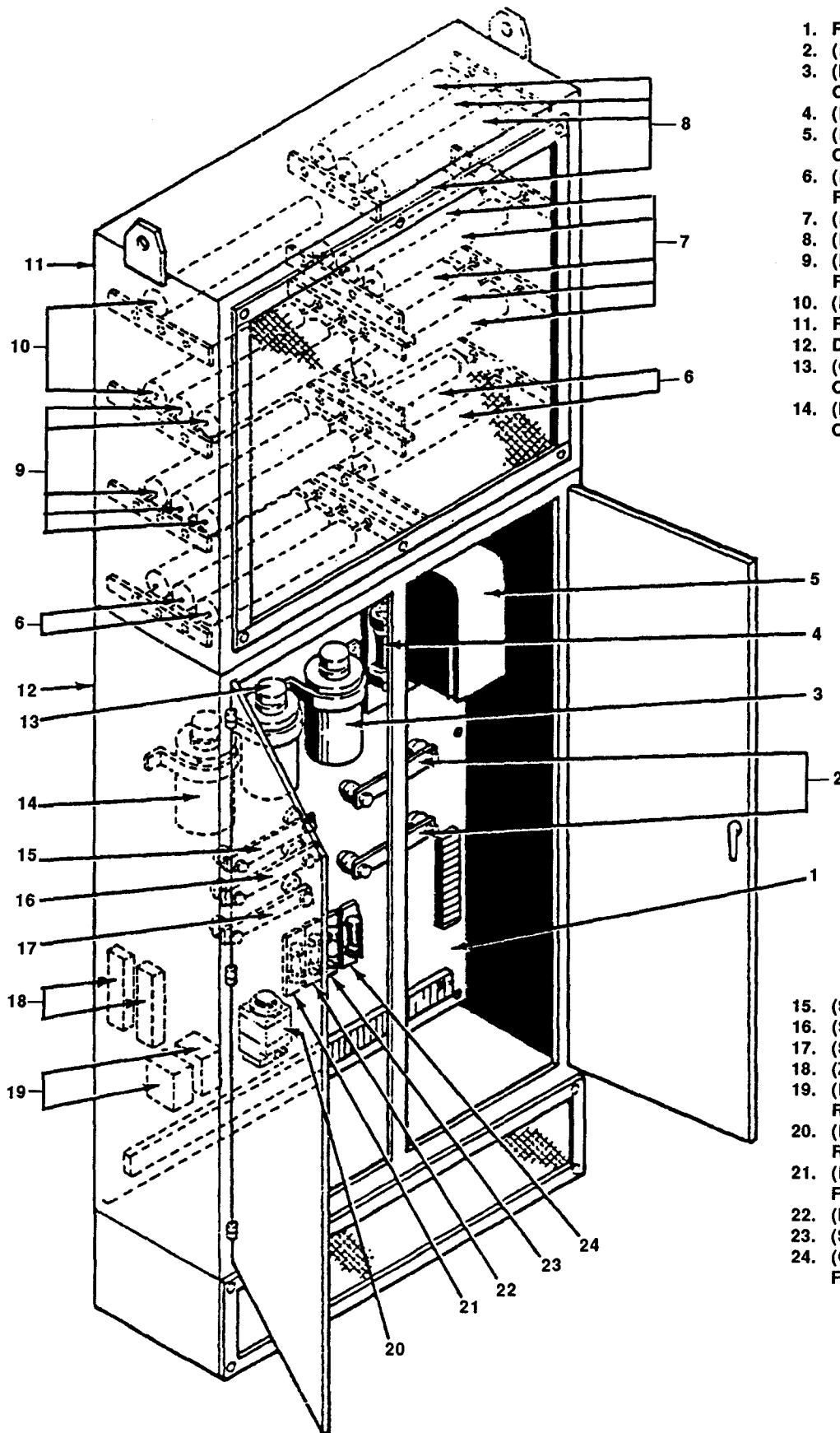
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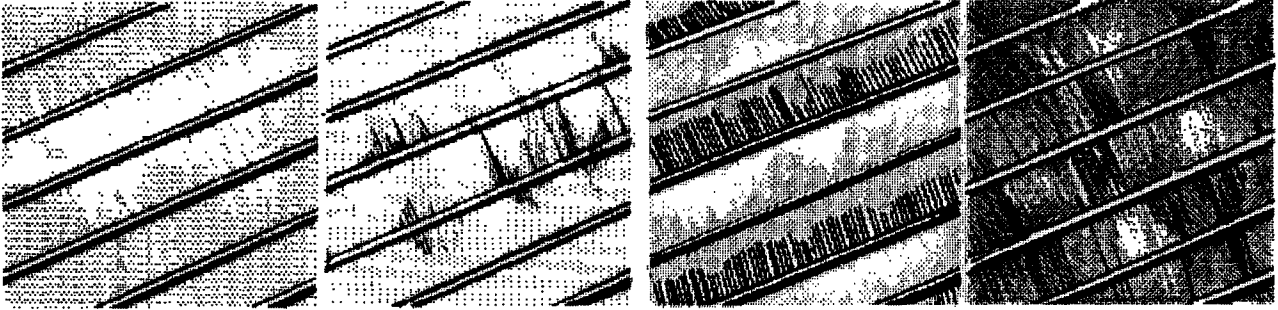
- 1. FIXED PANEL
- 2. (BUS) BUS BAR
- 3. (PMC) PROPER MOTOR CONTACTOR
- 4. (DTF) DIPPER TRIP FUSE
- 5. (DTC) DIPPER TRIP CONTACTOR
- 6. (RE15) DIPPER TRIP RESISTORS
- 7. (RE3) SWING RESISTORS
- 8. (RE4) CROWD RESISTORS
- 9. (RE2) HOIST MOTOR FIELD RESISTORS
- 10. (RE1) EXCITER RESISTORS
- 11. RESISTOR CABINET
- 12. DC CONTROL CABINET
- 13. (CMC) CROWD MOTOR FIELD CONTACTOR
- 14. (HMC) HOIST MOTOR FIELD CONTACTOR

- 15. (SHC) CROWD SHUNT
- 16. (SHS) SWING SHUNT
- 17. (SHH) HOIST SHUNT
- 18. (ZDCH) CABINET HEATER
- 19. (EXR) EMERGENCY TRIP RELAY
- 20. (DTTR) DIPPER TRIP TIMING RELAY
- 21. (EMF) EMERGENCY TRIP FUSE
- 22. (HF) HOIST CONTROL FUSE
- 23. (SF) SWING CONTROL FUSE
- 24. (CF) CROWD CONTROL FUSE

DC CONTROL CABINET
 FIGURE 1-1-4

COMMUTATOR CHECK CHART FOR COMPARING COMMUTATOR SURFACE MARKINGS

SATISFACTORY COMMUTATOR SURFACES



LIGHT TAN FILM over entire commutator surface is one of many normal operating conditions often seen on a well-functioning machine.

MOTTLED SURFACE with random fill pattern is probably most frequently observed condition of commutators in industry.

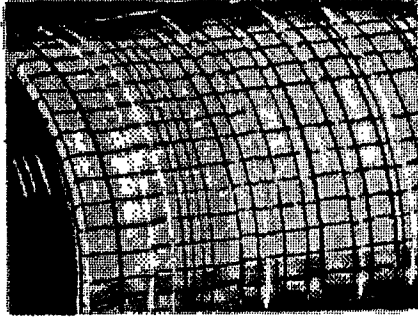
SLOT BAR-MARKING, a slightly darker film appears on bars in a definite pattern related to number of conductors per slot.

HEAVY FILM can appear over entire area of efficient and normal commutator and, if uniform, is quite acceptable.

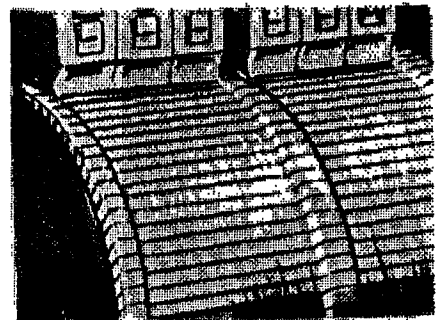
WATCH FOR THESE DANGER SIGNS



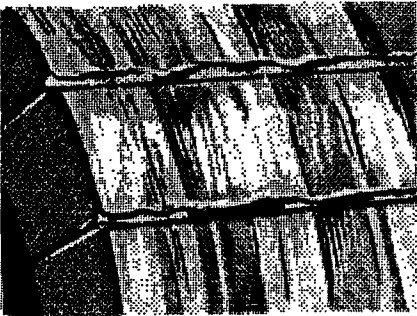
STREAKING on the commutator surface signals the beginning of serious metal transfer to the carbon brush.



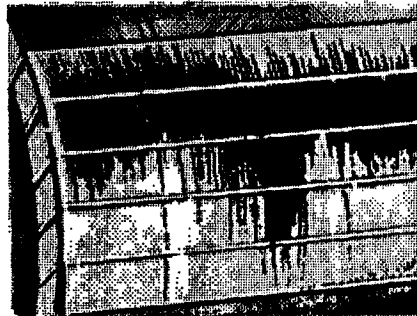
THREADED of commutator with fine lines results when excessive metal transfer occurs. It usually leads to re-surfacing of commutator and rapid brush wear.



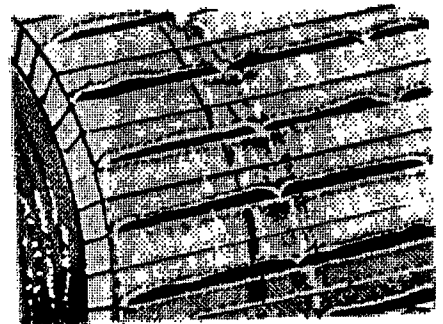
GROOVING is a mechanical condition caused by abrasive material in the brush or atmosphere. If grooves form, start corrective action.



COPPER DRAG, an abnormal build-up of commutator material, forms most often at trailing edge of bar. Condition is rare but can cause flashover if not checked.



PITCH BAR-MARKING produces low or burned spots on the commutator surface. The number of these markings equals half of all the number of poles on the motor.



HEAVY SLOT BAR-MARKING can involve etching of trailing edge of commutator bar. Pattern is related to number of conductors per slot.

FIGURE 1-2-4

Mounting Couplings on Shaft

The location of a coupling on the shaft will determine the load carrying ability of the assembly. The location will vary with different coupling designs depending on hub wall thickness. Because of this variation, locate the couplings as recommended by the manufacturer.

Mounting Pinion on Shaft

WARNING: Successful operation of the gearing largely depends on the proper mounting of the pinion on the armature shaft. Mounting pinions by heating them in boiling water and driving them on the shaft with a blow from a heavy sledge hammer is not recommended because it resulted in uncontrolled advance of the pinion of the shaft. Too great an advance can cause breakage of the pinion core. While insufficient advance can cause pinion slippage and wear in spite of the presence of the key. In addition, hammer blows can injure the finished surface of the anti-friction bearings.

Pinions must be mounted to a definite advance on the shaft, without hammer blows. This requires heating the pinion to a higher temperature than is obtainable with boiling water, and is based on a difference in temperature between the pinion and shaft. Following is the recommended method for mounting pinions:

1. Thoroughly clean the pinion seating surface on the shaft and the bore of the pinion, using toluol or percholoethylene; do not use kerosene.

! CAUTION: Solvents may be toxic or flammable. Adequate ventilation must be provided to minimize fire and health hazards caused by using solvents for cleaning. Use away from sparks, heat and flame to prevent fire or explosion.

Remove any scoring from either part. Spot the cold pinion on the shaft by hand to obtain at least a 75 percent fit. Check the fit with bluing. Remove the pinion.

2. Break all sharp edges of the key and the keyway with a fine file, so there will be a radius of about 1/64th inch at each edge. Fit the key to the shaft, taking care to avoid upsetting the metal of the shaft adjacent to the key. If previously upset, file lightly, check the fit with bluing until a 75 percent fit results. Try the pinion on the shaft to make certain it does not bind on the key.

3. Mount the pinion cold by placing it on the shaft and snapping it into position by hand. Measure the "cold" position of the pinion, using a micrometer depth gauge. Figure 1-2-10 illustrates the method of using the depth gauge. Mark the places where the depth gauge was resting so measurements can be made from the same position after the pinion has been mounted.

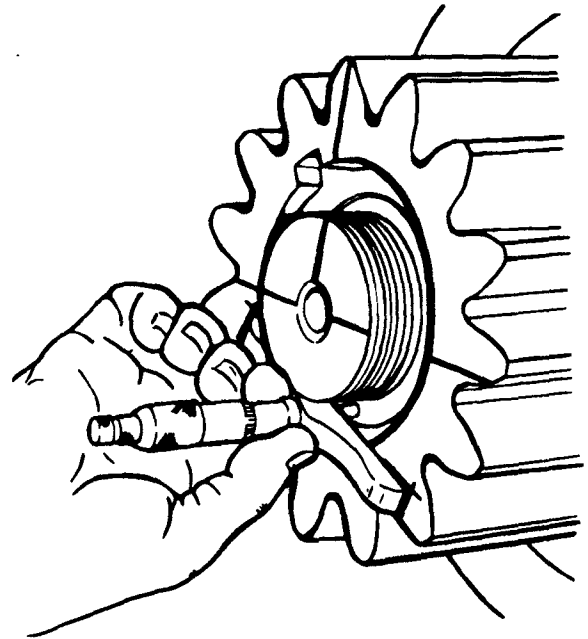


FIGURE 1-2-10

4. Remove the pinion from the shaft and heat it in a suitable oven to the temperature specified by the motor manufacturer. If the pinion is heated in oil, the bore must be thoroughly cleaned before mounting; to avoid this complication, the use of an oven is recommended.

The pinion temperature is indicated as a temperature difference between the shaft and pinion; this temperature difference is estimated only and can be adjusted to maintain the specified advance. Heat the pinion in the oven until the temperature is uniform at the required number of degrees above the shaft temperature. For example, if the shaft temperature is 25°C (77°F) and the estimated difference is 125°C (225°F), heat the pinion to 150°C (320°F) for mounting.

! CAUTION: Pinion temperature must never exceed 190°C.

Some accurate method must be provided for measuring the pinion and shaft tempera-

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specific circuit, loosen the adjusting screw and slide it up or down to open or close the contact sooner or later as desired.

The markings on the vernier plate represent 2° increments of adjustment. The adjustment affects the opening and closing of the contact unit by the same amount. If incremental adjustment is required for either opening or closing positions, the closing position must be set on another cam and the two contact units electrically tied together. After settings are established, firmly tighten the adjusting screw.

To re-position the hoist limit switch:

1. Position the dipper so the padlocks are within six inches of the boom point sheaves and set the hoist brake.
2. Loosen the locknut on the drum shaft and of the flexible cable.
3. Turn the adapter clockwise to increase the padlock to sheave clearance. Turn the adapter counterclockwise to decrease clearance.
4. It should not be necessary to adjust the lower mode as it will be correct if the original cam setting was not altered.

CROWD LIMIT SWITCH ADJUSTMENTS

Initial adjustment is accomplished as follows:

1. Position the dipper handle with the rear stop six inches from the saddle block with the heel of the dipper on the ground. The crowd retract drum is now at the maximum crowd position and will turn in a counterclockwise direction. The limit switch will turn in a clockwise direction.
2. Position the adapter at the crowd-retract drum and drum shaft so that four threads (1/2 inch) extend out of the locknut.
3. Remove the cover of the limit switch. Position the first cam of the limit switch to open the circuit when the dipper handle is positioned as in step 1.
4. Roughly adjust the second cam of the switch to open the circuit when the switch rotates clockwise 115 degrees.
5. Re-position the dipper so the handle hangs vertically and retract the handle until the

front stop is about six inches from the saddle block.

6. Fine-adjust the second cam to open the switch at this point. The vernier adjustment (figure 1-2-22) is used to fine-adjust the contact arm position. The vernier adjustment screw varies the relative position of the cam follower with the operating cam. To adjust a specific circuit, loosen the adjusting screw and slide it up or down to open or close the contact sooner or later as desired.

The markings on the verier plate represent 2° increments of adjustment. The adjustment affects the opening and closing of the contact unit by the same amount. If incremental adjustment is required for either opening or closing position is necessary, the closing position must be set on another cam and the two contact units electrically tied together. After settings are established, firmly tighten the adjusting screw.

To re-position the crowd limit switch:

1. Position the dipper with the rear stops six inches from the saddle block, and the heel of the dipper on the ground.
2. Loosen the locknut on the drum-shaft end of the cable.
3. Turn the adapter clockwise to increase clearance between the rear stops and the saddle block. Turn the adapter counterclockwise to decrease clearance.
4. It should not be necessary to adjust the retract mode, as it will be correct if the original cam-setting was not altered.

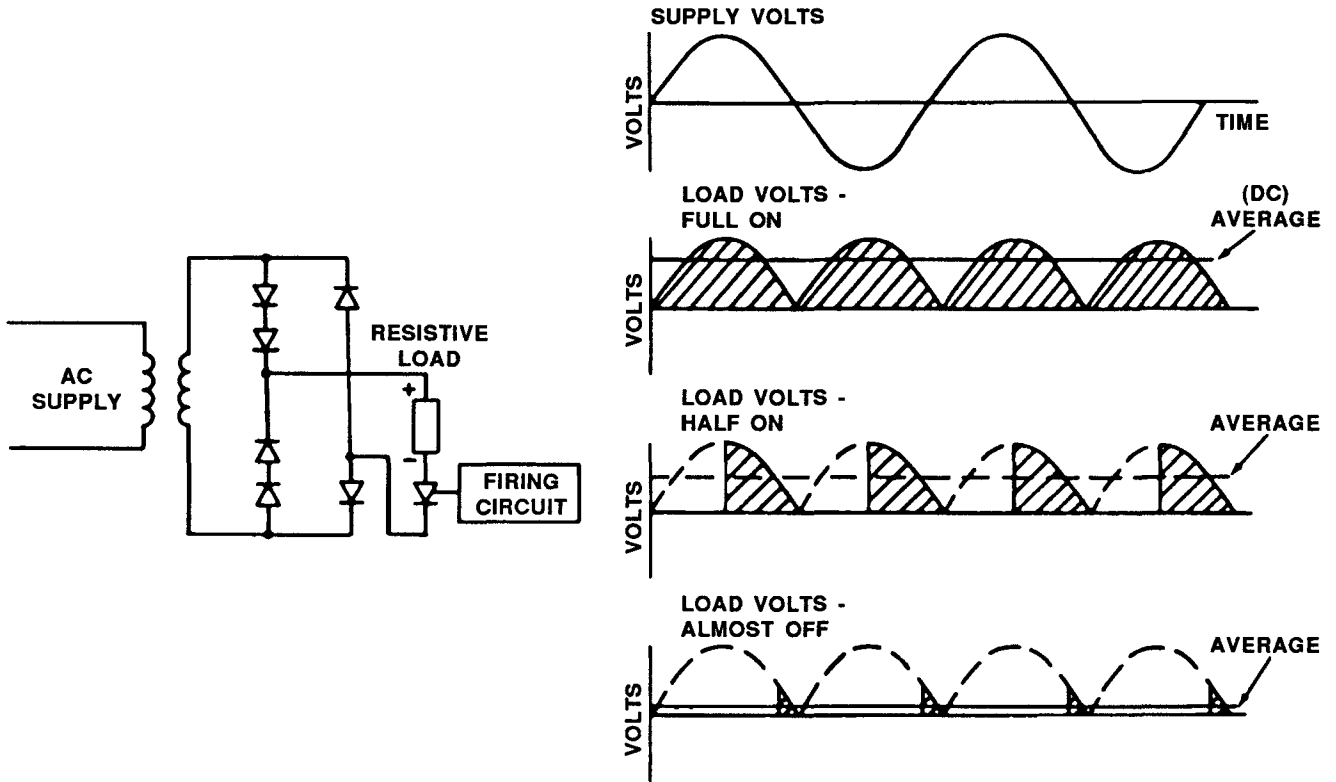


FIGURE 2-2-7

Note that the circuit shown in figure 2-2-7 is not capable of reversing the polarity of load volts.

The SCR is inherently a non-reversing device and the generator output is reversed by using two separate circuits, one having the reverse effect of the other.

The previous examples have used resistive loads. Since the generator field is quite inductive, some

additions to the circuit are necessary. A commutating rectifier is placed across the generator shunt field as shown in figure 2-2-8.

The inductive load current will appear as smooth DC whereas the resistive load current would appear as a pulsating DC, similar to the voltage wave shapes. Since an inductive load resists any change in current magnitude, the load current continues to flow when the rectified AC voltage

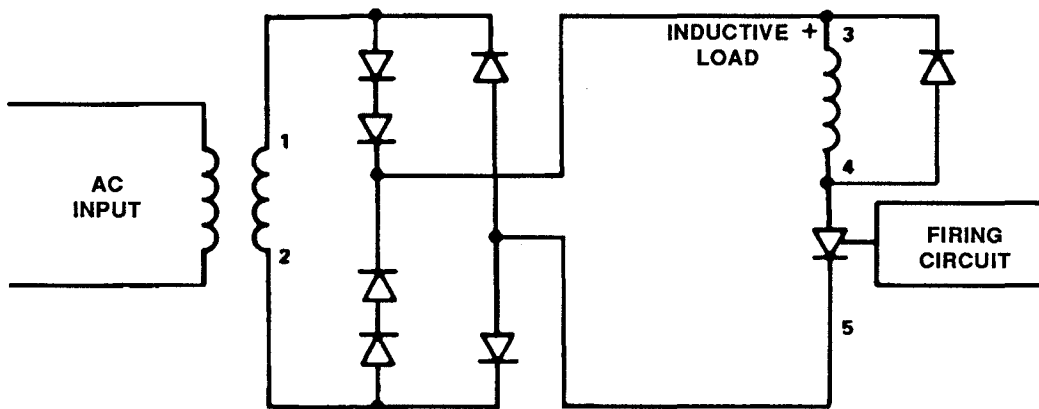


FIGURE 2-2-8

This portion of the circuit serves a dual purpose. It provides isolated voltages for the amplistat cores and also provides the square wave that is used to fire the SCR cells. The clipping circuit is illustrated in figure 2-2-14.

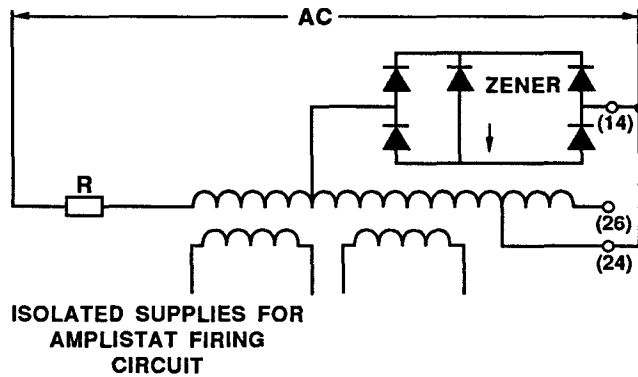


FIGURE 2-2-14

FIRING AMPLISTAT

The amplistats used in the Firing Circuit Module were specially designed for firing SCR cells. Each firing amplistat has two gate windings. Rectifiers in series with the amplistat gate windings rectify the square wave and produce a firing pulse of approximately 5 volts amplitude each half cycle at the output of the amplistat. The firing pulses are then applied to the gate circuit of the SCR. Figure 2-2-15 shows the signal applied to the gate for various values of control ampere-turns.

The solid line indicates the actual signal applied to the SCR gate. The dotted line represents the square wave as generated by the clipping circuit.

As can be seen from figure 2-2-15, amplistat firing has all the characteristics required for reliable firing of SCRs, namely, nearly 180° phase shift control, sharp leading edge on the voltage pulse, and continuous, nearly constant gate signal during the firing portion of the cycle.



FIGURE 2-2-15

Firing Cycle

Firing amplistats 1A and 2A and the clipping circuit are connected to the gates of SCR-F and SCR-R as shown in figure 2-2-16. The square wave being generated at each secondary winding of amplistat transformer AT is in phase with the rectified AC voltage appearing across the generator field and SCR, since the clipping circuit obtains its voltage from one leg of the center-tapped transformer supplying the exciter.

Assume that the DC current flowing through the control fields causes amplistat 1A to saturate. The voltage produced by AT causes current to flow through 1A, the 22 ohm resistor, the diode, the gate of SCR-R and back through terminal 1 of FCM. The gate of the SCR receives a pulse each half-cycle.

The gate voltages of SCR-F and SCR-R appear across terminals 3-1 and 11-13 of FCM, respectively; terminals 3 and 11 being positive. The output voltage of amplistats 1A and 2A can be observed across terminals 2-1 and 12-13, respectively; terminals 2 and 12 being positive.

Bias Circuits

Bias rheostats 8RH and 4RH are located external to the firing circuit module. These are adjusted at the factory to turn the SCRs on just enough to produce an equal minimum voltage across each generator field - approximately 3 volts. If further adjustments should be necessary in the field, care should be taken, as extreme adjustments of these rheostats could turn the SCRs full on and produce excessive currents in the generator fields.

Filter Circuits

Filter circuits have been included in the firing circuit module to prevent the SCRs from transient voltage spikes that might do permanent damage.

Since the output of the SCR contains a large 120

torque and current peaks on voltage regulated drives, and voltage limit, to prevent excessive speed on current regulated drives.

Two types of regulators are normally used on excavators. The hoist, drag, and crowd motions utilize voltage regulators with current limit, while the swing motion is normally supplied with a current regulator with voltage limit. The voltage regulator with current limit allows the generator current to vary unrestricted within predetermined current limits. Once the generator armature current exceeds the predetermined value, the "current limit" circuit overrides the voltage regulator to prevent excessive current peaks. This type of regulator provides maximum torque (current) response within the limits of the equipment.

The current regulator with voltage limit provides nearly constant torque from zero speed up to the point where the voltage limit overrides the current regulator to prevent overvoltage (overspeeding) the equipment. The current regulator provides the torque required for smooth acceleration and deceleration. The operator, by actually being able to control the torque, can easily set the desired acceleration and deceleration rates.

To better understand how each of these regulators perform the desired functions, consider the following examples:

VOLTAGE REGULATOR WITH CURRENT LIMIT

Figure 2-2-20 shows the basic circuit requirements for a voltage regulator with current limit. The motor and generator are connected in a Ward-Leonard loop, and speed control is obtained by varying the generator output. The current limit, feedback, and reference windings are all amplistat control windings used for determining the magnitude of the SCR exciter output. Current flowing in a control winding from an odd to an even terminal increases the exciter output, and a reverse current flow decreases the exciter output.

Voltage Regulator

Assume a reference signal is applied whose polarity and current flow is as indicated on the reference winding circuit. This signal will cause the exciter output to increase, increasing the generator terminal voltage, as indicated. The generator voltage will cause a current to flow in

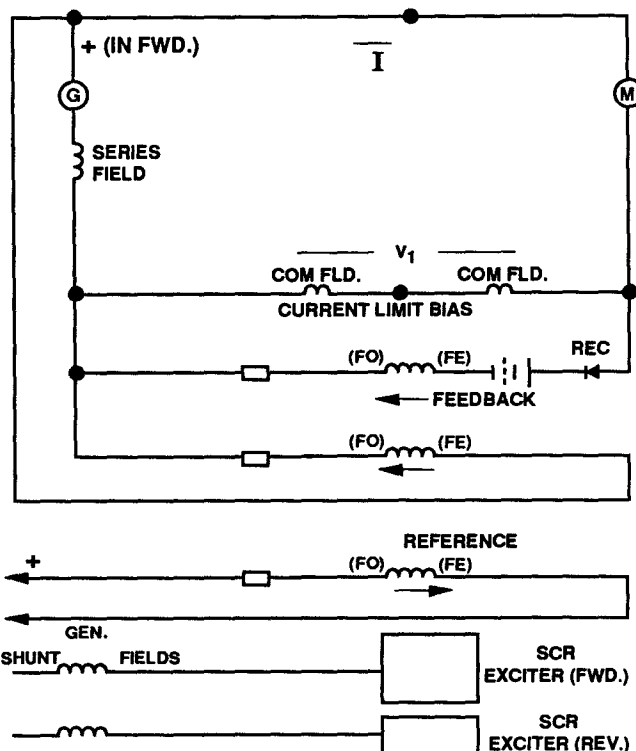


FIGURE 2-2-20

the feedback windings in such a direction as to tend to reduce the exciter output. The generator voltage will continue to increase to the point where ampere-turns* produced by the reference and feedback currents almost balance, leaving only the required net** ampere turns necessary to maintain the desired generator output. A change in the feedback signal will upset the balance and cause the exciter output to vary in the proper direction to bring the generator output back to the desired level. Similarly, a change in reference will establish a new operating level.

Current Limit

With the armature current as indicated, a voltage V_1 appears across the motor and generator commutating fields. This voltage is proportional to armature current and is used to detect when limiting action should take place. For discussion purposes, a battery and rectifier are connected in series with the current limit winding. The battery will not cause a current flow as its path has been blocked by the rectifier. If, however, the voltage across the commutating fields (V_1)

* Ampere turns = amps flowing through winding X turns in winding.

** Difference in ampere turns trying to increase exciter output and ampere turns trying to decrease exciter output.

tween terminals 3 and 5. Resistor 4RS and the bias circuits, representing the load, are connected to the module as indicated. The value of 4RS has been selected to limit zener diode current to a safe value and still allow regulation.

The module must maintain a constant voltage output under two types of varying conditions - changes in AC voltage, or changes in load current. A change in AC voltage, or changes in load current. A change in AC voltage changes zener current, and will vary the current through 4RS, and consequently the voltage across it. However, both zener voltage and load voltage will remain constant because of the zener's characteristics.

If the load current should change, the zener will absorb or supply this required change in current, while the voltage across 4RS will remain constant.

CROWD RATE CIRCUITRY

This machine is equipped with a combination elastic cushion and electronic feedback circuit to reduce the effects of impact loading on the crowd motion. Extensive field tests were run to determine the exact magnitude of shock obtained when running the handle into the bank at top speed. This data was then formulated to provide measured true damping characteristics of the drive machinery and rope system which were entered into a computer simulation program and in turn, used to study all electrical and mechanical aspects of the crowd motion. The ultimate result of this circuitry is increased crowd rope life, reduced crowd chock force, and less frequent replacement of elastic cushions and sheaves due to shock overload protection.

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APPENDIX 5A - MONTHLY ELECTRICAL CHECK LIST (Cont.)

MOTOR	AIR IN	AIR OUT	DATE	AMBIENT T°
HOIST				
CROWD				
SWING (1)				
SWING (2)				
PROPEL				

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