DC-TO-DC CONVERTER
KS-19303 L1
OPERATING METHODS

CONTENTS PAGE

1. GENERAL

1.01 This section covers the operation of the KS-19303 L1 dc-to-dc converter which is primarily intended as a power supply for the 651A power plant. The converter is a dc voltage multiplier which enables a positive or negative 130-volt dc supply to be obtained from a 48-volt battery, and is designed to mount on a 23-inch relay rack.

1.02 This section is reissued to incorporate information on the Q1 through Q4 transistors and to delete reference to the KS-19303 L2 converter.

1.03 The KS-19303 L1 converter is designed to operate on 44 to 52 volts direct current, 9 amperes. The output is adjustable from 120 volts to 140 volts direct current, 2 amperes at full load. The dc output is transformer-isolated from dc input so that either positive or negative output can be grounded, or positive or negative dc output can be left ungrounded, regardless of input ground polarity.

1.04 Two or more converters may be connected in parallel to provide additional current to the 130-volt dc load. Each converter is self-protected against overload; in the event of overload, the dc output voltage will decrease as necessary to limit the output current to a safe value. When two converters of the same list number are operated in parallel, the settings of the output voltage adjustment should be identical.

1.05 Keep the ventilating passages of the converter unobstructed. This is especially important to insure adequate cooling during operation.

1.06 The abbreviations cw and ccw, used herein, refer to clockwise and counterclockwise, respectively.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
KS-16346 L2	Soldering Copper
—	3-inch C Screwdriver
—	P Long-Nose Pliers
TEST APPARATUS	
KS-14510	Volt-Ohm-Milliammeter

3. OPERATION

3.01 *General*

(a) This dc-to-dc converter contains an inverter which changes 50-volt direct current input to square-wave alternating current, a power transformer which increases inverter output voltage to higher ac voltage, and a power rectifier which converts this alternating current to 130 volts direct current. Both dc input and dc output circuits are filtered to prevent transmission of noise to input battery or dc load.

(b) An output voltage regulator maintains dc output voltage within plus-or-minus 1 percent of value to which it is adjusted at any output current between zero and rated output current of 2 amperes, despite variation of dc input voltage between 44 volts and 52 volts.

(c) An external alarm is given if dc output voltage decreases to 125 volts or in event of dc output failure. If dc output voltage should increase to 135 volts, the converter is automatically turned off and an external alarm is given. These alarm conditions are indicated by an alarm lamp.

3.02 ***Input Circuit***

(a) F1 input fuse opens to break negative dc input if some unsatisfactory circuit condition should cause input current to become excessive. Input CB1 circuit breaker is controlled by an alarm and shut-off circuit, described below, to break negative dc input if dc output voltage should increase to 135 volts.

(b) L1 choke and C1 capacitor form an input filter which prevents transmission of noise to input battery.

3.03 ***Oscillator***

(a) Q1 through Q4 transistors, with T1 power transformer, form an oscillator. These transistors conduct in pairs: Q1 and Q3 conduct while Q2 and Q4 are at cutoff, then Q2 and Q4 conduct while Q1 and Q3 are at cutoff.

(b) Terminal 1 of a T1 feedback winding between terminals 1 to 2 is connected to positive dc input. Terminal 2 of this winding is connected through series R1, R13, and R15 resistors to negative dc input, causing current to flow through this circuit. Voltage developed across T1 feedback winding and R1 is applied as negative base-emitter potential to Q1, causing Q1 base current to flow, so that Q1 is driven to conduction.

(c) When Q1 conducts, current flows from positive dc input through Q1 emitter and collector, T1 primary windings between terminals 4 to 14, and Q3 emitter and collector to negative dc input. Primary current induces voltage in T1 feedback windings; feedback windings between terminals 1 to 12 and terminals 3 to 4 furnish positive base-emitter potential to Q2 and Q4, prevent flow of base current, and drive these transistors to cutoff; feedback windings between terminals 1 to 2 and terminals 13 to 14 supply negative base emitter potential to Q1 and Q3, increase base current, and drive these transistors to maximum conduction.

(d) With Q1 and Q3 at maximum conduction, dc input voltage is applied almost entirely across T1 primary windings, and T1 primary current increases rapidly until T1 becomes saturated. At this time, T1 feedback current decreases until it is no longer sufficient to sustain conduction of Q1 and Q3. Voltage developed across Q1 and Q3 emitters and collectors then causes T1 primary current to decay, reversing polarity of T1 feedback voltage, so that Q1 and Q3 are driven to cutoff while Q2 and Q4 are driven to maximum conduction.

(e) When Q2 and Q4 conduct, current flows from positive input through Q2 emitter and collector, T1 primary windings between terminals 14 to 4, and Q4 emitter and collector to negative input. Note that direction of T1 primary current has now reversed. Again, T1 primary current increases rapidly until T1 becomes saturated to cause another similar reversal. This cycle is self-sustaining. It causes square-wave T1 primary current.

(f) R1 through R4 resistors limit base current of Q1 through Q4 transistors. R14 resistor balances effect of starting R15 resistor to prevent unbalance which would be caused by flow of dc through primary windings of T1 power transformer.

3.04 ***Power Rectifier, Output Filter***

(a) T1 power transformer is a step-up transformer. Its secondary windings between terminals 6 to 16 furnish alternating current through outer-leg gate windings of T2 magnetic amplifier to full-wave split-bridge CR1 power rectifier, which changes this ac to direct current. Current flows from positive CR1 output through a T2 center-leg control winding between terminals 9 to 11, and L2 and L3 output chokes, to dc load, with return path through R19 resistor to negative CR1 output.

(b) F2 output fuse, CR12 diode, and an output ammeter can be connected in series with positive output if negative 130-volt dc load is grounded or in series with negative output if positive 130-volt dc load is grounded. These options are selected by position in which a reversible plug is inserted.

(c) CR12 output diode conducts to permit flow of output current from the converter but, in the event of output failure, CR12 diode blocks to prevent flow of output current from any parallel-connected dc-to-dc converter through output of this unit. CR12 diode thus assures that an output failure alarm will be given as described in 3.08.

(d) L2 and L3 chokes, in series with positive output, and C3 and C4 capacitors, connected across dc output, form an output filter which smooths ac ripple from power rectifier outputs so that the converter output will more nearly approach pure direct current. R5-C2 resistance-capacitance network protects CR1 power rectifier against voltage peaks.

3.05 ***T2 Magnetic Amplifier***

(a) T2 magnetic amplifier is controlled by an output voltage regulator and an output current limiter, described below, to increase or decrease effective ac voltage supplied by T1 power transformer to CR1 power rectifier. T2 magnetic amplifier has a 3-legged core which carries two gate windings, one on each of its two outer legs, and three control windings on its center leg.

(b) As noted above, T1 supplies alternating current through T2 gate windings to CR1. Since each gate winding is in series with two diode sections of CR1, direct current flows through alternate T2 gate windings on alternate ac half-cycles. Each time T1 secondary voltage changes polarity, T2 magnetic amplifier is initially unsaturated and T1 secondary voltage appears almost entirely across T2 gate windings. Gate winding current then increases relatively slowly until T2 becomes saturated, at which time gate winding voltage decreases sharply and T1 secondary voltage is supplied almost entirely to CR1.

(c) Current through T2 control windings either aids or opposes T2 saturation, to a greater or lesser extent, depending upon direction and amount of control current. When control current aids saturation, it causes T2 to become saturated earlier during each half-cycle; hence, it increases the portion of each half-cycle during which T2 is saturated to increase effective CR1 voltage. Likewise, when control current opposes saturation, it prevents T2 from becoming saturated until later during each half-cycle, decreases portion of each half-cycle during which T2 is saturated, and reduces effective CR1 voltage. In this manner, T2 controls dc output voltage.

(d) Note that T2 gate winding current increases as dc output current increases. As gate winding current increases, it causes T2 to become saturated earlier during each half-cycle, increases portion of each half-cycle during which T2 is saturated, and increases effective voltage supplied to CR1. This property of magnetic amplifier T2 partially offsets resistive voltage drops which would otherwise cause dc output voltage to decrease as output current increases. As a refinement, a T2 control winding between terminals 9 to 11 is connected in series with positive dc output to further aid T2 saturation as output current increases.

3.06 ***Output Voltage Regulator***

(a) Two regulator circuits supply control current to T2 magnetic amplifier. Since any increase or decrease of dc input voltage causes a corresponding increase or decrease of T1 power transformer secondary voltage, one regulator circuit supplies control current which causes T2 to compensate for this effect. Another regulator supplies control current to T2 to compensate for any actual variation of dc output voltage.

(b) Current flows from positive input through R12, R11, and R10 resistors to negative input, and also from positive input through CR2 zener diode, a control winding between terminals 7 to 8 of T2 magnetic amplifier, part of R11, and R10 to negative input. Note that CR2 zener diode conducts in reverse direction. Characteristics of this diode are such that, once this occurs, essentially constant voltage appears across CR2 while any increase or decrease of dc input voltage will result in increase or decrease of voltage developed across other circuit elements.

(c) R11 resistor is adjusted so that voltage developed across R12 and adjacent portion of R11, as a result of dc input voltage, will be slightly greater than constant CR2 voltage. Difference voltage between R12-R11 voltage and constant CR2 voltage determines the amount of current which flows from positive input through CR2, T2 control winding, part of R11, and R10. This current opposes T2 saturation.

(d) Any decrease of dc input voltage causes a corresponding decrease of R12-R11 voltage. Since CR2 voltage remains constant, T2 control winding voltage and control current which opposes T2 saturation are reduced. This causes T2 to increase effective ac voltage supplied to CR1 power rectifier. Similarly, any increase of dc input voltage causes a corresponding increase of R12-R11 voltage, increases T2 control winding voltage and current, and causes T2 to reduce effective voltage supplied to CR1. In either case, T2 thus compensates against decrease or increase of T1 power transformer secondary voltage caused by decrease or increase of dc input voltage.

(e) Two series circuits are connected across dc output to form a second regulator circuit. One of these is made up of R6, R7, and R8 resistances; another consists of R9 resistor, temperature-compensating CR5 and CR6 diodes, CR3 zener diode, temperature-compensating CR7, CR8, and CR9 diodes, CR4 zener diode, and temperature-compensating CR10 and CR11 diodes.

(f) CR3 and CR4 zener diodes are similar to CR2; each conducts in reverse direction and develops essentially constant voltage despite variation of dc output voltage. Since CR3 and CR4 voltage is, however, subject to slight variation as a result of temperature variation, temperature-compensating CR5 through CR11 diodes are connected in series with CR3 and CR4 to offset this effect. Resultant voltage, which appears across CR3 through CR11 diodes, remains constant despite variation of either dc output voltage or temperature.

(g) R7 potentiometer is adjusted so that voltage developed across R8 resistor and adjacent portion of R7, as a result of dc output voltage, will be slightly less than CR3 through CR11 diode voltage. This difference voltage causes current to flow from positive dc output through R9, a T2 control winding between terminals 6 to 5, part of R7, and R8 to negative dc output. Control current supplied by this circuit aids T2 saturation.

(h) If dc output voltage decreases, R7-R8 voltage also decreases. Since CR3 through CR11 diode voltage remains constant, R8-R7 difference voltage increases and causes T2 control current to increase; T2 then increases effective ac voltage supplied to CR1 power rectifier to increase dc output voltage. Similarly, if dc output voltage increases, difference voltage decreases, T2 control current is reduced, and T2 decreases effective ac voltage supplied to CR1 to decrease dc output voltage.

3.07 ***Output Current Limiter***

(a) R20 resistor and CR13 diode are connected in series across dc output. Since CR13 is a forward-biased silicon diode, it develops a low but essentially constant voltage. This voltage is applied to maintain emitter potential of Q5 transistor constant with respect to negative output of CR1 power rectifier.

(b) As noted above, R19 resistor is connected in series with negative dc output; thus, voltage developed across R19 is proportional to dc output current. So long as dc output current does not increase beyond its rated value, R19 voltage remains lower than constant CR13 voltage. Difference voltage between R19 and CR13 causes negative base-emitter potential to be applied to Q5 at this time to prevent flow of Q5 base current and drive Q5 to cutoff.

(c) R19 resistor is adjusted so that, as dc output current increases beyond its rated value, R19 voltage will increase to exceed CR13 voltage. This reverses potential of R19-CR13 difference voltage, applies positive base-emitter potential to Q5, causes Q5 base current to flow, and drives Q5 to conduction.

(d) When Q5 conducts, current flows from positive dc output through R9 resistor, Q5 collector and emitter, and CR13 to negative dc output. Note that Q5 emitter and collector and CR13 are in shunt with CR3 through CR11 diodes. Since voltage developed across Q5 emitter and collector plus CR13 voltage is now lower than the usual CR3 through CR11 voltage, current flows from positive dc output through R6 resistor, part of R7 potentiometer, control winding between terminals 5 to 6 of T2 magnetic amplifier, Q5 collector and emitter, and CR13 to negative dc output. Since this current is opposite in direction to the control current usually supplied through this T2 control winding, it opposes T2 saturation and causes T2 to decrease effective ac voltage supplied to CR1 power rectifier; thus, T2 reduces dc output voltage to prevent further increase of dc output current.

3.08 *Alarm, Shut-Off Circuits:* Two voltage-sensing circuits are furnished to give an external alarm if dc output voltage should decrease to 125 volts and to supply automatic shut-off, also giving an external alarm if dc output voltage should increase to 135 volts.

(a) ***Low-Voltage Alarm***

(1) R42 resistor and CR19 zener diode are connected in series across dc output. CR19 diode is similar to CR2, CR3, and CR4 diodes described above. It conducts in reverse direction and CR19 voltage remains essentially constant, while any increase or decrease of dc output voltage is developed across R42. Voltage developed across CR19 holds emitter potential of Q14 transistor constant with respect to negative dc output.

(2) R34 resistor and R35 potentiometer are also connected in series across dc output so that voltage developed across that portion of R35 between its slider and negative output is proportional to dc output voltage. Under usual conditions, this R35 voltage exceeds constant CR19 voltage and furnishes positive base-emitter potential to Q14; base current flows and drives Q14 to conduction. When Q14 conducts, current flows from positive dc output through R38 resistor, coil of K2 relay, Q14 collector and emitter, and CR19 to negative dc output, operating K2 relay. So long as Q14 continues to conduct, K2 relay remains operated.

(3) R35 potentiometer is adjusted so that, if dc output voltage decreases to 125 volts, its slider-to-negative-output potential will no longer be sufficient to drive Q14 to conduction. This releases K2 relay. Contacts of K2 relay, released, furnish ground to light OUTPUT FAILURE lamp, give an external minor alarm connected at either of alarm terminals 5 or 6, and supply closed loops between alarm terminals 7 to 8 and 9 to 10 to give an external major alarm.

(4) C17 capacitor is normally charged by difference voltage between Q14 collector to base. If a sudden increase of dc output current should cause output voltage to instantaneously decrease to less than 125 volts, C17 capacitor discharges through Q14 base and emitter to maintain Q14 in conduction until this momentary condition is corrected. This prevents a false alarm.

(b) ***High-Voltage Shut Off***

(1) CR19 zener diode also maintains emitter potential of Q13 transistor constant with respect to negative dc output. R36 resistor and R37 potentiometer are connected in series across dc output so that voltage developed across a portion of R37 between its slider and negative output is proportional to dc output voltage. Under usual conditions, this R37 voltage is lower than constant CR19 voltage, so that negative base-emitter potential prevents flow of Q13 base current and maintains Q13 at cutoff.

(2) R37 potentiometer is adjusted so that, if dc output voltage increases to 135 volts, its slider-to-negative-output potential will increase to a value greater than CR19 voltage.

This applies positive base-emitter potential to Q13, causes Q13 base current to flow, and drives Q13 to conduction.

(3) When Q13 conducts, current flows from positive dc output through R38 resistor, the coil of K1 relay (operating K1), collector and emitter of Q13 transistor, CR19 zener diode to negative dc output. Contacts of K1 relay, operated, supply ground to input CB1 circuit breaker and cause CB1 to open, turning off converter.

(4) With dc output voltage absent, a low-voltage alarm is given as described above.

Preparing to Start (Fig. 1)

3.09 When preparing to put the converter into service initially, check that:

(a) All external connections are made in accordance with the SD drawing covering the associated circuit of which the unit is a part. To gain access to the input and output terminals on the KS-19303 L1 converter, release the two twist-type fasteners and remove the rear cover. (See Fig. 2.)

Caution 1: Before making electrical connections, be certain that the CB1 input circuit breaker is in the OFF position.

Caution 2: Inductive filtering should not be used between the 48-volt battery and the converter input, since an input filter may cause voltage peaks which would damage transistors.

Note: Positive dc input (terminal 2) is connected to chassis ground by a jumper. This protects transistors against damage in case input battery polarity is incorrect. If desired, this jumper can be removed once proper input connections have been made.

(b) The reversible plug designated "+130" and "−130" (see Fig. 2) is positioned as follows.

(1) For use in a positive (negative ground) system, the "+130" designation shall read upright; the F2 output fuse, CR12 diode, and the ammeter will then be in series with positive dc output.

(2) For use in a negative (positive ground) system, the "−130" designation shall read upright; the F2 output fuse, CR12 diode, and the ammeter will then be in series with negative dc output.

(c) 130-volt dc load at OUTPUT terminals 3 (positive) and 4 (negative) is connected.

(d) Nominal 50-volt dc at input terminals 1 (negative) and 2 (positive) is connected.

(e) To cause OUTPUT FAILURE lamp to light in event of high or low dc output voltage or output failure, check that nominal 50-volt negative battery is supplied at terminal 11 of alarm terminal strip. (See Fig. 2.) Alarm terminals 5 and 6 furnish positive 50-volt ground, while terminals 7 to 8 and terminals 9 to 10 each supply a closed loop to give an external alarm in event of any alarm conditions. If two converters are operated in parallel, closed-loop alarm terminals of each unit can be connected in series to give an external major alarm.

(f) F2 output fuse is connected in series with either positive or negative dc output (option) as necessary to cause it to protect whichever side of dc output is ungrounded. Since this converter is self-protected against overload, an overload condition will not cause either the F1 input fuse or F2 output fuse to open. If necessary to replace either fuse, replace only with fuse type and size or equivalent as follows.

F1 INPUT fuse:	Bussmann type AGC cartridge, 10 amperes
F2 OUTPUT fuse:	Bussmann type AGC cartridge, 3 amperes

Initial Adjustments (Fig. 1)

3.10 To turn converter on or off, throw toggle of INPUT CB1 circuit breaker to ON or OFF position.

(a) The ***dc output voltage*** is varied by adjusting the OUTPUT VOLTS ADJ potentiometer (R7) to any value between 120 and 140 volts. To increase the output voltage, rotate screwdriver adjustment shaft cw; to decrease output voltage, rotate shaft ccw.

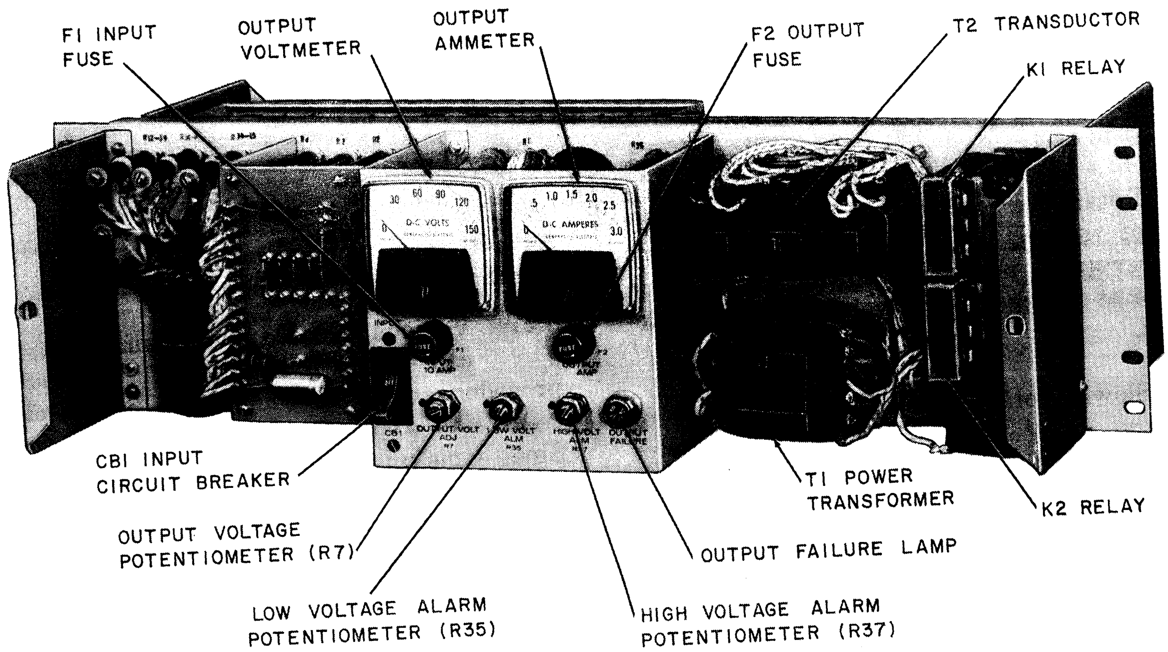


Fig. 1 — KS-19303 L1 Converter (Front View — Cover Removed)

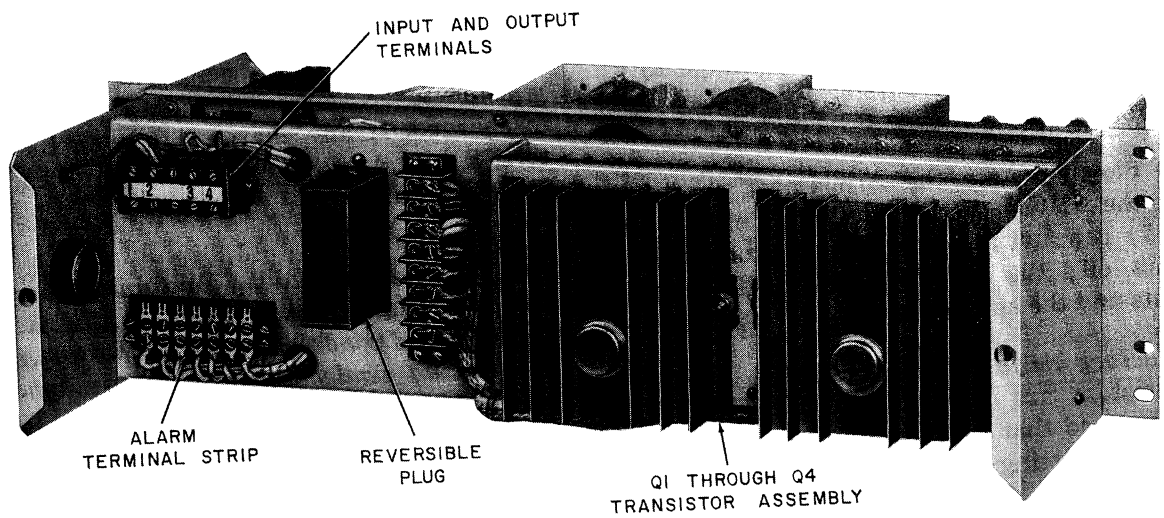


Fig. 2 — KS-19303 L1 Converter (Rear View — Cover Removed)

(b) To adjust the ***low output voltage alarm,*** proceed as follows.

(1) Rotate the screwdriver adjustment shaft of the LOW VOLT ALM potentiometer (R35) to extreme ccw position.

(2) Rotate the screwdriver adjustment shaft of the OUTPUT VOLTS ADJ potentiometer (R7) to set the output voltage to a value at which the low-voltage alarm is desired.

(3) Slowly rotate the adjustment shaft of the LOW VOLT ALM potentiometer (R35) cw until the OUTPUT FAILURE lamp lights and the alarm is given.

(c) To adjust the ***high output voltage alarm,*** proceed as follows.

(1) Rotate the screwdriver adjustment shaft of the HIGH VOLT ALM potentiometer (R37) to extreme cw position.

(2) Rotate the screwdriver adjustment shaft of the OUTPUT VOLT ADJ potentiometer (R7) to set the output voltage to a value at which the automatic cutoff is desired. [See 3.10 (a).]

(3) Slowly rotate the adjustment shaft of the HIGH VOLT ALM potentiometer (R37) ccw until the converter automatically shuts off; the OUTPUT FAILURE lamp lights and the alarm is given.

(d) ***Factory Adjustments:*** R8, R11, and R19 resistors are factory adjusted and it is recommended that no change be made in these adjustment settings.

4. ROUTINE CHECKS

4.01 As often as local experience demands, the relays should be inspected for adjustment and condition of contacts, making sure that they are in accordance with the Bell System Practices which apply.

4.02 The dc output voltage and current should be checked periodically to make certain that they are correct.

4.03 Electrolytic capacitors should be maintained in accordance with Section 032-110-701.

5. TROUBLES

General

5.01 Various trouble symptoms and possible causes are listed in 5.05. A trouble test procedure opposite each cause will isolate the trouble to a few possible defective components. Since some unsatisfactory conditions will damage more than one component, all checks listed under a given cause should be made even though defective components are revealed before the entire check procedure has been completed.

5.02 Component test procedures are made with the converter disconnected from the external output circuit. Before testing the components, place the CB1 circuit breaker in the OFF position and remove the F1 or main distribution fuse and F2 fuses. Where necessary, momentarily shunt capacitors with a 100-ohm resistor to be certain that they are completely discharged. If any charge is left on the capacitors, it may cause inaccuracy in resistance reading. (See Fig. 3.)

Caution: In making continuity checks, use the ohmmeter portion of the KS-14510 meter. Do not use the X10,000 position for testing semiconductors as the higher voltage used may damage them.

5.03 Before disconnecting leads, mark or record the connection.

Caution: Soldering operation on semiconductors shall be done at the lowest possible temperature and in the shortest time practicable in order to localize the heating effect and thus prevent damaging the semiconductors. Because of its low operating temperature, use the KS-16346 L2 12-watt soldering copper. For the protection of the semiconductors, use the P long-nose pliers as a heat sink.

5.04 Q1 through Q4 transistors are part of a separately removable heat sink assembly. In the event of failure of any Q1 through Q4 power transistors, it is recommended that this entire heat sink assembly be replaced.

Troubleshooting

5.05 Reference to input fuse shall be interpreted to mean the F1 fuse.

A. Low-Voltage Alarm Given, Input Fuse Open

POSSIBLE CAUSE	PROCEDURE
Failure of one or more of Q1 through Q4 transistors.	Replace complete transistor heat sink assembly.
Short circuit of C3 or C4 capacitor.	Replace defective C3 or C4 capacitor. Check CR1 rectifier and Q1 through Q4 transistors, replace if defective.
Short circuit of two diode sections of CR1 rectifier.	Replace CR1 rectifier. Check Q1 through Q4 transistors, replace if defective.
Open circuit of Q5 transistor or R20 resistor.	Replace defective Q5 transistor or R20 resistor.

B. Low-Voltage Alarm Given, Neither Input Fuse Nor CB1 Circuit Breaker Open, DC Output Voltage Low

POSSIBLE CAUSE	PROCEDURE
High-resistance dc input connection.	Tighten clamp screws of input terminals.
Short circuit of CR3 or CR4 zener diode.	Replace defective CR3 or CR4 zener diode.
Short circuit of CR13 diode.	Replace defective CR13 diode.
Open circuit of control winding between terminals 5 to 6 of T2 magnetic amplifier or associated wiring.	Continuity check. Repair defective wiring or replace defective T2 magnetic amplifier.
Open circuit of R1, R2, R3, R4, R8, R9, or R12 resistor, open circuit between slider of R7 potentiometer and R8 resistor, open circuit between slider of R11 potentiometer and R12 resistor, open circuit of associated wiring.	Continuity check. Repair defective wiring, replace defective resistor or potentiometer.

C. Low-Voltage Alarm Given, Neither Input Fuse Nor CB1 Circuit Breaker Open, DC Output Voltage and Output Current Zero, Converter Emits Usual High-Pitched Hum

POSSIBLE CAUSE	PROCEDURE
Open circuit of R19 resistor, open circuit of T1 transformer secondary winding between terminals, open circuit of CR1 rectifier, open circuit of L2 or L3 choke, open circuit in associated wiring.	Continuity check. Repair defective wiring; replace any defective component.

D. Low-Voltage Alarm Given, Neither Input Fuse Nor CB1 Circuit Breaker Open, Converter Does Not Emit Usual High-Pitched Hum

POSSIBLE CAUSE	PROCEDURE
Open circuit of dc input connection.	Repair defective wiring; tighten clamp screws of input terminals.
Open circuit of wiring between input terminals, C1 capacitor, oscillator circuit.	Continuity check. Repair defective wiring.
Open circuit of T1 transformer primary winding between terminals 4 to 14, open circuit of associated wiring.	Continuity check. Repair defective wiring; replace defective T1 transformer.

E. Low-Voltage Alarm Given, CB1 Circuit Breaker Open

POSSIBLE CAUSE	PROCEDURE
Temporary condition has caused CB1 circuit breaker to open.	Throw toggle of CB1 circuit breaker to ON position to reset; if temporary condition has caused CB1 circuit breaker to open, it will remain closed.
Open circuit of CR2, CR3, or CR4 zener diode, open circuit of R6 or R10 resistor, open circuit between slider of R7 potentiometer and R6 resistor, open circuit between slider of R11 potentiometer and R10 resistor, open circuit of associated wiring.	Rotate screwdriver adjustment shaft of HIGH VOLT ALM potentiometer (R37) to extreme clockwise position to obtain maximum value of shut-off voltage, then throw toggle of CB1 circuit breaker to ON position to reset; if CB1 circuit breaker remains closed, repair defective wiring, replace any defective component; in the event of open circuit of either CR3 or CR4 zener diode, replace Q5 transistor.
Short circuit of Q12 or Q13 transistor, short circuit of CR19 zener diode.	Rotate screwdriver adjustment shaft of HIGH VOLT ALM potentiometer (R37) to extreme clockwise position to obtain maximum value of shut-off voltage, then throw toggle of CB1 circuit breaker to ON position to reset; if CB1 circuit breaker again opens, replace defective component; in the event of short circuit of Q13 transistor, check for and correct if necessary open circuit of R39 resistor which will damage Q13 and Q14 transistors; in the event of short circuit of Q13 transistor, check for and correct if necessary open circuit between slider of R37 potentiometer and negative dc output which will damage Q13 transistor.

Note: CB1 circuit breaker will open in event of open circuit of R42 resistor if dc input is connected and disconnected repeatedly.

F. No Low-Voltage Alarm Given Despite Low DC Output Voltage

POSSIBLE CAUSE	PROCEDURE
Short circuit of Q14 transistor, short circuit of CR19 zener diode, open circuit between slider of R35 potentiometer and negative dc output.	Continuity check; repair defective wiring; replace defective CR19 zener diode, or defective R35 potentiometer; check for and correct if necessary open circuit of R39 resistor which will damage Q13 and Q14 transistors; check for and correct if necessary short circuit of C17 capacitor which may damage Q14 transistor.
Short circuit of CR12 diode (applies only if two or more converters are operated in parallel).	Replace defective CR12 diode.

G. No Shut Off Despite High DC Output Voltage

POSSIBLE CAUSE	PROCEDURE
Open circuit of Q13 transistor, open circuit of CR19 zener diode, short circuit of CR20 diode, short circuit of C18 capacitor, open circuit of R36 resistor, open circuit between slider of R37 potentiometer and R36 resistor	Continuity check; repair defective wiring; replace any defective component; check for and correct if necessary open circuit of R39 resistor which will damage Q13 and Q14 transistors; check for and correct, if necessary,

POSSIBLE CAUSE	PROCEDURE
	open circuit between slider of R37 potentiometer and negative dc output which will damage Q13 transistor.

H. Variation of Ambient Temperature Causes Variation of DC Output Voltage

POSSIBLE CAUSE	PROCEDURE
Short circuit of one or more CR5 through CR11 diodes.	Replace defective diode.

I. DC Output Voltage and Output Current Zero, No Fuse or Circuit Breaker Open, No Low-Voltage Alarm Given

POSSIBLE CAUSE	PROCEDURE
Poor contact of output polarity selector plug.	Clean contacts if necessary; reinsert plug to make proper contact.

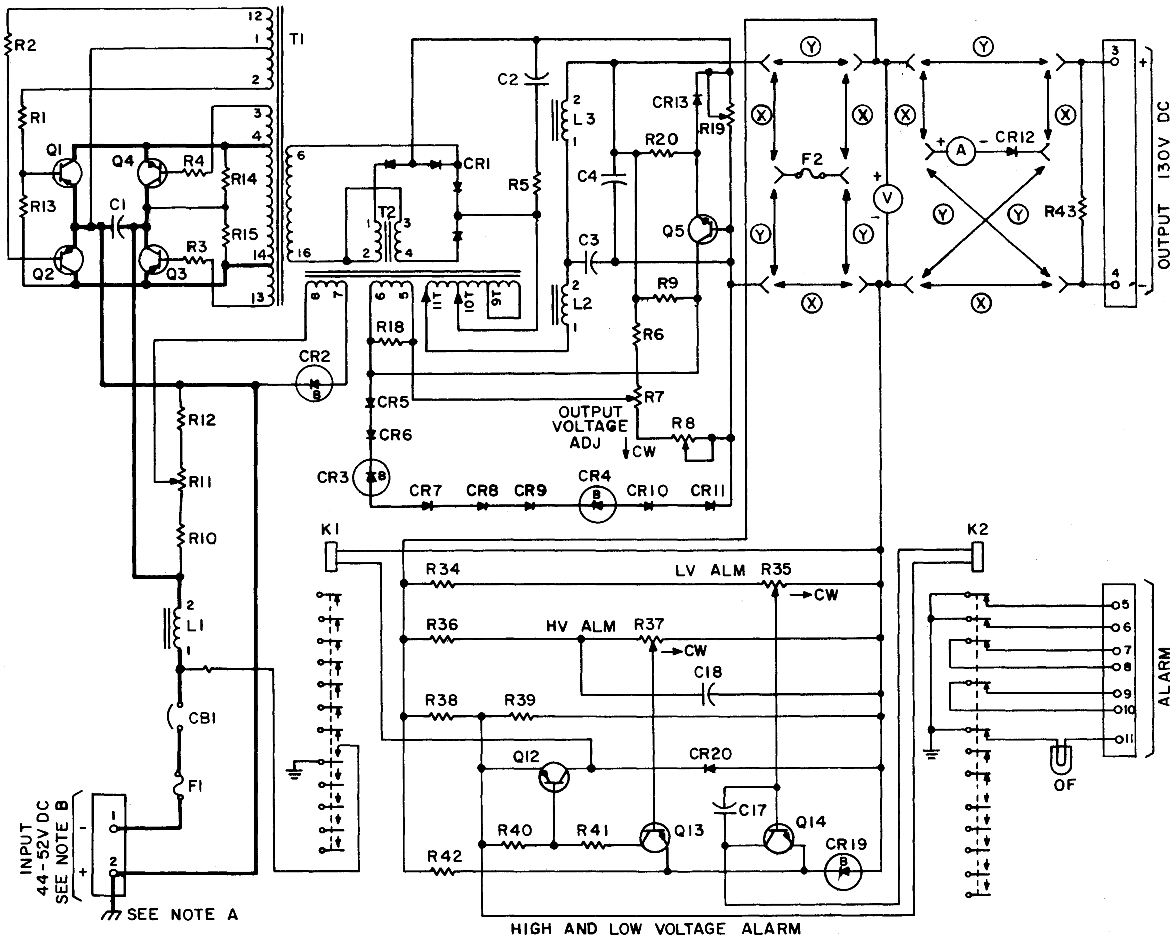
J. Noise At Input Battery

POSSIBLE CAUSE	PROCEDURE
Open circuit of C1 capacitor, short circuit of L1 choke.	Replace defective capacitor or choke. To test L1 choke for short circuit, with converter in operation, carefully apply a short circuit across L1 choke; if this does not increase noise at dc input, a short circuit of L1 choke exists.

K. Noise at DC Load

POSSIBLE CAUSE	PROCEDURE
Open circuit of C3 or C4 capacitor, short circuit of L2 or L3 choke.	Replace defective C3 or C4 capacitor; replace defective L2 or L3 choke. To test L3 choke for short circuit with converter in operation, carefully short-circuit L3 choke; if this does not increase noise at dc input, short circuit of L3 choke exists.

Caution: Under no circumstances should a short circuit be applied across L2 choke. Short circuit of L2 choke may cause failure of one or more Q1 through Q4 transistors.



NOTES:

A. POSITIVE GROUND TO CHASSIS PROVIDED BY JUMPER. REMOVAL OPTIONAL AFTER INSTALLATION.

B. CONNECT INPUT TO BATTERY SIDE OF FILTER IN PLANTS HAVING DISCHARGE FILTER IN SERIES WITH LOAD.

C. Ⓧ OPTION CAN BE OBTAINED BY HAVING REVERSIBLE PLUG IN "NEG GROUND" POSITION.
Ⓨ OPTION CAN BE OBTAINED BY HAVING REVERSIBLE PLUG IN "POS GROUND" POSITION.

PARTS LIST

DESIG	DESCRIPTION	DESIG	DESCRIPTION	DESIG	DESCRIPTION
C1	2000 MFD 60V DC CAP.	L1	INPUT CHOKE	R13	3000Ω 5W RESISTOR
C2	0.1 MFD 600V DC CAP.	L2.3	OUTPUT CHOKE	R14,15	750Ω 5W RESISTOR
C3,4	440 MFD 150V DC CAP.	OF	48C LAMP, OUTPUT FAILURE, 48V,.	R18,40	1000Ω 1/2W RESISTOR
C17	20 MFD 50V DC CAP.		04A	R19	1Ω 10W POT.
C18	800 MFD 75V DC CAP.	Q1-4	LORAIN PRODUCTS CO., PART NO.	R20	27,00CΩ 2W RESISTOR
			1411AS, 2N174 TRANSISTOR ASSEMBLY.	R34,36	6000Ω 5W RESISTOR
CB1	HEINEMANN CKT BKR	Q5,13,14	2N333A TRANSISTOR	R35,37	750Ω 2W POT.
		Q12	2N525 TRANSISTOR	R38	1500Ω 25W RESISTOR
CR1	4JA411CM1AD1 SILICON RECT STACK			R41	3300Ω 1/2W RESISTOR
CR2-4	SV-11 BREAKDOWN DIODE	R1-4	4Ω 10W RESISTOR	R42	20,000Ω 2W RESISTOR
CR5-11	S-320G TEMP COMP DIODE	R5	250Ω 10W RESISTOR	R43	10,000Ω 5W RESISTOR
CR12	1N1344A DIODE	R6	1000Ω 25W LOW TEMP COEFF		
CR13,20	1N537 DIODE		RESISTOR	T1	POWER TRANSFORMER
CR19	1N750A ZENER DIODE	R7	75Ω 4W POT.	T2	TRANSDUCTOR
		R8	250Ω 10W DIVIDOHM		
F1	10 AMP ABC INPUT FUSE	R9	25,000Ω 10W RESISTOR	A	0-3A DC AMMETER
F2	3 AMP AGC OUTPUT FUSE	R10	1500Ω 10W RESISTOR		
		R11	400Ω 10W POT.	V	0-150V DC VOLTMETER
K1,2	WECO WIRE SPRING RELAY	R12,39	400Ω 5W RESISTOR		

Fig. 3 — Schematic Diagram — KS-19303 L1 DC-to-DC Converter