INSTRUCTION MANUAL

FOR

VON MODEL BI-.35S1

THE VON CORPORATION
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Additional sections and revisions to this manual for the VON Model BI35S and BI-. 35S1 will be sent as they are written. Please address any correspondence concerning this manual to the attention of Fred von Herrmann.

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I INTRODUCTION

Your new BI-.35S or BI-.35S1 was designed to provide fault locating, high voltage D.C. testing and megohm measuring capabilities in one complete and simple to use package. All major components have been built and carefully tested to give you years of trouble free service.

We, at the VON Corporation, are constantly trying to improve our equipment. We would appreciate any comments or suggestions which you may have.

We hope you will share any techniques or applications you find especially useful with us, so that we may share them with all VON users through application notes and instruction manual changes.

Please keep us informed of the names of personnel to receive application notes and instruction manual changes.

For any questions concerning this equipment or its application, write or call:

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II RECEIVING AND CHECKING OUT

The BI-.35S or BI-.35S1 is packed to arrive in good condition. Unpack and check to see that there is no physical damage. The correct operation of the input ammeter, output microammeter, and kilovoltmeter will give assurance that all is well. The unit may be checked out by the following tests.

A) Prepare the unit to test as described in the suggested procedure in Section VI. Short the output lead to its shield. Push the "on/off-discharge" lever down to switch the unit "on" and turn the variable autotransformer slowly clockwise. The input ammeter should increase smoothly. The output microammeter should increase smoothly and go off scale on all ranges. If there is any arcing noise or erratic indication, see Section VIII. Turn the variable autotransformer full counterclockwise and pull the "on/off-discharge" lever up to switch the unit "off".

B) Disconnect the output lead from the BI-.35S or BI-.35S1. Push the "on/off-discharge" lever down to switch the unit "on" and turn the variable autotransformer slowly clockwise to run the voltage up to 35kv. The kilovoltmeter should increase smoothly as the variable autotransformer is increased. If there is any arcing noise or erratic indication, see Section VIII. Turn the variable autotransformer full counterclockwise and pull the "on/off-discharge" lever up to switch the unit "off".

C) Prepare the unit to fault locate as described in Section VI-C. Plug the output lead into the output impulse socket. Connect a three foot (1 meter) or longer piece of #12 wire between the center of the high voltage output lead and its shield to short circuit the output. Turn the impulse control gap full clockwise to close it. Push the "on/off-discharge" lever down to switch the unit "on". Turn the variable autotransformer slowly clockwise. The input ammeter should increase smoothly. The kilovoltmeter should stay on zero. The output current meter will stay zero since it is not in the circuit during impulse fault locating. When the current reaches about 2.5 amps (1.5 amps for BI-.35SE), turn the impulse control gap handle counterclockwise to open the gap and allow the capacitor to charge up to voltage. Continue adjusting the gap until 30kv is reached. If adjustment is erratic, the gap enclosure should be checked for cleanliness. Turn variable autotransformer full counterclockwise and pull the "on/off-discharge" lever up to shut the unit down. The BI-.35S or BI-.35S1 responds to a short circuit on its output cable the same as it does on a faulted cable.

A good way to gain familiarity in operating the unit in the test mode is to test a reel of shielded high voltage cable. It will be necessary to peal back the semiconductor and shield wires for four to six inches at both ends of the cable being tested. The unit can also be used to check the spill over voltage of lightning arrestors if their voltage spill over rating is 35,000 volts or less.

Practice with the unit in the fault locating mode can be done with a short piece of shielded cable by driving a nail through the insulation to the conductor and then pulling it out. Be sure to prepare the ends of the cable so that the impulse will bang at the fault and not at the ends from the central conductor to the ground shield or semiconducting layer.

III SAFETY

Personnel safety is a most vital concern when testing and fault locating. The wearing of insulated safety gloves is strongly recommended while fault locating and must be worn when making or disconnecting connections to the cable being worked on. Follow company safety practice of grounding before touching a cable termination.

Always ground the cable to be tested or fault located upon before connecting or disconnecting this unit. This equipment is designed to be used on unenergized cable only. Some users have mistakenly connected this equipment to energized 15kv cable. This does considerable equipment damage and is very hazardous since the leads used and the internal components are not large enough to handle likely system fault current.

This fault locating unit has a special low inductance 1 microfarad 30kv capacitor designed to deliver heavy current, very steep wave front impulse. This capacitor is in the circuit when testing as well as during fault locating. Extreme care should be taken that no one accidentally comes in contact with the high voltage.

Normally, a piece of high voltage test equipment such as this will be connected to a piece of insulation having a relatively high capacity. Contact with the high voltage lead output clamp while it is connected to such a piece of insulation will quite likely be lethal regardless of the characteristics of the test equipment being used. Therefore, all terminations of insulation during testing or fault locating should be roped off or otherwise protected so that the unaware can not come in contact with them.

In fault locating, grounding is the most important concern for safe operation. The set is provided with two ground check relays. One relay requires a positive ground on the case of the equipment and a ground on the power source. Its circuit checks for continuity (less that 50 ohms) between the case and the ground connection in the socket where the input cord is connected. Thus the case of any portable generator used must be grounded. The second relay requires the shield of the high voltage test lead with its output ground clamp be connected to a ground within 50 ohms of the ground on the case. A ground stud is provided in the lead compartment for connecting the case to a driven ground. Use a #12 or larger cable for this connection.

One ground check relay controls the power to the HV transformer. The discharge resistor in the "on/off-discharge" lever activates a limit switch in the ON position. This switch energizes the relay only if the case of the unit is grounded and has continuity with the ground terminal of the socket where the input power cord is connected. Also the case ground must have continuity with the output ground clamp at the end of the high voltage test lead. The 2.5 megohm discharge resistor is designed to bring the voltage to zero rapidly without oscillations or a violent bang.

Varistors protect the equipment from the discharge returning through the input power cord from the input power source ground. The discharge may return through the power source ground when it is closer to the fault than the ground on the case of the unit. Caution in making the ground connections is very important for good operation as well as safety. Firm connections should be made from the case with short heavy leads to all grounds available including the system neutral.

THE MOST IMPORTANT SAFETY FEATURE

A full recognition on the part of the operator of the inherent danger always present with the use of high voltages will be the most important safety feature that can be applied in the use of this equipment. Your operating procedures should be so designed as to minimize this danger. The operator of the VON test unit should be responsible for seeing that each member of the assisting crew is thoroughly familiar with the dangers involved. Most personnel who normally work with high operating voltages have a healthy respect for high voltages. It may be necessary for the operator of this equipment to convince them that a small testing unit is actually capable of delivering the high voltages he will be using.

This manual recommends that all grounds and neutrals be tied together for safety to present the lowest possible resistance to the return impulse. The impulse is similar to a lightning bolt. In most utility situations, it is next to impossible to isolate the concentric neutral of the faulted cable from the system neutral.

Some companies try to isolate the neutral of the faulted cable from the system neutral. To be effective, this policy requires more than just disconnecting the cable neutrals at both ends of a concentric neutral cable. If an impulse fault locator is connected to system power, then the impulse will attempt to return to the impulse capacitor through the input power cord. This is especially true if other primary cables are buried in the same trench. The problem is further increased if the neutral of the faulted cable is open between the tester and the fault. Since we believe the input cord is an undesirable return path, VON testers do not have the input neutral tied to the case as common with competitive units. 361 Volt varistors are provided to limit the voltage difference between the input and the case. 361 volt varistors are also provided to limit the voltage difference between the shield of the high voltage test lead with its ground clamp and the case.

To isolate the unit from the system neutral, it must be operated from the inverter or a portable generator which is also isolated from the system neutral and only tied to the faulted cable neutral. Connecting the tester to an auxiliary driven or screw ground close to the case and separate from the system neutral is recommended in this situation. If the auxiliary ground is not used, the tester case and the portable generator or truck are then treated as hot, since instantaneous voltage differences are likely to appear between the earth and the faulted cable neutral. The wearing of insulated safety gloves by the tester operator would be mandatory.

IV DESCRIPTION

The BI-.35S and BI-.35S1 are two man portable 30kv capacitive discharge cable fault locators, 35kv D.C. testers and 30kv megohmmeters. The basic fault locating system consists of a 1 microfarad 30kv capacitor, an impulse control gap, and a power supply. The VON BI-.35S and BI-.35S1 use an enclosed air gap to connect and disconnect the capacitor to the faulted cable. This has several advantages over relays, solenoids, and rotating gaps. The simple gap has no moving parts and is maintenance free other than occasional cleaning of the plastic enclosure. The capacitor bank can be charged to its rated level of joules regardless of the fault characteristics. Many important advantages are offered by the VON capacitive discharge system in the field since 1958.

One - The specially designed 1 microfarad capacitor is tested at 150% of its rating as opposed to the industry standard of 110%.

Two - Heavy duty internal connections provide the strength and flexibility to withstand almost instant discharge. Thus, the series resistance and inductance found in most competitive units are not needed to protect the capacitor. This allows the impulse gap to produce a discharge with a rise time as short as 6 nanoseconds (as measured by the National Research Council of Canada).

Three - The VON impulse gap will discharge the capacitor only when it has charged to the voltage necessary to jump over the adjustable gap. The gap may be adjusted in use by the operator to get the maximum bang at the fault.

Four - The very fast rise time pulse (steep wave front of approximately 10 nanoseconds) provides maximum noise without extensive burning of the fault. Water filled faults are normally an advantage.

Five - The almost silent gap allows one to find underground cable faults even when the unit is set up directly over them.

The maximum number of discharges per minute is determined by the size of the D.C. power supply. After each discharge, the power supply must charge the capacitor bank. The variable autotransformer on the power supply is used to adjust the rate of discharge. The BI-35 is designed for a continuous rate of discharge every six seconds at 30kv.

The high voltage D.C. test portion of the tester has the VON feature of current metering in the high voltage output lead. This automatically guards out the leakage in the test equipment itself so that true leakage reading can be obtained whatever the age and condition of the test equipment. The high quality 0-10 microamp taut band current meter is shunted to provide seven overlapping ranges. The protective circuit prevents the meter from being damaged electrically due to overload or flashover.

The kilovoltmeter is a special high torque meter built for the VON Corporation to provide excellent repeatability. It is connected directly to the high voltage output through a resistance divider network selected for low temperature coefficient.

The megohm measuring capability of this equipment is provided on the output current meter through two megohms scales just above the 0-10 and 0-30 microamp scales. By selecting the desired test voltage and the most readable output current range, megohms can be read directly without the use of a calculator or graph paper.

THE VON CORPORATION ®

VON MODEL BI-.35S1 IMPULSE FAULT LOCATOR (THUMPER) & HI-MEG D.C. TESTER

6 MA CONTINUOUS AT 35 KV
612 JOULES AT 35 KV

TWO MAN PORTABLE COMBINATION 30 KV CAPACITOR DISCHARGE CABLE FAULT LOCATOR, 35KV 6MA D.C. TESTER AND 35KV MEGOHMMETER

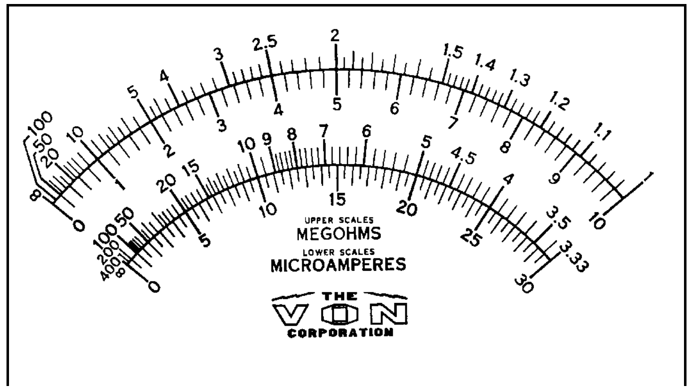
24 HOUR TELEFAX NUMBER (205) 780-4015

1038 Lomb Avenue, S.W. Birmingham, Alabama 35211 Phone (205) 788-2437

WEIGHT - 115 pounds (52.3 kg)
WIDTH - 15.125" (38.5 cm)
HEIGHT - 24.5" (62.3 cm)
LENGTH - 23" (58.4 cm) over handles
INPUT - 110-125 volts 50-400 hz A.C. or 12 volts D.C. (optional)
IMPULSE - 6 nanosecond rise time, 450 joules at 30kv continuous, up to 612 joules at 35kv intermittent, random timing (6 second cycle at 30kv)
TESTING - 6 ma to 35kv, 1% ripple
CASE - Aluminum with grey finish

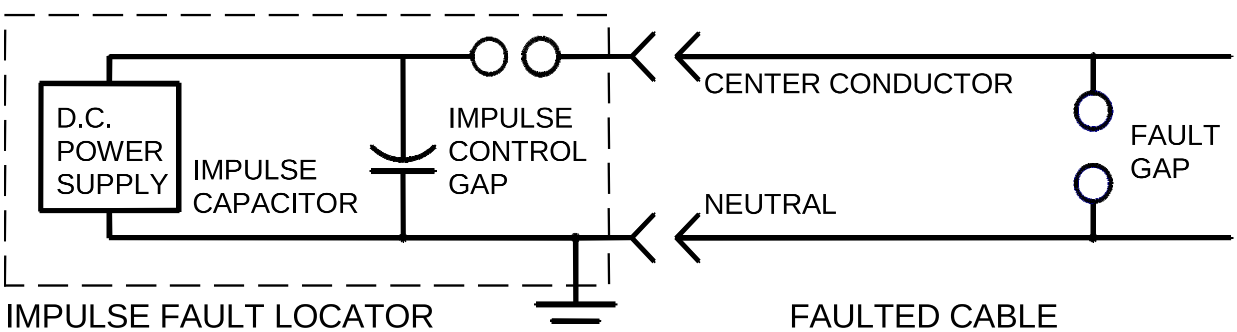
This two man portable unit contains:

1. A 35kv 1mfd. low inductance impulse service capacitor.
2. A VON continuously adjustable impulse control gap.
3. High reliability VON voltage doubler circuit with silicon rectifiers.
4. The fully protected output meter in the high voltage lead indicates true leakage readings. Ranges 0-10 mic, 0-30 mic, 0-100 mic, 0-300 mic, 0-1 ma, 0-3 ma, 0-10 ma.
5. Megohm scales on the output meter allow direct resistance reading from 100,000 ohms to 300,000 megohms.
6. A 0-5 amp A.C. ammeter in input of the 110 volt to 13kv air insulated epoxy impregnated high voltage transformer.
7. A rugged taut band high torque kilovoltmeter wit ranges of 0-10kv, 0-35kv.
8. A variable autotransformer for continuous voltage adjusment.



9. Power on and off-discharge switch discharges cable through a 2.5 megohm resistor.
10. Two ground relay systems require that the case ground, the 120 volt source ground, and the test lead ground be within 100 ohms or each other in order to operate the unit.
11. Separate sockets for testing and fault locating.
12. Varistors are provided between the 120 volt input lines and the case to provide surge protection to the equipment.
13. Shielded test lead, 35 feet (10.6M) long. Other lengths are available such as 60 feet and 75 feet.
14. Optional built in inverter with 15 ft.(4.6m) battery leads permits operation from a 12 volt truck battery.

THEORY: The capacitive discharge system is the most universally accepted way to locate underground cable faults. It is still the only system that works reliably on shielded cable such as URD type concentric neutral cable.



The basic capacitor discharge system consists of a capacitor, a high voltage D.C. power supply, and a means of connecting and disconnecting the capacitor to the center conductor of the faulted cable such as an impulse control gap. These components are shown in the simplified diagram below. The fault is shown as a gap. This is an accurate description of faults on URD type cable since a fault is a hole or cut in the insulation between the center conductor and the grounded semiconductor, shield wires and earth.

The objective of the system is to dump the stored electrical energy in the impulse capacitor into the cable fault such that an audible noise or thump is made. The thump should be loud enough to be heard and felt by personnel without detectors walking above the cable. The amount of energy available at the fault to "thump" the ground or ductwork is related to the characteristics of the fault gap, the electrical impedance of the path from the discharge capacitor to the fault and back, the energy in the discharge, the voltage of the discharge, and the rise time of the discharge. A fast rise time provides maximum noise at the fault with the least energy.

After each discharge, the power supply must charge the capacitor bank. The variable autotransformer on the power supply is used to adjust the rate of discharge. VON systems are designed for a continuous rate of discharge every six seconds at 30kv. The discharge voltage of the capacitor is related to the impulse control gap voltage and the fault gap voltage since they are in series. By adjusting the impulse control gap, the impulse capacitor can be charged to its rated voltage regardless of the characteristics of the fault gap. This allows the fault to be located with minimum energy and voltage. To locate a fault the voltage rating of the discharge capacitor must exceed the voltage rating of the fault gap. The 35kv maximum discharge voltage has proven to be sufficient for all presently installed solid dielectric distribution cable.

BIG THUMP FAULT LOCATOR AND HI-MEG D.C. TESTER
OPERATING INSTRUCTIONS

Caution: The output of this unit can be as lethal as a live high voltage AC conductor. Wear insulated safety gloves when connecting or disconnecting the unit to cable and equipment. We recommend that insulated safety gloves be worn while impulse fault locating. **Always externally ground cable and equipment terminals to be sure they are not energized!**

Safety: Standard safety practices must be followed when operating this high voltage equipment. ALWAYS externally ground all cable or equipment terminals before making or breaking connections. Make sure that good ground connections are made to the case of the unit. The high current (100,000 amp) very fast discharge impulse (6 nanosecond rise time) returns to the unit by the lowest impedance path to ground. **Never install or remove the hv test lead unless the on-off lever is in the off-discharge position and the kilovoltmeter reads zero.** A ground relay is provided to prevent this unit from operating when the resistance between the 120 volt input line ground, the HV test lead ground clamp, and the case ground exceeds 100 ohms. The 120 volt input lines and the case are tied together with varistors so an alternate ground is always available.

General:

1.   Prepare cable and equipment by disconnecting it from service and grounding it to insure it is unenergized. ALWAYS externally ground cable and equipment before making and breaking connections. Isolate all terminations with safety tape or barriers so that personnel cannot come in contact with high voltage. Disconnect any accessories such as CT's that cannot withstand the test voltage to be used.

2. Remove the top cover. Open the end storage compartment. Remove the coaxial test lead, ground lead, and the input power cord.

3. Insure that the on-off lever is in the OFF-DISCHARGE position, the variable autotransformer is turned to zero, and the voltmeter reads zero before plugging the test lead into the output test or output impulse socket as required. A slight mechanical resistance will be felt as banana plugs in the HV test lead connector mate. Tighten the wing nut to hold the HV connector in position.

4.   Connect the case ground stud to a good ground. Connect the HV test lead ground clamp to the cable neutral or equipment ground and any nearby grounds such as the system neutral. The shield of the HV test lead provides the return path for the impulse and must be grounded to operate the ground relay. If no ground is available at the terminations, run a separate lead to the HV test lead ground clamp from a good ground. The flexible #16 ground lead furnished is suitable for testing, but at least a #10 lead should be used when fault locating.

5.   **Follow all company safety practices when connecting or disconnecting the conductor under test. Ground** the cable or equipment to insure it is unenergized before connecting or disconnecting. Connect the center conductor of the test lead to the termination of the cable or sample under test. When testing clean all terminations of the cable to prevent surface leakage. When testing above 30kv, it will be necessary to wrap the sharp edges of all terminations of the cable with polyethylene bags, sheet plastic, or glass jars, duct seal, etc., to eliminate corona from the leakage measurements.

6. A. Line - Plug the power cord into a 110 to 130 volt 60 to 600 hertz service with its third ground wire actually connected to a ground with a resistance of less than 50 ohms to the case ground.
    B. Inverter - Connect the battery leads from the inverter to a 12 volt battery with red-positive and black-negative. The negative side of the battery <u>must</u> be grounded for the unit to operate. A high frequency hum indicates the inverter is working. Plug the input line cord into the inverter for power. Due to 20 ampere battery drain while fault locating, leave the vehicle engine operating. Battery drain is only 5 amps while testing.

7.   Set the kilovoltmeter range switch for best resolution at the maximum test or discharge voltage selected.

8.   After locating the fault or completing the test as described below, pull the on-off lever up for off and discharge. Watch the kilovoltmeter to insure the voltage is zero. Place a solid external ground on the cable.   **Follow all company safety practices when disconnecting the test lead from the cable.**

FAULT LOCATING: Decide the best voltage at which the faulted cable should be impulsed or thumped. For 15kv and above rated cable, this would be between 12kv and 30kv. Turn the control gap handle in the storage compartment full clockwise to close. Be sure the test lead is installed in the output impulse socket. Push the on-off lever down. A click will be heard as the ground relay picks up. Turn the variable autotransformer clockwise until the input ammeter reads about 2.5 amps. Open the impulse control gap by turning the handle in the counterclockwise direction until the kilovoltmeter reads the desired voltage upon discharge. A rise and fall of the kilovoltmeter indicates the capacitor is discharging across the fault. Adjust the variable autotransformer until the average current is 2.5 amps for maximum rate. The resistance of a wet or carbonized fault is apt to change for a while as it is pulsed. Therefore during the first 15 minutes or so, adjust the gap and variable autotransformer as necessary to keep the impulse voltage stable. Faults are located by the noise of the discharge that occurs at the point of failure. For direct buried cable, walk the cable listening and feeling for a thump. In rigid conduit, duct or overhead, listen for a ping or a crack.

TESTING: Decide the test voltage to be used. Be sure the test lead is installed in the output test socket.   Push the on-off lever down. A click will be heard as the ground relay picks up. Rotate the variable autotransformer clockwise until the test voltage selected is reached. Turn the output current range switch to the lowest range or until the output current meter reads in the upper two thirds of its scale. Hold test voltage on the cable for the specified time. Record test voltage and output current or record megohm resistance.

THE MEGOHM SCALE: Megohms are listed above both the 0-10 and 0-30 scales on the output current meter. To measure megohms resistance with minimum calculation, set the output voltage precisely on a value selected from the chart. Turn the output current range switch to the lowest range or until the output meter reads in the middle or the right third of its scale. Record the megohm reading just above the current scale used and multiply this by the multiplier found on the chart for megohms resistance. As a check, the minimum, center scale, and maximum resistance readings are listed for each range setting.

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	RANGE	MEGOHM MULTIPLIER				
VOLTAGE TEST	SWITCH SETTING	UPPER SCALE	LOWER SCALE	MAXIMUM OHMS	CENTER OHMS	MINIMUM OHMS
1,000 V	10 mA	.1		10 MEG	200,000	100,000
	3 mA		.1	40 MEG	666,000	333,000
	1 mA	1		100 MEG	2 MEG	1 MEG
	300 mic		1	400 MEG	6.66 MEG	3.33 MEG
	100 mic	10		1,000 MEG	20 MEG	10 MEG
	30 mic		10	4,000 MEG	66.6 MEG	33.3 MEG
	10 mic	100		10,000 MEG	200 MEG	100 MEG
2,500 V	10 mA	.25		25 MEG	500,000	250,000
	3 mA		.25	100 MEG	1.66 MEG	832,000
	1 mA	2.5		250 MEG	5 MEG	2.5 MEG
	300 mic		2.5	1,000 MEG	16.6 MEG	8.32 MEG
	100 mic	25		2,500 MEG	50 MEG	25 MEG
	30 mic		25	10,000 MEG	166 MEG	83.2 MEG
	10 mic	250		25,000 MEG	500 MEG	250 MEG
5,000 V	10 mA	.5		50 MEG	1 MEG	500,000
	3 mA		.5	200 MEG	3.33 MEG	1.66 MEG
	1 mA	5		500 MEG	10 MEG	5 MEG
	300 mic		5	2,000 MEG	33.3 MEG	16.6 MEG
	100 mic	50		5,000 MEG	100 MEG	50 MEG
	30 mic		50	20,000 MEG	333 MEG	166 MEG
	10 mic	500		50,000 MEG	1,000 MEG	500 MEG
10,000 V	10 mA	1		100 MEG	2 MEG	1 MEG
	3 mA		1	400 MEG	6.66 MEG	3.33 MEG
	1 mA	10		1,000 MEG	20 MEG	10 MEG
	300 mic		10	4,000 MEG	66.6 MEG	33.3 MEG
	100 mic	100		10,000 MEG	200 MEG	100 MEG
	30 mic		100	40,000 MEG	666 MEG	333 MEG
	10 mic	1,000		100,000 MEG	2,000 MEG	1,000 MEG
20,000 V	10 mA	2		200 MEG	4 MEG	2 MEG
	3 mA		2	800 MEG	13.3 MEG	6.66 MEG
	1 mA	20		2,000 MEG	40 MEG	20 MEG
	300 mic		20	8,000 MEG	133 MEG	66.6 MEG
	100 mic	200		20,000 MEG	400 MEG	200 MEG
	30 mic		200	80,000 MEG	1,333 MEG	666 MEG
	10 mic	2,000		200,000 MEG	4,000 MEG	2,000 MEG
30,000 V	10 mA	3		300 MEG	6 MEG	3 MEG
	3 mA		3	1,200 MEG	19.9 MEG	9.99 MEG
	1 mA	30		3,000 MEG	60 MEG	30 MEG
	300 mic		30	12,000 MEG	199 MEG	99.9 MEG
	100 mic	300		30,000 MEG	600 MEG	300 MEG
	30 mic		300	120,000 MEG	1,999 MEG	999 MEG
	10 mic	3,00		300,000	6,000 MEG	3,000 MEG

VI-B OPERATION - GENERAL

To operate, plug the high voltage lead into the test or impulse socket. Fasten firmly with the wing nuts. Connect the shield of the high voltage test lead with its ground clamp to a good ground. Also the case of the unit must be connected to a good ground with a heavy lead. A ground stud is located in the lead compartment. When cable fault locating, the shield of the high voltage test lead must be tied to the neutral of the faulted cable.

The unit is designed to be used only on unenergized equipment. Always momentarily ground the cable or machine under test before connecting them to the center conductor of the test lead. If a ground is not convenient at the test point, run a ground wire from the test lead ground clamp to a good ground. Connect the output high voltage lead to the cable or machine under test after being sure they are not energized. Plug the unit into a 120 volt power socket (240 volt for BI-.35SE) whose ground terminal is actually within 50 ohms of case ground. The ground relay circuit requires continuity between the case, the ground terminal of the socket where the input cord is connected, and the shield of the high voltage test lead with its ground clamp.

The variable autotransformer is used to vary the voltage. The "on/off-discharge" lever is located in the lead compartment. The circuit breaker on the top panel with the toggle handle is normally always left ON. Watch the kilovoltmeter to insure the voltage is zero before touching the high voltage output connector with a ground. It takes several seconds for the voltage to reach zero after turning the "on/off-discharge" lever to OFF-DISCHARGE.

When testing, the output microammeter located under the clear plastic window indicates the charging and leakage current. The meter is protected against continuous and intermittent overload with a varistor.

When fault locating, the discharge voltage is adjusted by opening and closing the control gap with the 1.125" diameter white plastic handle within the lead compartment. The discharge repetition rate and load on the tester is adjusted by the variable autotransformer. With the VON system, the slowest repetition rate is at the maximum voltage.

Operation with a 30kv pulse at faster than a 4 second cycle on a continuous 15 minute or more basis will overheat the unit and may cause permanent damage to the variable autotransformer.

VI-C OPERATION - TESTING PROCEDURE

1. Prepare the cable for testing by disconnecting it from service. Isolate all terminations of the cable with safety tape or barriers so that personnel cannot come in contact with high voltage. **ALWAYS** externally ground cable and equipment terminals to be sure they are not energized before connecting the unit! Wear insulated safety gloves when connecting or disconnecting the unit to the cable and equipment. Disconnect any accessories such as CT's that can not withstand the test voltage to be used.

2. Remove the top cover. Open the end storage compartment. Remove the coaxial high voltage test lead, the ground lead, and the input power cord.

3. Insure that the "on/off-discharge" lever is in the OFF-DISCHARGE position, the variable autotransformer is turned to zero, and the kilovoltmeter reads zero before plugging the HV test lead into the output test socket. **NEVER** install or remove the HV test lead unless the "on/off-discharge" lever is in the OFF-DISCHARGE position and the kilovoltmeter reads zero. A slight mechanical resistance will be felt as the banana plugs in the HV test lead connector mate. Tighten the wing nut to hold the HV connector in position.

4. Connect the case ground stud to a good ground. Connect the HV test lead ground clamp to the cable neutral or equipment ground and any nearby grounds such as the system neutral. The shield of the HV test lead provides the return path for the impulse and must be grounded to operate the ground relay. If no ground is available at the terminations, run a separate lead to the HV test lead ground clamp from a good ground. If the resistance between grounds exceeds 50 ohms the unit will not operate.

5. FOLLOW ALL COMPANY SAFETY PRACTICES WHEN CONNECTING OR DISCONNECTING TO CABLE AND EQUIPMENT. GROUND the cable and equipment to insure it is unenergized before connecting or disconnecting. Connect the center conductor of the HV test lead to the termination of the cable or equipment under test. When testing, clean all terminations to prevent surface leakage. When testing above 30kv, it will be necessary to wrap the sharp metal edges of all terminations with polyethylene bags, sheet plastic, or glass jars, duct seal, etc., to eliminate corona from the leakage measurements.

6. Rope off or suitably protect personnel from the terminations of the insulation under test.

7. A. Line - Plug the power cord into a 110 to 130 volt 60 to 600 hertz service with its third ground wire actually connected to a ground with a resistance of less than 50 ohms to the case ground. The BI-.35SE is designed to operate from a 210 to 280 volt 50 hertz service.

B. Inverter - Connect the battery leads from the inverter to a 12 volt battery with red-positive and black-negative. The negative side of the battery must be connected to a ground with a resistance of less than 50 ohms to the case ground for the unit to operate. A high frequency hum indicates the inverter is working. Plug the input line cord into the inverter for power. Battery drain is about 5 amps while testing.

8. Set the kilovoltmeter range switch for best resolution at the maximum test or impulse voltage selected.

9. Push the "on/off-discharge" lever down to ON. The pilot light should turn on and a slight click may be heard as the ground relay picks up.

10. Rotate the variable autotransformer clockwise until the required test voltage is reached. Hold test voltage on the cable for the specified time.

11. Turn the output current range switch to the lowest range or until the output current meter reads in the upper two thirds of its scale.

12. Hold voltage for required time and record test voltage and output current or record megohms resistance using the chart in the top cover.

13. Turn variable autotransformer to zero.

14. Pull the "on/off-discharge" lever up to OFF-DISCHARGE.

15. Attach the external ground to the insulation under test after the kilovoltmeter reads zero. If the insulation is not returned to service immediately, the ground should be left on for three to five times as long as any high voltage was applied.

Photograph of the unit set up for cable testing and operation from its inverter. The combination high voltage output and ground return cable goes off to the left. A ground must be connected to the case. The input power cord is plugged directly into the inverter. The battery leads go to a 12 volt battery with red to positive and black to negative.

VI-D OPERATION - CABLE FAULT LOCATION PROCEDURE

1. Prepare the cable for testing by disconnecting it from service. Isolate all terminations of the cable with safety tape or barriers so that personnel cannot come in contact with high voltage. **ALWAYS** externally ground cable and equipment terminals to be sure they are not energized before connecting the unit! Wear insulated safety gloves when connecting or disconnecting the unit to the cable and equipment.

2. Remove the top cover. Open the end storage compartment. Remove the coaxial high voltage test lead, the ground lead, and the input power cord.

3. Insure that the "on/off-discharge" lever is up in the OFF-DISCHARGE position, the variable autotransformer is turned to zero, and the kilovoltmeter reads zero before plugging the HV test lead into the output test socket. **NEVER** install or remove the HV test lead unless the "on/off-discharge" lever is in the OFF-DISCHARGE position and the kilovoltmeter reads zero. A slight mechanical resistance will be felt as the banana plugs in the HV test lead connector mate. Tighten the wing nut to hold the HV connector in position.

4. Connect the case ground stud to a good ground. Connect the HV test lead ground clamp to the cable neutral and any nearby grounds such as the system neutral. Due to the high currents involved while fault locating, insure that the very best ground possible goes to this clamp. The shield of the HV test lead provides the return path for the impulse and must be grounded to operate the ground relay. If no ground is available at the terminations, run a separate lead to the HV test lead ground clamp from a good ground. Use at least a #10 ground lead. If the resistance between grounds exceeds 50 ohms the unit will not operate.

5. FOLLOW ALL COMPANY SAFETY PRACTICES WHEN CONNECTING OR DISCONNECTING TO CABLE AND EQUIPMENT. GROUND the cable and equipment to insure it is unenergized before connecting or disconnecting. Connect the center conductor of the HV test lead to the termination of the cable to be fault located. measurements.

6. Rope off or suitably protect personnel from the terminations of the insulation under test.

7. A. Line - Plug the power cord into a 110 to 130 volt 60 to 600 hertz service with its third ground wire actually connected to a ground with a resistance of less than 50 ohms to the case ground. The BI-.35SE is designed to operate from a 210 to 280 volt 50 hertz service.
   B. Inverter - Connect the battery leads from the inverter to a 12 volt battery with red-positive and black-negative. The negative side of the battery must be connected to a ground with a resistance of less than 50 ohms to the case ground for the unit to operate. A high frequency hum indicates the inverter is working. Plug the input line cord into the inverter for power. Due to 20 ampere battery

drain while fault locating, leave the vehicle engine operating.

8. Turn the control gap handle in the storage compartment full clockwise to close. Be sure the HV test lead is installed in the output impulse socket. Push the "on/off-discharge" lever down to ON. The pilot light should turn on and a slight click may be heard as the ground relay picks up.

9. Adjust to the desired fault locating voltage with the variable autotransformer and the impulse control gap. For 5kv and above cable the impulse voltage will normally be between 10kv and 30kv. Turn the variable autotransformer clockwise until the input A.C. ammeter reads about 2.5 amps (1.5 amps for BI-.35SE). Adjust the impulse voltage with the gap by one of the methods below.

   A. Start with the gap closed and open by turning counterclockwise until the desired discharge voltage is reached.

   B. Open gap very wide. Set desired voltage with the variable autotransformer. Close gap by turning clockwise until impulsing starts. Leave gap at this setting.

   C. Start with gap set as previously used on a fault. Raise the voltage slowly until the capacitor discharges, being careful not to exceed 35kv. Then open or close gap, to maintain discharge at 30kv or below. This is the most popular method.

The variable autotransformer is then used to adjust the time interval between pulses by controlling the speed with which the impulse capacitor is charged. For maximum rate of discharge, set the average input current on 2.5 amps (1.5 amps for BI-.35SE). Do not be concerned with the peak current if the current is less than 2.5 amps (1.5 amps for BI-.35SE) for an equal amount of time. Do not impulse faster than every four seconds. Impulsing at a very fast rate causes the fault gap to heat up reducing the noise. Eventually the fault may begin burning instead of making a "thump" sound.

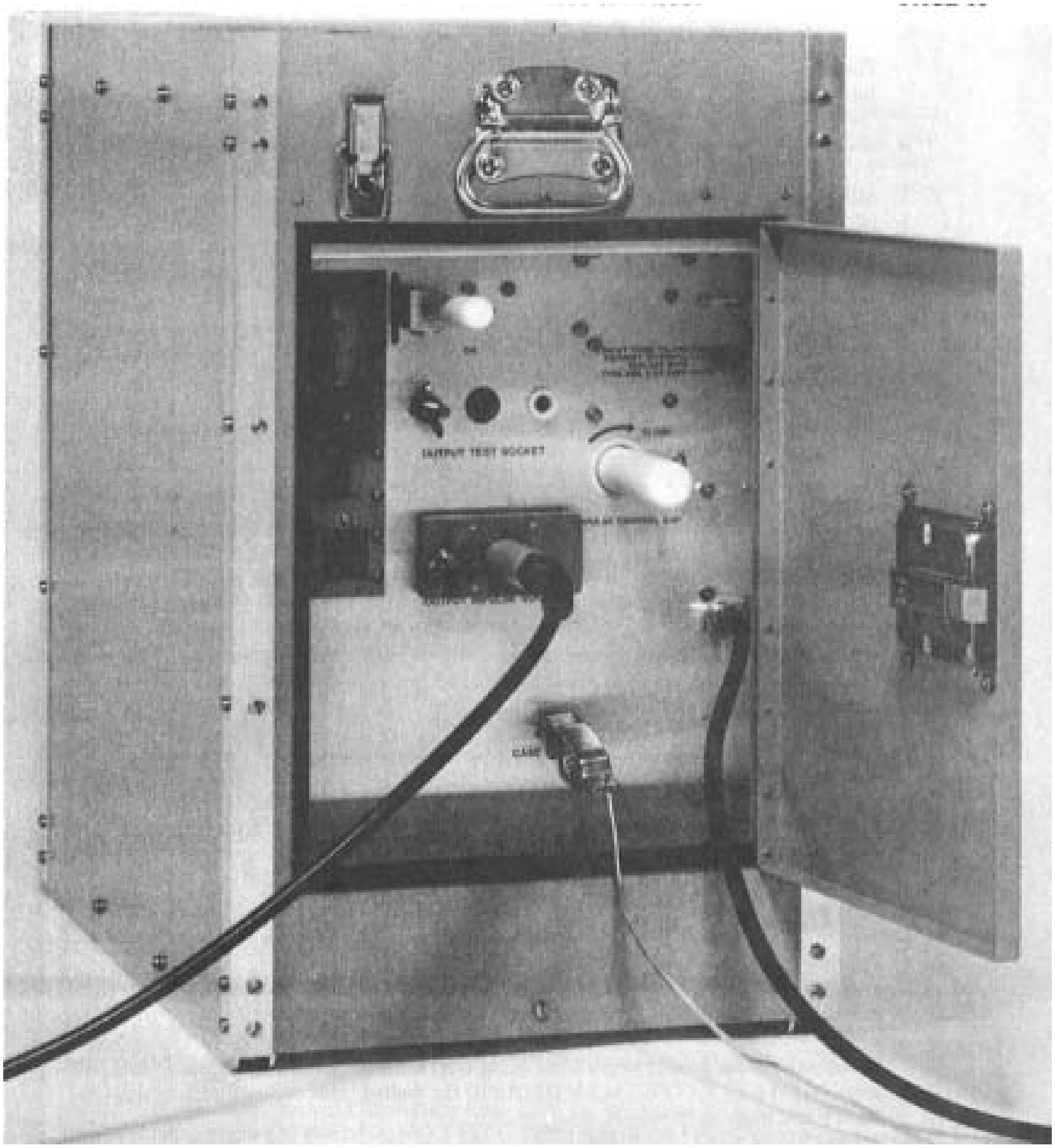
10. Faults are located by the noise of the discharge that occurs at the point of failure. Locate the fault by walking along the bad cable.

11. Turn variable autotransformer counterclockwise to zero.

12. Pull the "on/off-discharge" lever up to OFF-DISCHARGE.

13. Turn the impulse control gap full clockwise to zero.

14. Attach an external ground to the cable being worked on after the kilovoltmeter reads zero. ALWAYS EXTERNALLY GROUND the faulted cable before disconnecting the HV test lead



Photograph of the unit set up for cable fault locating. The high voltage output and ground return cable goes off to the left. The input power cord is off to the right. The required ground lead to the case goes off to the right. The main ground return through the test lead should be connected solidly to the neutral of the cable to be thumped and the system neutral. The impulse control gap handle is located in the right corner of the lead compartment to the right of the output impulse socket.

VI-E OPERATION - PROCEDURE FOR ADDING ADDITIONAL CAPACITORS

Additional discharge capacitors may be added in parallel with the internal 1 microfarad discharge capacitor. An accessory impulse control gap and impulse service capacitor are all that is required. With each additional microfarad added, the time between each discharge will increase. To connect the external capacitor bank to the BI-.35S or BI-.35S1.

A. Plug the test lead into "output impulse." Close the control gap internal to the BI-.35S or BI-.35S1 by turning full clockwise.

B. Connect the center of the output lead to the high voltage terminal of the external capacitor being added.

C. Connect the ground terminal of the output lead to the ground terminal of the external capacitor.

D. Run a heavy lead from the external capacitor ground to the cable neutral and all available grounds.

E. Mount the control gap on the output of the external impulse service capacitor.

F. Connect the output of the external impulse control gap to the faulted cable with a heavy short lead.

Operate the unit as normal except the discharge voltage is adjusted with the external impulse control gap instead of the internal gap.

VI-F OPERATION FROM INVERTER

Connect the two D.C. leads to a grounded battery, red to positive, black to negative. The negative terminal of the battery must be tied to the same ground that the tester is connected to. A high pitched hum indicates the inverter is working. Turn on the circuit breaker if no hum is heard. Plug the BI-.35 input power cord into the inverter receptacle when you are ready to operate the unit. In all cases the ground stud on the case of the BI-.35S or BI-.35S1 must be tied to a good ground for the unit to operate. With the BI-.35SE or BI-.35S1E set the input voltage selector to 240 volts.

The inverter is provided with a shorting diode to protect the transistors in case the positive and negative leads are reversed. The 30 amp circuit breaker will open when this occurs.

The inverter has no-load current of about 5 amps and draws almost 25 amps at full load when fault locating. Therefore, it is recommended that the vehicle be left running when fault locating for more than 10 minutes.

The inverter is self-protecting and will go into harmonics when overloaded. Continued blowing of the circuit breaker indicates incorrect input polarity or a failed transistor. The inverter is removed from the cabinet for servicing by taking out the screws around the edge. When the inverter is removed from the unit, the hole in the storage compartment must be covered to keep the operators hands out of the unit. When testing at high D.C. voltages, the inverter offers the most stable readings. It compares favorably with operation at 60 hertz from a very good voltage regulator.

VI-G OPERATION - TIPS

1. Always have the best grounds available connected to the test lead ground clamp and to the case ground stud. This gives the best bang and the safest operation.

2. A rule of thumb in impulse fault locating is that the better the ground connections and the shorter the test lead, the better the thump.

3. A fault while testing is indicated by a sudden increase in output current and a drop in the output voltage. Shut down and fault locate. DO NOT burn down a fault unless you wish to use radar to localize the fault. The first bang of the fault locator usually clears out the carbon formed by any such burning attempt.

4. This unit will locate one or more faults. It is a good idea to check both halves of a faulted cable before repairing. Multiple faults may require additional impulse fault locating. After repair, the insulation should be checked again before returning to service.

5. The test lead should be kept clean. If a reading is obtained on the microammeter at 35kv when the end is hanging free and protected from corona by wrapping with polyethylene, the end should be remade by peeling back the outer PVC & shield to expose fresh insulation.

6. On long runs where radar will not be used to determine a distance the fault, many find it helpful to impulse the cable for 3 to 5 minutes before searching for the fault. This is usually the time required to get a stable noise at the fault. The set will have to be watched and adjusted during this time to insure that the voltage stays on scale and out of the red region on the meter scale.

7. At 25-35kv watch out for corona at the terminations when testing. It can be eliminated by wrapping the terminations with polyethylene or covering with a plastic Clorox bottle.

8. Never store the unit in a closed area when it is wet. The set is partially sealed so it can be operated in a light rain. Be careful to keep water from collecting on the panel and getting into the meters. After operation when wet, dry the unit out overnight by leaving in a warm, low humidity location with air blowing across the unit.

9. The input ammeter provides an indication of how hard the tester is working. Since the BI-.35S or BI-.35S1 is rated 300 watts, keep the average reading at 2.5 amps (1.5 amps for BI-.35SE) or below. Don't worry about short time pegging of the meter if the time average is okay.

10. On unshielded secondary cable start with the lowest voltage at which a thump is indicated on the ammeter. This is normally between 6kv and 8kv. Increase the voltage as necessary to hear the thump sound at the fault.

11. If the fault gap voltage is higher than 30kv, do not hesitate to thump to the full 35kv rating of the unit. The 30 to 35kv portion of the kilovoltmeter scale is colored red only to indicate that for normal operation one should not continuously thump above 30kv. The life of the internal discharge capacitor may be shortened if the unit thumps at 35kv all the time.

12. Make connections to a dead-front distribution system so that the cable elbows are not disturbed if possible. One method is to connect the tester output clamp to a stud in one bushing of an insulated feed-through with the cable elbow on the second bushing. Be sure the drain wire is connected to the elbow. Remember to put the far end of the cable on an insulated standoff to prevent flashovers inside the elbow.

VII TEST LEAD

The high voltage test lead is meant to be easily replaced by the operator when it becomes unserviceable. Its condition can be checked by plugging into the test mode, hanging the end free with the hot line clamp wrapped in polyethylene, and measuring the leakage at high voltage. If any leakage can be read on the 10 microamp range up to 35kv, the polyethylene insulation at the end is probably dirty. Clean it up. If this does not eliminate the leakage, increase the distance of the hot terminal to the nearest ground and any ungrounded metal object. From about 25kv to 35kv, it may be necessary to bag the end with polyethylene to eliminate the corona from any sharp points on the connector. If the lead still shows leakage, it may be necessary to remake the end to provide the creepage distance of clean polyethylene.

The wire used in the test lead is RG-8U with polyethylene insulation. It can be obtained at most radio supply houses. If various length test leads are desired, additional plugs or extra leads can be obtained at the factory.

For testing the lead can be made as long as several hundred feet. For fault locating the lead should be kept as short as possible consistent with convenience. The 35 foot length furnished with the tester is expected to be suitable for most applications.

When installing the HV connector on a new cable, remove the outer PVC jacket of the RG-8U and push the shield wires back for 8" (20.3 cm) of insulation. Strip back the insulation at the end for the banana plug and tin the conductor. Install the plastic strain relief and then the handle and plate which are the outside part of the connector over the outer cable jacket. Cut down the diameter of the insulation for one inch (2.5cm) at the end so it will fit through the threaded hole of the plastic probe. Push the cable through the probe and solder on the giant banana plug. When the plug cools, thread it into the plastic probe. Be careful not to twist the cable while screwing the banana plug into the plastic probe. Solder the ground wires to the giant banana plug screwed into the plastic plate. Cut off all excess wire that would prevent the two halves of the connector from fitting together. Fasten the outside and inside halves of the connector together with the four screws. Tighten the plastic strain relief in the handle against the outside of the cable.

VIII IN CASE OF DIFFICULTY

The number one cause of difficulty encountered is attempting to operate the unit without proper grounds. The ground relay circuit prevents the unit from operating without a grounded power supply, a ground on the case of the unit, and a ground on the shield of the high voltage output lead. The input green ground wire must be within 50 ohms of the case ground. Also the shield of the output test lead with its ground clamp must be connected to all grounds available including the electrical system neutral to insure it is within 50 ohms of the case ground. See circuit diagrams.

Light does not come "on" when unit is plugged into inverter or	1.	The light operates only when "on/off-discharge" lever is ON and circuit breaker is ON.

120 volt power (240 volt power for units with option E)

2. Check input circuit breaker.
3. Check the input fuse.
4. Check grounding of unit.
5. Check bulb for serviceability.

Tester will not operate when operating lever is pulled down

1. Check for ground on the input power circuit, the output test lead, and the case. Be sure to check the ground prong on any extension cord used. There must be continuity between the ground on the socket where the input cord is connected, the shield of the output test lead and the case of the unit for the equipment to operate.
2. Check unit by running a jumper from the input power cord green grounding wire to the case of the unit. If this lets the tester operate, correct input power circuit ground. There must be less than 50 ohms between the case ground and the input power circuit ground.
3. Check unit by running a jumper from the ground where the test lead ground clamp is connected to the case of the unit. If this lets the tester operate, correct the grounds. There must be less than 50 ohms between the case ground and the test lead shield ground.
4. Check to insure circuit breaker is ON and input fuse (close to the input cord) is good.
5. Read operating instructions again.

6. Take side off unit and check
   a. for loose connections.
   b. to insure discharge resistor depresses microswitch SW2BI when it is ON.
   c. to insure 12 volts A.C. is available from T7.
   d. for continuity in the coil on relay H3.

Tester will not thump

1. Check circuit connections to insure there is a good return path for the electrical discharge.
2. If there is current but no voltage, open the control gap.
3. If there is voltage but no current, close the control gap.
4. If voltage goes to 30kv when gap is closed you are connected to a good cable. Discharge cable and ground. Then change over to the faulted cable.

NOTE: To check the gap, short circuit the output test lead to its shield wire using a three foot or longer piece of #12 wire. Impulse the short length of wire. With the gap closed, there should be A.C. input amps but no charging and discharging action. As the gap is opened, the capacitor should charge up and discharge in a normal manner. It should be possible to open the gap until the capacitor charges to 30kv with each discharge.

5. If the gap does not control the voltage, the gap case may have tracked. Clean gap to remove track marks.
6. After a good deal of operation, the control gap may become tracked and bridge the control gap. Remove the sides of the tester in order to disassemble the control gap for cleaning. Clean with solvent such as mineral spirits.

Varistor melts	Caused by fault locating without adequate grounds when the impulse returns through the 120 or 240 volt system neutral to the capacitor instead of through the test lead shield.
Corona noise in the unit while testing	1. Check for loose connections. 2. Begin storing the unit in a location where it will be more dry.
Arcing noise in unit while thumping.	1. Check connections between test lead handle and socket. 2. Take side off unit and check connection between impulse control gap and brass impulse socket. 3. Check for hole in impulse control gap case.
Breaker trips while thumping above 20kv	1. The average input A.C. amperes should not exceed 2.75 amps. (1.5 amps for BI-.35SE) 2. Check capacitor C-1. Normally if there are no holes or cracks in the capacitor, it is okay. 3. Check capacitor #C2 for oil leaks or bulge in the case.
Breaker trips or fuse blows when the unit is plugged in.	1. Check that input power source is 110 to 150 volts A.C. 2. Check to insure variable auto- transformer is not turned to maximum. 3. Check for shorts inside the unit between the 120 volt or 240 volt power leads and the case. Check wires to top panel inside the six prong connector to insure they are not shorted to the case. See the maintenance and storage section for disassembly instructions.

Tester will not operate from a portable generator	1. Check generator case and ground terminal of its output socket to see if grounded. There must be less than 50 ohms resistance between the case ground and input supply ground. Connect grounds. 2. If driven ground is used on the generator, insure that it is a good as the ground on the case.
Maximum output voltage less than 3kv although ground relay picks up	Indicates open in neutral of input supply. 1. Check input circuit breaker. 2. Check input power cord for broken wires or loose connections.
Input fuse blows	Indicates 120 volt input power cord was connected to 240 volts or 277 volts. With BI-.35SE indicates the selector switch where provided was in the 120 volt position. Fuse is designed to protect autotransformer.
Oil in bottom of unit	Indicates leak in impulse service capacitor. Leak must be repaired immediately before service capacitor fails. Capacitor can be repaired for much less than a new capacitor. Repair may be handled on a trade-in basis. The service capacitor is the most expensive part in the Bi-.35S and BI-.35S1. Contact factory for instructions.
No voltage indication on kilovoltmeter	1. Observe kilovoltmeter to insure the pointer is not sticking. Check kilovoltmeter for proper operation (0-50 microamps D.C. movement). Ground all components before doing the following checks with the back side of the unit removed. 2. Check 9,900 ohm resistor R2 between service capacitor and output current meter box. 3. Check kilovoltmeter resistor around output test socket to insure it is not loose or broken. 4. Check connection between the aluminum portion of the output test socket holding the kilovoltmeter resistor and the output current meter assembly.

	5. Check for short circuit to the case in wire connection between kilovoltmeter resistor R-1 and the kilovoltmeter on the top panel.
No output current indication	Ground all components before doing the following checks with the side off the tester. 1. Check wire connection between the brass center of the aluminum output test socket and the red lead from output current meter assembly. 2. Check output test socket assembly to insure that the brass center connection is insulated from the outside aluminum connection. 3. Disassemble output current meter assembly. Check capacitor across meter.
Shock from case of BI-.35S or BI-.35S1 tester when plugging in	Indicates case of tester is not grounded or is connected to a ground that has more than 50 ohms resistance to the 120 volt or 240 volt source ground.
Shock from case of BI-.35S or BI-.35S1 tester when thumping	Indicates case of the unit is not satisfactorily grounded. Use a heavier lead to the system neutral and tie to all grounds available. If this does not stop the problem it will be necessary to drive a special ground rod near the case and connect it with a heavy lead to the case ground stud in the lead compartment.
Arcing on test lead	Tighten connections until arcing stops.
Hole in test lead	Cut off bad portion of lead. Peel outer PVC and copper shield wires back 18" from end. Remake the end and install the hot line clamps per Section VII.
High input A.C. amps.	1. Check for shorts inside the unit between the 120 volt or 240 volt power leads and the case. 2. Check capacitor C-1. Normally if there are no holes or cracks in the capacitor, it is okay. 3. Check the two high voltage rectifiers. Normally if there are no black areas or cracks on the rectifiers, they are okay. 4. If problem cannot be found, run unit from three to five minutes with 2.5 amps (1.5 amps for BI-.35SE) input. This will heat up the defective part. Ground all parts before touching to determine heat. The rectifiers

and capacitors in the unit normally run at room temperature.

IX MAINTENANCE AND STORAGE

No maintenance should be required except to keep the unit clean, dry and tighten any loose screws. The banana plugs on the test lead connector should be replaced if they becomes burned. Consult the factory for replacements.

After two or three years of operation, the impulse control gap will have to be taken apart and cleaned with a good cleaner such as mineral spirits. It may be necessary to replace the brass receptacle of the impulse socket at this time as it may burn and not fit the test lead banana plug snugly.

If it becomes necessary to open the unit, pull the input plug and insure the kilovoltmeter reads zero volts. To enter the unit, take off one or both sides but not the aluminum corner angles. To take off a side, remove all screws on that side. Loosen the screws on both ends of the unit which also hold the outer corner angles. This will allow the side to slip out.

Always ground the large discharge capacitor with a separate lead before working on the unit. All checks should be down with the output cable shorted so that voltages will be kept to a minimum for safety.

Storage of the unit should be in a location where water will not condense on the insulation internal to the unit. If storage must be in a damp location like a basement, keep the unit slightly warmer than its surrounds to prevent condensation. A 60 watt bulb burning under the storage shelf works well.

If the banana plug on the test lead is burned or damaged, replace to prevent pitting of the sockets. Use Smith #285 giant banana plug.

Verification of A-1 operating condition of the unit may be accomplished by duplicating three tests done on the final checkout of the unit at the factory. The only extra equipment required is an inexpensive transistor radio preferably without automatic volume control.

The first test consists of setting the unit up with the output lead in the test socket. Short the output lead to its shield with a lead long enough to make a loop around the radio. The unit is turned on and the variable autotransformer turned clockwise until the input ammeter reads 2.5 amps (1.5 amps for BI-.35SE). Any loud or unusual noise other than a little static caused by turning the variable autotransformer indicates an open circuit. Correct any opens before the second test.

The second test consists of hanging the test lead end away from all grounds and running the unit up to its rated voltage. Remember the ground clamp of the test lead must be tied to ground. The kilovoltmeter should increase smoothly. The unit should operate without radio noise. At the factory, the unit is required to be corona free at 120% of its voltage rating before shipment.

The third test consists of plugging the output lead into the output impulse socket. Connect a three foot or longer piece of #12 wire between the center of the high voltage output lead and its shield to short circuit the output. Remember the ground clamp of the test lead must be tied to ground. Turn the impulse control gap full clockwise to close it. Push the "on/off-discharge" lever down to switch the unit ON. Turn the variable autotransformer slowly clockwise. The input ammeter should increase smoothly. The kilovoltmeter should stay on zero. The output current meter will stay zero since it is not in the circuit during impulse fault locating. When the current reaches at 2.5 amps (1.5 amps for BI-.35SE), turn the impulse control gap counterclockwise to open and allow the capacitor to charge up to voltage. Continue adjustment up to 30kv. Turn variable autotransformer full counterclockwise and pull the "on/off-discharge" lever up to the OFF-DISCHARGE position to shut the unit down. If the voltage does not adjust smoothly, check and clean impulse control gap. Tighten any connections that arc during the test.

X CIRCUIT DIAGRAM,PARTS PLACEMENT, AND PARTS LIST

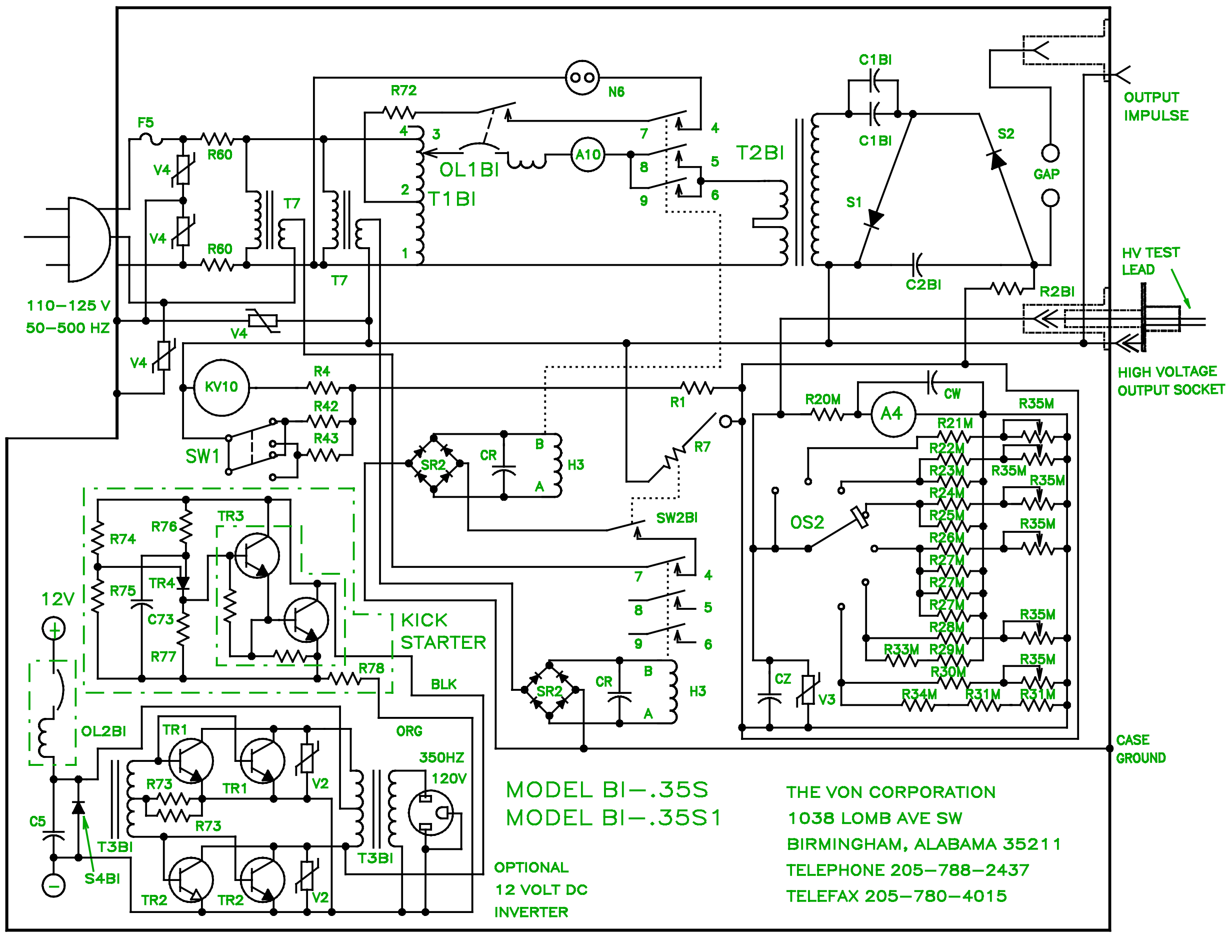


Figure 1 Circuit diagram of 120 volt Model BI-.35S

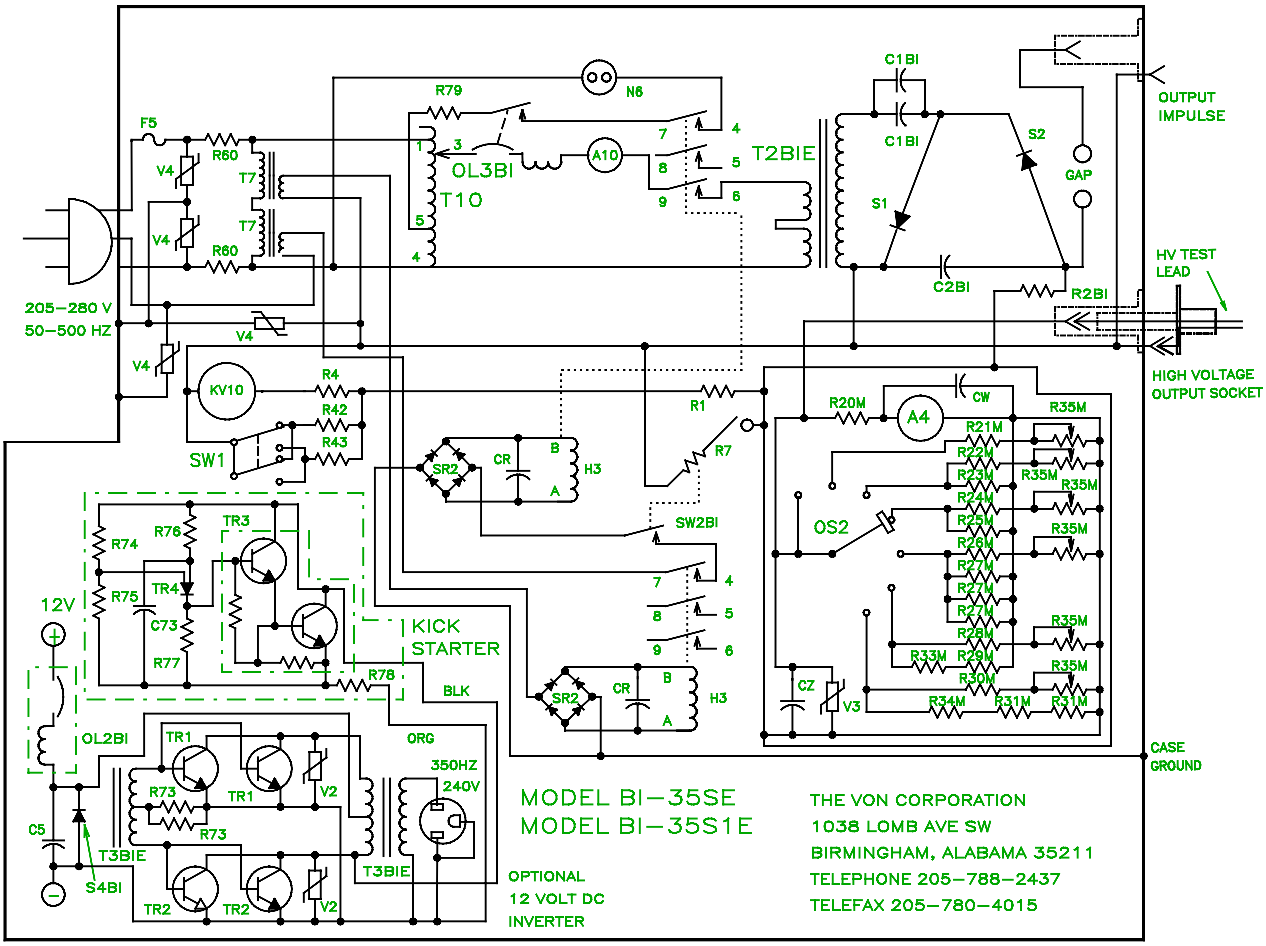


Figure 2 Circuit diagram for 240 volt Model BI-.35SE and BI-.35S1E

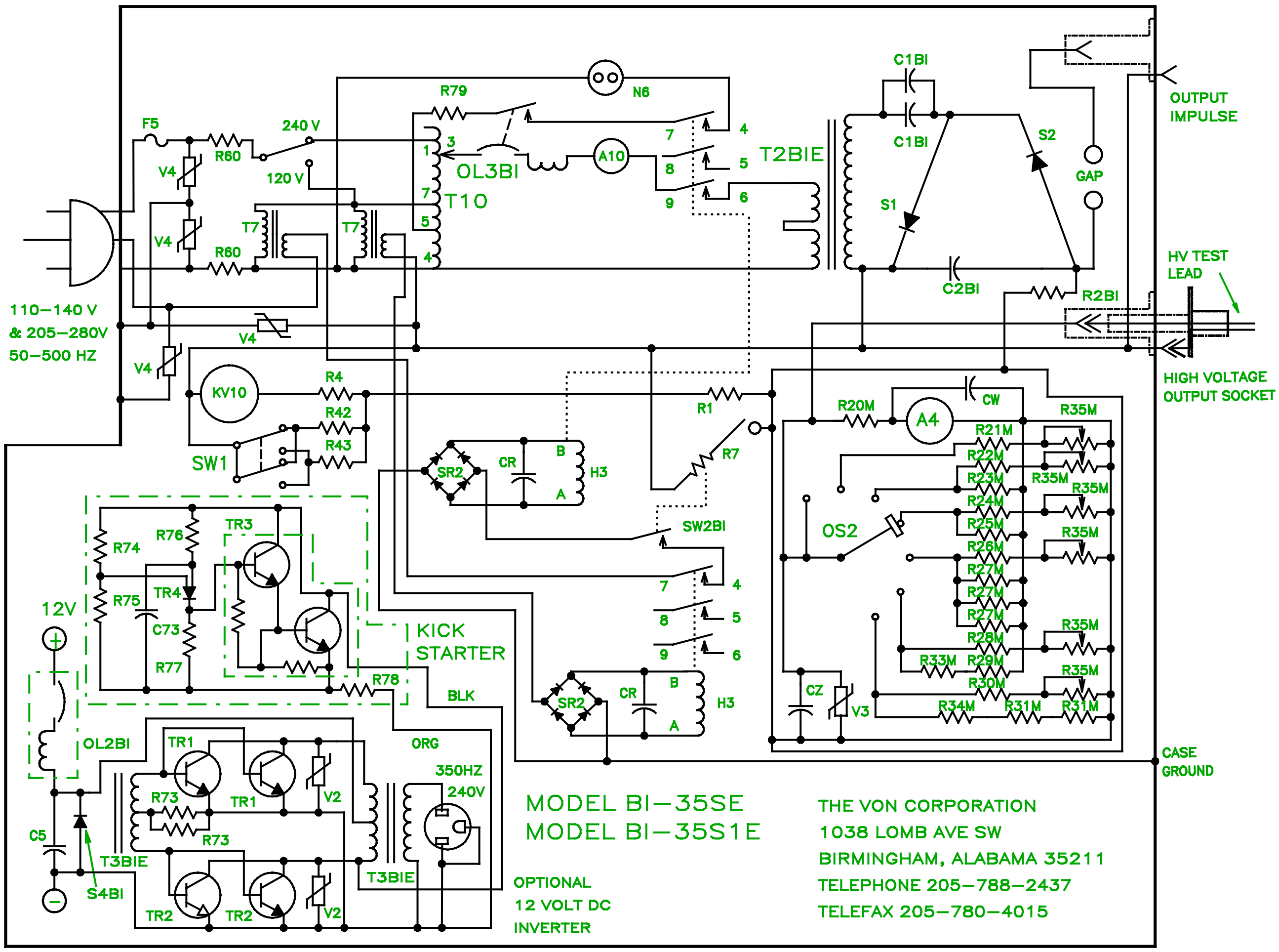


Figure 3 Circuit diagram for 120/240 volt Model BI-.35SE and BI-.35S1E

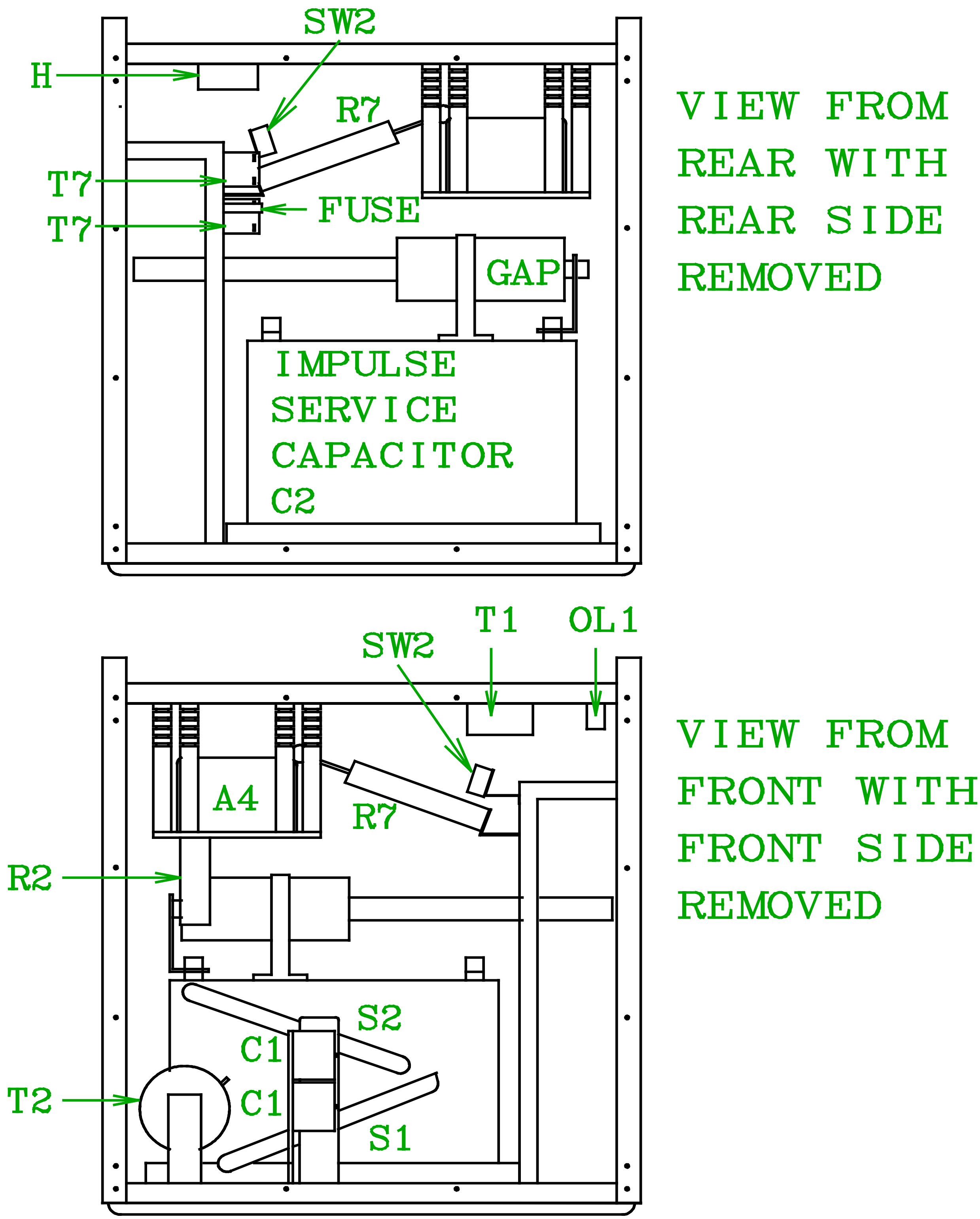


Figure 4 Parts placement in Model BI-.35S

PARTS LIST FOR VON MODEL BI-.35S and BI-.35S1

A10 - Meter, 0-5 A.C. amps Triplett 330G
A4 -Meter, 0-10 microamps D.C. Triplett 420G

C1BI - Capacitor, 40kv 1800 pfd. ceramic
C2BI - Capacitor, 35kv 1mfd. impulse service
C5 - Capacitor, 50 volt 760 mfd. or 25 volts 645 mfd. for inverter
C73 - Capacitor .1mfd 50 volt ceramic
CR - Capacitor, ground relay 150 volts 33 mfd.
CW - Capacitor 25 volts 10 mfd. - part of current meter calibrating board
CZ - Capacitor 200 volts .047 mfd. - part of current meter calibrating board

H3 - Relay 3PDT 12 VOLT D.C coil IDEC #RR3B-US-DC12 to check grounding of the unit.

K1 -Kick starter for inverter

KV10 - Meter, 0-50 D.C. microamps reading 0-10/35 kilovolts Triplett 420G

N6 - Lamp, 28 volts bayonet base #757

OL1BI - Circuit breaker 2.6 amp short delay sealed toggle (standard)
OL2BI - Circuit breaker, 30 amp D.C. toggle
OL3BI - Circuit breaker, 1.5 amp sealed toggle (export version)

SW1 - Switch, kilovolt range 2 pole double throw toggle #4X850

OS2 - Switch, current range 1 pole 7 position shorting for units with printed circuit board & trimpot current meter calibration

R1 - Resistor, kilovoltmeter 175 megohms
R2BI - Resistor 9,900 ohm
R7 - Resistor, discharge 2.5 megohms
R4 - Resistor, 150,000 ohms 2 watts
R20M - Resistor, 1.5 megohm 1/4 watt
R21M - Resistor, 715K ohm 1/4 watt
R22M - Resistor, 348K ohm 1/4 watt
R23M - Resistor, 301K ohm 1/4 watt
R24M - Resistor, 165 ohm 1/4 watt
R25M - Resistor, 71.5K ohm 1/4 watt
R26M - Resistor, 78.7K ohm 1/4 watt
R27M - Resistor, 53.6K ohm 1/4 watt
R28M - Resistor, 34.8K ohm 1/4 watt
R29M - Resistor, 487 ohms 1/4 watt
R30M - Resistor 11K ohm 1/4 watt
R31M - Resistor 40.2 ohms 1/4 watt
R33M - Resistor, 5K ohms 2 watts
R34M - Resistor, 1.5K ohm 10 watts
R35M - Resistor, 50K ohms
R36M - Resistor, 50 ohms 220 watts (240 volt units for export)

R42 - Resistor, calibrating 10kv range
R43 - Resistor, calibrating 35kv range
R60 - Resistor, 1 ohm 50 watts
R72 - Resistor, 350 ohms 3 watts
R73 - Resistor, 1 ohm 25 watt
R74 - Resistor, 10k ohms .25 watt
R75 - Resistor, 27k ohms .25 watt
R76 - Resistor, 200k ohms .25 watt
R77 - Resistor, 100 ohms .25 watt
R78 - Resistor, 33 ohms 1 watt
R79 - Resistor 220 ohms 3 watts

S1,2 - Rectifier, high voltage 50kv piv, 15ma

S4BI - Rectifier, diode crowbar #MR750 for inverter
SR2 - Rectifier, bridge 1,000 volts 1 amp for 12 volt relay
SW1 - Switch, input selector
SW2BI- Switch, snap action rigid lever Grainger 6X284

T1BI- Autotransformer, variable 120 volts 2.75 Staco #033-1750 - standard
- Autotransformer, variable 120 volts 3.1 amp Technipower #W2 (special)

T2BI- Transformer 100 volt 13kv air insulated high voltage
T2BIE Transformer 200 volt 13kv air insulated high voltage
T3BIE- Transformer, inverter 240 volt square wave output
T3BI- Transformer, inverter 120 volt square wave output
T7 - Transformer, 120 volts/12 volts 2.4va Signal #241-3-12

T10 -Autotransformer, variable 220 volts Technipower 3W5H (export)
TR1,2 - Transistor, #MJ13330 or equivalent for inverter
TR3 - Transistor, #TIP102
TR4 - Transistor. programmable unijunction # 2N6027

V2 - Varistor 68 volts Panasonic 14K680
V3 - Varistor 121 volts Panasonic 20K121
V4 - Varistor 361 volts Panasonic 32EK361

XI CAPACITOR DISCHARGE OR IMPULSE CABLE FAULT LOCATING(THUMPING) THEORY

The capacitive discharge system is the most universally accepted way to locate underground cable faults. Though a very old system, it is still the only system that works reliably on shielded cable such as URD type concentric neutral cable. It also works on unshielded underground secondary and street light cable.

The basic capacitor discharge system consists of a capacitor, a high voltage D.C. power supply, and a means of connecting and disconnecting the capacitor to the center conductor of the faulted cable such as a control gap. The objective of the system is to dissipate the electrical energy stored in the capacitor at the cable fault such that an audible noise or thump is made. The thump should be loud enough to be head and felt by personnel without detectors walking above the cable. The energy dissipated in the fault should be in the form of shock waves which are easily transmitted through the ground or ductwork.

The noise at the fault is related to the energy in the discharge, the voltage of the discharge, the electrical impedance of the path from the discharge capacitor to the fault and back, and the rise time of the discharge. Under ideal conditions, the current in the discharge will be several hundred thousand amperes. The voltage at which the capacitor is discharged determines the joules of energy stored in the capacitor and thus the amount of energy available at the fault. A simplified diagram shows the various components of the system.

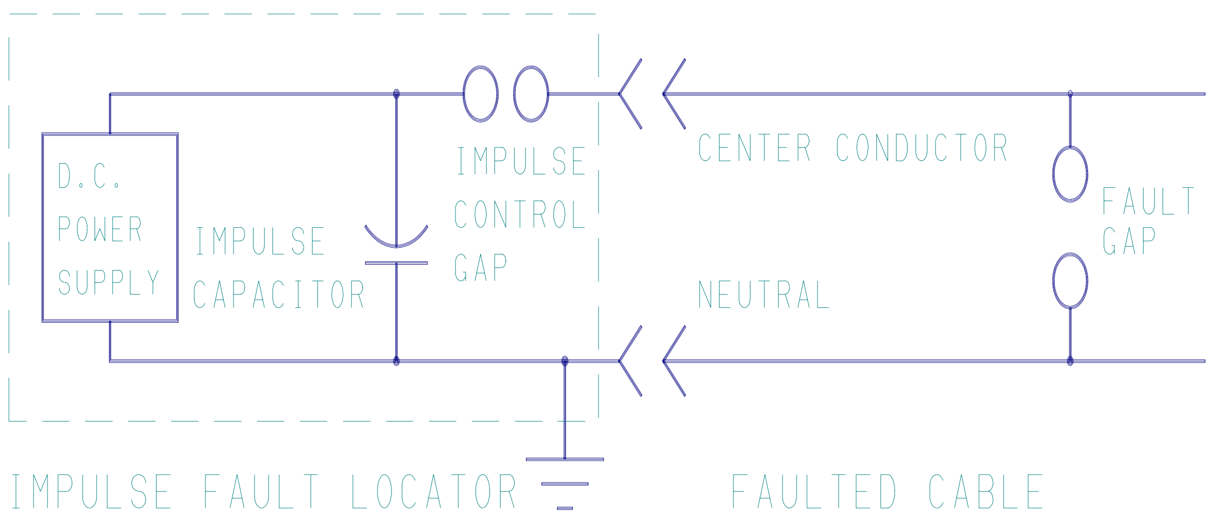


Figure 5 CAPACITOR DISCHARGE CIRCUIT

Note the fault is shown as a gap. This is an accurate characterization of a fault. A fault is a hole or cut in the insulation between the center conductor and the grounded semiconductor, shield wires and earth. An actual fault may have water, carbon or dirt in the hole such that the conductor measures zero resistance to earth with an ohmmeter. The fault still acts as a gap to the impulse unless this contamination can carry many thousand amperes.

The maximum number of discharges per minute is determined by the size of the D.C. power supply. After each discharge, the power supply must charge the capacitor bank. The variable autotransformer on the power supply is used to adjust the rate of discharge. VON systems are designed for a continuous rate of discharge every six seconds at 30kv.

The impulse control gap controls the voltage at which the capacitor discharges and thus determines the energy supplied to the fault. The energy stored in a capacitor is related to the square of its voltage. At one-half the voltage rating one-fourth of the rated energy is available. At one-third of the voltage rating one-ninth of the rated energy is available.

Water is the typical contamination in a service fault. It helps make a bigger thump since wet earth carries sound better than dry earth and any water in the fault is vaporized by the discharge. Conducting material which bridges the fault gap such that no arc or thump occurs is called a "bolted fault". Modern concentric neural cables do not have this type of fault except under an extremely rare occasion such as a steel sign post driven into the cable conductor. On this type of cable closing the fuse or circuit breaker into a service fault normally increases the fault gap since the concentric neutral wires and semiconducting material are melted back from the hole in the insulation. Bolted faults do sometimes occur in paper lead cables. The closing of a breaker into the faulted cable several times may melt some of the lead and cause it to bridge the fault gap. This type of fault cannot be found with a thumper without accessory magnetic detectors, tracers, or radar.

Some utilities believe that impulse fault locating on cable shortens the life of the remaining cable. The BI-.35S uses the least amount of energy to locate a fault of any impulse fault locator on the market. Experience over the last 30 years and the results of EPRI funded research in 1989 provides no evidence that "thumping" reduces the life of the cable. Those utilities who "thump" 600 volt secondary cable at 15kv and higher have reported no loss of cable life. We do not know any utility that limits the maximum voltage on the cable while "thumping" by installing a lightning arrestor at the far end.

Thumping impulses have a much shorter time duration than the surges put on the cable from lighting and switching. The number of "thumps" is large compared to the number of lightning and switching surges but their voltage is almost always much less. Remember that lightning arrestors can be tested with D.C. to determine their minimum operating voltage. The number of "thumps" required to locate a fault can quickly be reduced with the use of Thumpphone I or II listening devices and MI-88 magnetic detectors. The number of "thumps" can be further reduced with the use of radar with its high voltage coupler to approximately locate the fault. The training and experience of the operator and his help will always determine the time required to locate a fault.

We believe that the repeated application of fault current and switching surges may have the greatest influence on how soon additional failures will occur in a cable run on which you have a fault. While sectionalizing the system to pinpoint the faulted cable, almost every utility applies switching surges and fault current to the cable from two to ten times while closing into one part of a loop circuit at a time. High fault current physically moves the cable and disturbs any weak points in the insulation. In order to reduce the application of fault current, some companies never close into a faulted cable until fault indicators are installed. A few companies go so far as to disconnect each cable from its transformer and D.C.test it so that fault current is not reapplied to the cable.

XII-A APPLICATIONS - FAULT LOCATING ON SHIELDED CABLE

The capacitor discharge method is still the only system available for accurately pinpointing the actual location of a fault on a shielded high voltage cable. Fault prelocation systems using radar or high speed transient recorders can provide an approximate location for a cable fault. The time required to "thump" a cable to pinpoint the faults location can be reduced with a prelocation system. Underground shield cable with corroded or missing neutral may require the use of the earth gradient method with the impulse fault locator. This method is described section XII-B. When the cable neutral is intact, the earth gradient system is seldom used since it often provides an erroneous location.

Every fault is unique due to the difference between fault gaps and the difference in the electrical impedance of the ground return path. The fault gap differs between cable types and ratings. Faults in cable terminations and splices are most likely to have a high fault gap voltage.

For maximum noise at the fault a capacitive discharge system must be operated at the maximum voltage rating of the capacitor bank. This is because the energy stored in the capacitor is related to the square of the voltage. Thus at one-half voltage (15kv) one-fourth of the maximum energy is available (112 joules). On 5kv and above cable, the control gap will normally be adjusted so that the capacitor charges to a minimum of 15kv between thumps. Some companies use a procedure of attempting to locate the fault at 8 to 15kv first. Although the energy available at the fault when discharging at 10kv with a 1 mfd capacitor bank is only 50 joules, there is usually enough noise to locate the fault.

The voltage rating of the capacitor bank must meet or exceed the fault gap voltage. Otherwise, the capacitor cannot discharge across the fault gap and make a thump. The 35kv rating of most VON impulse fault locators should be sufficient for faults on URD type distribution cable presently installed in the United States.

The impedance of the electrical path from the capacitor to the fault gap and back determines the current available for making a thump in the ground. The more current in the fault gap, the more noise in the fault. Heavy, short connections should be used from the discharge capacitor to the system neutral and all available grounds such as water pipes. Instantaneous voltage differences will develop between neutrals if all grounds are not tied together due to the inductance of a concentric neutral.

XII-B APPLICATIONS - FAULT LOCATING ON UNSHIELDED CABLE

CAPACITOR DISCHARGE METHOD

Unshielded cable can be impulse fault located upon (thumped) using this unit with the following precautions: All nearby unshielded secondary cable must be pulled from service and grounded. Any secondary and unshielded cables in the same trench must be pulled from service and grounded. When the fault cable is unshielded, it is possible for a high voltage pulse to be created in any adjacent unshielded cable by the impulse in the faulted cable. These high voltage surges on the good cables can cause damage to the customer's property.

The impedance in the return path on unshielded cable faults such as street light cable or 600 volt entrance cable can vary greatly. In the majority of cases, the moisture in the ground is enough to provide a low resistance return for the discharge and normal procedures may be followed. In dry sandy soil, the earth return may be of such high resistance that only a few hundred amperes flow into the fault gap so that only a very small thump noise is made. Several approaches are available to reduce the earth return impedance and thus increase the thump noise.

A. If the cable is open or corroded in two pieces, thump across the corrosion. This is done by connecting the far end of the faulted cable to a good conductor and then connecting this good conductor to the discharge capacitor ground. This procedure provides a low impedance return for the discharge. A slight ping may be heard in the metal riser pipe at the pole or meter when thumping. This should not be confused with the thump at a fault which can be felt.

B. When the fault is not a complete open and the earth return path has too much resistance for a thump, drive a ground rod about half way between the house and the pole or pad. Tie this rod to the other grounds with an external lead to reduce the ground impedance. Additional rods may be driven along the cable length until the ground impedance so the thump can be head.

C. When the fault is not a complete open and the earth return path has too much resistance for a thump, use an earth gradient detector or sensitive voltmeter (0-10 volt range or less). See the procedure under Earth Gradient cable fault locating.

<u>EARTH GRADIENT METHOD</u>

THEORY: If a D.C. pulse of high enough voltage is transmitted down an unshielded cable, it will go to ground at the point of fault in the insulation. The current in the pulse wants to return to the ground terminal of the discharge capacitor. If there is no metallic return nearby such as a concentric neutral, some of the pulse will start back immediately, and other parts will go a short distance before returning. A pattern of voltage is formed in the ground similar to that formed by a magnet. By measuring the slight voltage difference in the ground with a sensitive voltmeter, one may find the fault by locating the null point of the voltage.

EARTH GRADIENT PROCEDURE:

1. Set up to thump the fault being careful to ground the case of the unit. IMPORTANT SAFETY PRECAUTION! ALL SECONDARY CABLE IN THE SAME TRENCH WITH THE FAULTED SECONDARY MUST BE UNENERGIZED AND GROUNDED. Turn the unit on and open the control gap until it discharges at a regular rate. It will usually take a voltage of 2 to 8kv discharge before the unit will start thumping. The higher voltages are needed to break through the aluminum hydroxide at the fault to ground. Adjust the rate of discharge with the variable autotransformer to give a pulse every 2 to 5 seconds.

2. Connect two probes (large screwdrivers do fine) to the positive and negative sides of the detector using about six foot leads. If a sensitive D.C. voltmeter with a minimum of 0-10 volts full scale is used for the detector, it will be necessary to adjust its pointer needle off zero so the polarity of the pulse can be determined. If the VON detector is used, it will be necessary to balance the meter by use of the balance control and set the detector to minimum gain.

3. Insert the probes in the ground stretching out the full length of the leads.

4. Gradually increase the gain until the detector indicates the meter deflection with each impulse. Keep the pulse indication below full scale with the gain adjustment. The leads can be oriented so that the direction of the meter deflection indicates which probe is closed to the fault.

5. Move both probes along the path of the cable (keeping the same lead probe) until a reversal of the needle deflection indicates the fault has been passed over as shown in the figure on the following page.

6. Back up with the probes until another reversal is obtained. Keep moving the probes until a null is obtained. Mark off half the distance between the probes. Now place the probes at right angles to the line between the probes initial position. Then seek another null in the same manner.

7. The first null locates the line of the fault. The second locates the cable. To make certain an error was not made, the probes are placed at 45 degrees and other null obtained. It should cross the first intersection.

8. Another check on the results is to place one probe on the fault and make a circle with the other probe. There should not be a reversal in polarity.

9. To use the unit on asphalt or concrete, purchase two sponges. Moisten them and place the sponges on the pavement. With the probes on the wet sponges, use the detector as normal.

10. If there is difficulty in getting a pulse indication on the detector, increase the voltage of the discharge.

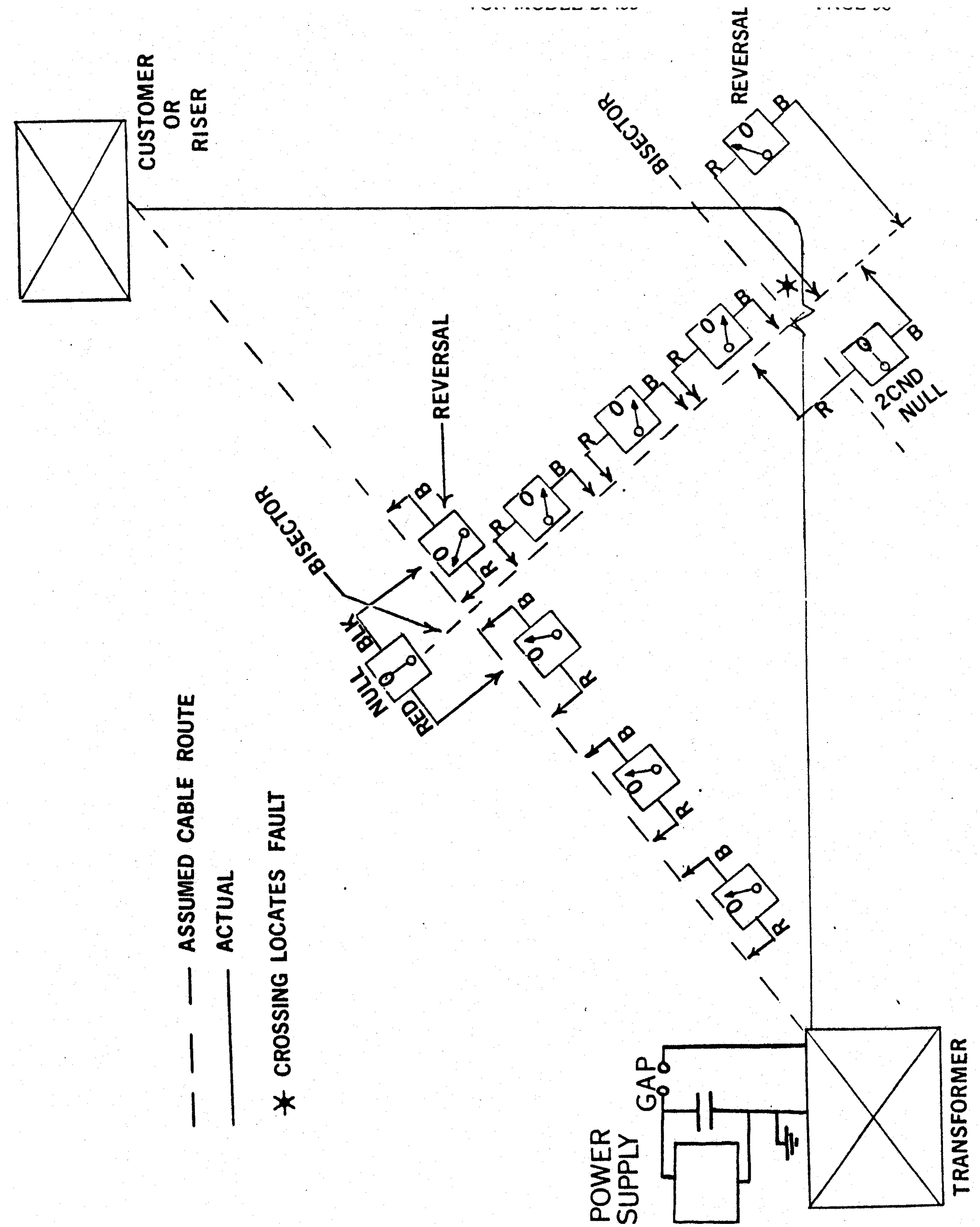


Figure 6 EARTH GRADIENT DETECTOR INDICATION

BIG THUMP FAULT LOCATOR AND HI-MEG D.C. TESTER
OPERATING INSTRUCTIONS

Caution: The output of this unit can be as lethal as a live high voltage A.C. conductor. Wear insulated safety gloves when connecting or disconnecting the unit to cable and equipment. We recommend that insulated safety gloves be worn while impulse fault locating. ALWAYS EXTERNALLY GROUND CABLE AND EQUIPMENT TERMINALS TO BE SURE THEY ARE NOT ENERGIZED!

Safety: Standard safety practices must be followed when operating this high voltage equipment. ALWAYS externally ground all cable or equipment terminals before making or breaking connections. Make sure that good ground connections are made to the case of the unit. The high current (100,000 amp) very fast discharge impulse (6 nanosecond rise time) returns to the unit by the lowest impedance path to ground. A ground relay is provided to prevent this unit from operating when the resistance between the 120 volt input line ground and the case ground exceeds 100 ohms. The 120 volt input lines and the case are tied together with varistors so an alternate ground is always available.

General:
1. Prepare cable and equipment by disconnecting it from service and grounding it to insure it is unenergized. ALWAYS externally ground cable and equipment before making and breaking connections. Isolate all terminations with safety tape or barriers so that personnel cannot come in contact with high voltage. Disconnect any accessories such as CT's that cannot withstand the test voltage to be used.
2. Remove the top cover. Open the end storage compartment. Remove the coaxial test lead, ground lead, and the input power cord.
3. Insure that the on-off lever is all the way up in the OFF-DISCHARGE position, the variable autotransformer is turned to zero, and the voltmeter reads zero before plugging the test lead into the output test or output impulse socket as required. A slight mechanical resistance will be felt as banana plug in the test lead connector mates. The body of the test lead plug-in should be against the nuts on the two connecting studs and the hold down wing nuts tightened firmly. Tight connections are especially important on output impulse due to the high current involved. When changing the test lead from one socket to the other be sure the on-off lever is in the OFF-DISCHARGE position and the voltmeter reads zero.
4. Connect the case ground stud to a good ground. Connect the HV test lead ground clamp to the cable neutral and any nearby grounds such as the system neutral. The shield of the HV test lead provides the return path for the impulse. If no ground is available at the terminations, run a separate lead to the test lead ground clamp from a good ground. The flexible #16 ground lead furnished is suitable for testing, but at least a #10 lead should be used when fault locating.
5. Follow all company safety practices when connecting or disconnecting the conductor under test. GROUND the cable or equipment to insure it is unenergized before connecting or disconnecting. Connect the center conductor of the test lead to the termination of the cable or sample under test. When testing clean all terminations of the cable to prevent surface leakage. When testing above 30kv, it will be necessary to wrap the sharp edges of all terminations of the cable with polyethylene bags, sheet plastic, or glass jars, duct seal, etc., to eliminate corona from the leakage measurements.
6. A. Line - Plug the power cord into a 110 to 130 volt 60 to 600 hertz service with its third ground wire actually connected to a ground with a resistance of less than 50 ohms to the case ground.
B. Inverter - Connect the battery leads from the inverter to a 12 volt battery with red-positive and black-negative. The negative side of the battery <u>must</u> be grounded for the unit to operate. A high frequency hum indicates the inverter is working. Plug the input line cord into the inverter for power. Due to 20 ampere battery drain while fault locating, leave the vehicle engine operating. Battery drain is only 5 amps while testing.
7. Set the kilovoltmeter range switch for best resolution at the maximum test or discharge voltage selected.
8. After locating the fault or completing the test as described below, pull the on-off lever up for off and discharge. Watch the kilovoltmeter to insure the voltage is zero. Place a solid external ground on the cable. Follow all company safety practices when disconnecting the test lead from the cable.

FAULT LOCATING: Decide the best voltage at which the faulted cable should be impulsed or thumped. For 15kv and above rated cable, this would be between 25kv and 30kv. Turn the control gap handle in the storage compartment full clockwise to close. Be sure the test lead is installed in the output impulse socket. Push the on-off lever down. A click will be heard as the ground relay picks up. Turn the variable autotransformer clockwise until the input ammeter reads about 2-1/2 amps. Open the impulse control gap by turning the handle in the counterclockwise direction until the kilovoltmeter reads the desired voltage upon discharge. A rise and fall of the kilovoltmeter indicates the capacitor is discharging across the fault. Adjust the variable autotransformer until the average current is 2-1/2 amps for maximum rate. The resistance of a wet or carbonized fault is apt to change for a while as it is pulsed. Therefore during the first 15 minutes or so, adjust the gap and variable autotransformer as necessary to keep the impulse voltage stable. Faults are located by the noise of the discharge that occurs at the point of failure. For direct buried cable, walk the cable listening and feeling for a thump. In rigid conduit, duct or overhead, listen for a ping or a crack.

TESTING: Decide the test voltage to be used. Be sure the test lead is installed in the output test socket. Push the on-off lever down. A click will be heard as the ground relay picks up. Rotate the variable autotransformer clockwise until the test voltage selected is reached. Turn the output current range switch to the lowest range or until the output current meter reads in the upper two thirds of its scale. Hold test voltage on the cable for the specified time. Record test voltage and output current or record megohm resistance.

THE MEGOHM SCALE: Megohms are listed above both the 0-10 and 0-30 scales on the output current meter. To measure megohms resistance with minimum calculation, set the output voltage precisely on a value selected from the chart. Turn the output current range switch to the lowest range or until the output meter reads in the middle or the right third of its scale. Record the megohm reading just above the current scale used and multiply this by the multiplier found on the chart for megohms resistance. As a check, the minimum, center scale, and maximum resistance readings are listed for each range setting.