A 'UNIVERSAL' BATTERY ELIMINATOR

All of the very early, and many later vintage receivers were battery operated. They are much more interesting when operational, but batteries have always been inconvenient and expensive, and there is a long history of powering these radios from the mains. This article will describe a universal power supply suitable for operating a wide range of battery receivers.

Dedicated power supplies for individual receivers can be compact and simple, as illustrated in the April 1989 article on the STC 509 portable. However, a supply capable of powering a wide range of receivers is a much more complex project.

Although the basic principles of power supplies have not changed, vastly improved performances are possible with modern technology.

Whereas battery eliminators of 60 years ago were barely adequate, today's power supplies can more than equal the performance of new batteries.

Specifications

The requirements of a large number of battery receivers dating from 1920 to 1960 were analysed.

As Table 1 shows, there has been a remarkable variety of filament requirements, varying from 150mA at 1.4 volts for the later low consumption miniature receivers to as much as 3A at 6.3 volts for vibrator equipped domestic sets. And whereas low current filaments are very sensitive to hum, vibrator receivers demand very low impedance voltage sources.

To cater for all possibilities with individual or switched outlets would be quite impractical. Consequently, the filament supply has been made continously variable from 1.2 to 9.0 volts and with a current capability sufficient for any conventional battery powered receiver.

High tension demands were less stringent. To cope with the ageing characteristics of dry cells, there was a wide tolerance of voltage variations.

Generally, 'B' batteries were required to give maximum nominal voltages of 90V or 135V, with tappings in multiples of 22.5 volts and total current demands less than 25mA. Most bias voltages were in the range -1.5V to -9.0V, with some early output valves requiring as much as -27 volts. The current drains on bias supplies were at the most, a few milliamperes.

Specifications for the supply to be described are listed in Table 2. Hum level from the unregulated 135V terminal is only 75mV, or .055%.

All other ouputs are regulated (see circuit) and their hum levels are practically unmeasurable. The filament and bias outputs are short circuit proof, and the regulated HT ouputs are capable of withstanding short duration heavy overloads.

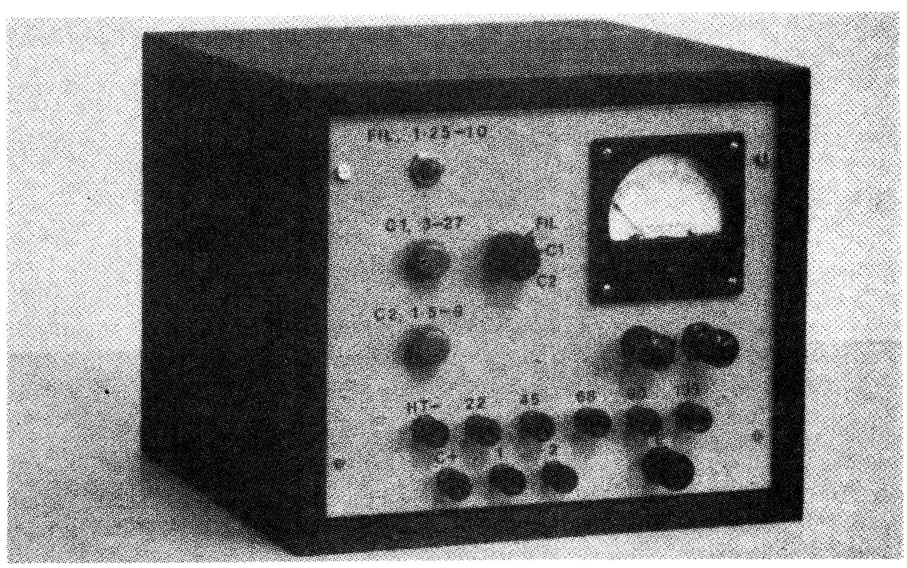
The voltmeter is good insurance. Although the filament and has voltage adjustment controls could be directly calibrated, this is an imprecise method and the cost of a meter is small compared to that of a set of rare valves which can be easily burnt out by an incorrect filament voltage.

Filament supply

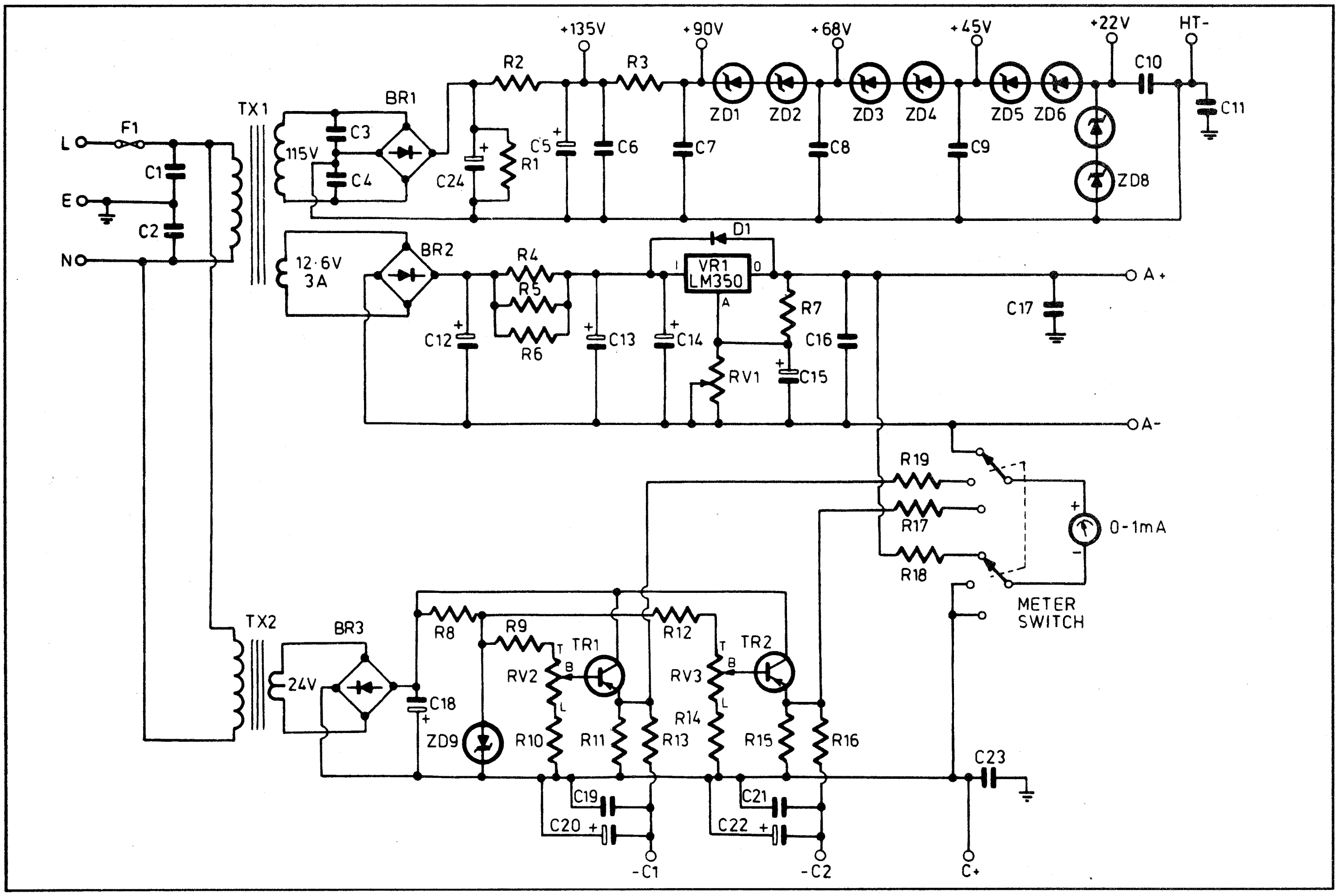
Rectified 12.6 volts AC is filtered by the three 2200uF capacitors and associated resistors. At full current output, the filter capacitors are subject to a considerable ripple current. To minimise heating, 35 volts working types are recommended.

As well as contributing to the filtering, the three resistors R4, R5 and R6 help reduce the dissipation of the LM350 voltage regulator. Adjustable upwards from 1.2 volts, the LM350 variable regulator could almost have been custom designed for this purpose.

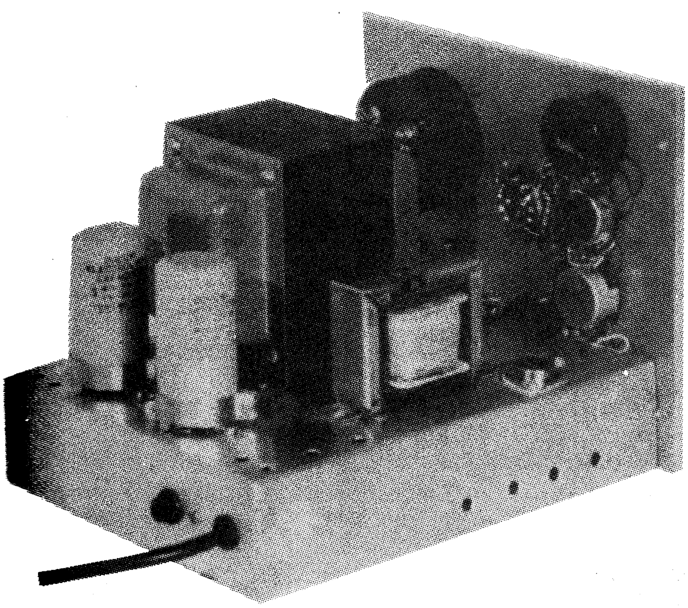
Not only does it provide extremely



The author's prototype eliminator, housed in a neat wooden case with an aluminium front panel. The meter is a surplus 0-1mA type.



There are really three separate supplies, for the HT (B), filaments (A) and bias (C) requirements.



Inside the author's eliminator, which is built on a traditional chassis.

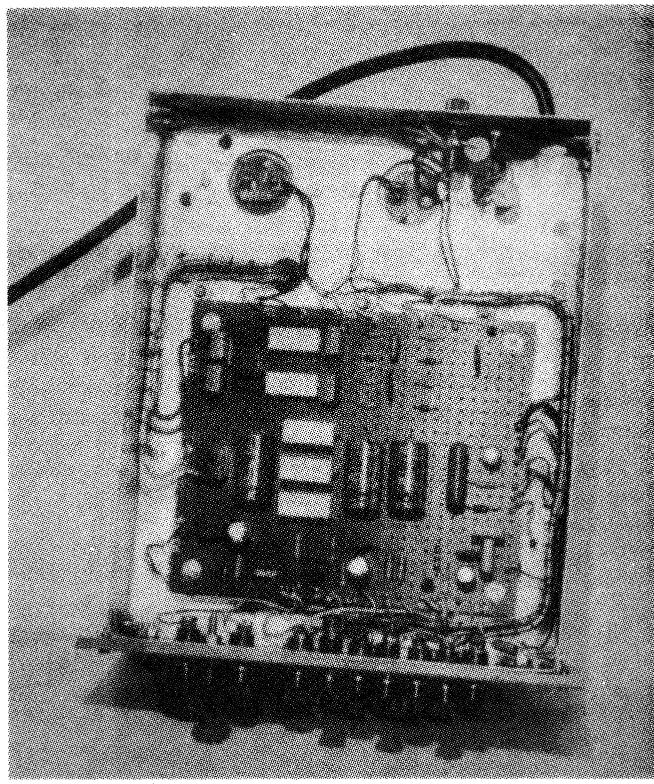
BATTERY RADIO FILAMENT SUPPLY VOLTAGES

VOLTAGE	SOURCE	ERA	VALVE TYPES
1.1 to 1.4	SINGLE DRY CELL	1920 - 27 1938 - 50 1948 - 60	RCA WD11, WD12 & European equivalents Octal & Loctal Based 1.4v series. 1.4v 7 Pin Miniatures & Rimlock.
2.0	SINGLE LEAD/ACID OR TWO AIR CELLS	1920 - 30 1930 - 50	Early European Types. American, European & Australian Standard Directly Heated Battery Range
3.3	DRY CELLS	1923 - 30	American '99,'20,'22. AWA 33.
4.0	TWO LEAD/ ACID CELLS	1920 - 30	European Standard.
5.0	6.0 VOLT LEAD/ACID	1920 - 30	Standard American Range of Triodes, Including '00A,'01A,112A,'71A.
6.0 & 6.3	6.0 VOLT LEAD/ACID	1926 - 30 1932 - 60	European. Wide International Range of 2.0 volt Directly & 6.3volt Indirectly Heated Valves Used in Vibrator Receivers. 1.4 volt Valves Also Used After 1938.
9.0	MAINS OR 9.0 VOLT DRY BATTERY	1947 - 60	1.4v Octal, Loctal, Miniature and Rimlock valves in Mains/ Battery Portable Receivers with Series Connected Filaments.

N.B. During the 1920's there were many non standard filament voltages. Some examples are;- 1.0. 1.25, 1.8, 2.6, 2.8, 3.5, 4.8, 4.9, 5.6.

BATTERY ELIMINATOR SPECIFICATIONS

Filament or "A" Supply	Voltage Range; 1.2v to 9.5v Continuously Variable @ 2.0 Amperes. (3 Amperes 5.0v to 7.5v).
High Tension or "B" Supply"	Unregulated Output; 135v @ 5.0 ma. 128v @ 30 ma. Regulated Outputs; 90v, 68v, 45v, 22v. (Total Available Regulated Current 25 ma)
Grid Bias or "C" Supply	Output #1; Continuously Variable 3.0v to 27.0v Output #2; Continuously Variable 1.5v to 9.0v



Right: A look under the chassis of the author's unit, showing the wiring board.

good hum filtering, but it is also short circuit and heat protected and requires only a minimum of external components.

Bias supply

Two variable bias outlets cater for most receivers. Emitter follower regulating transistors are used, to minimise errors which would be introduced by shunting the meter directly across resistive voltage dividers. Resistors in each output lead prevent transistor damage in the event of a short circuit.

The remainder of the bias supply consists of a transformer, bridge rectifier and filter capacitor. A 30V zener diode is used for voltage reference, and hum filtering.

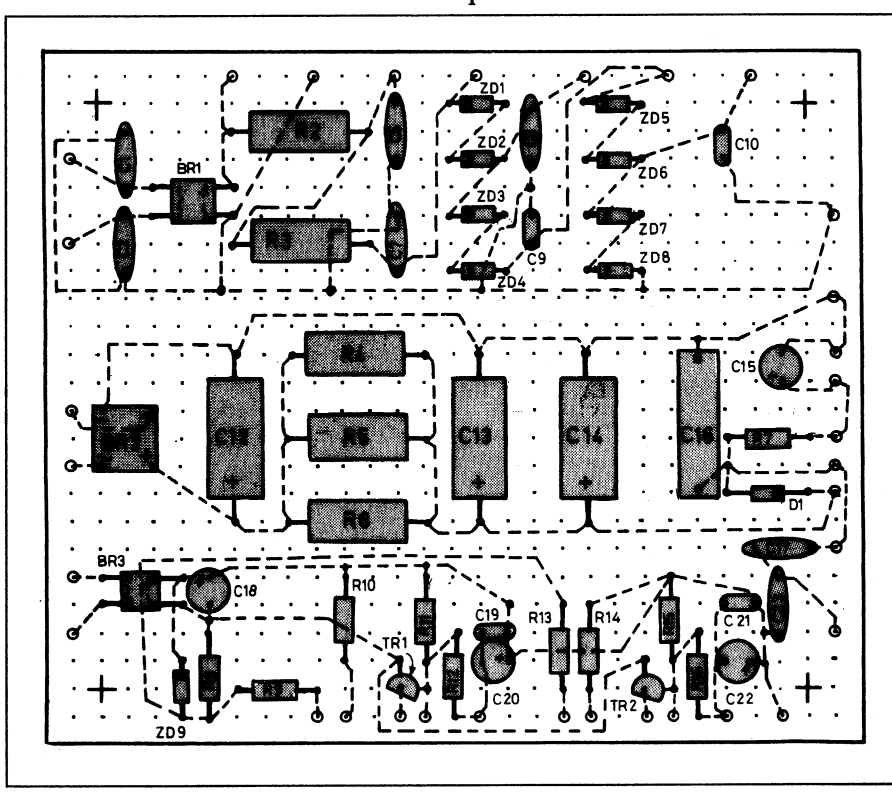
HT supply

For the HT supply a bridge rectifier is connected to a filter comprising a pair of 100uF capacitors and a 510-ohm series resistor. Voltage at the second capacitor and first HT terminal is 135V, varying only a few percent with load current.

Following the 1.2k resistor R3 is the 90 volt terminal, with a string of zener diodes operating at a standing current of about 35mA and feeding the remaining HT terminals at nominally 22.5 volt steps. The zener diodes are inexpensive regulators, very effective hum filters and stable voltage dividers.

The three supplies have very different transformer requirements. Converted to RMS figures, the filament winding needs to be capable of supplying about 12V at 4.5 amperes, the HT winding 115V at up to 75mA and the bias supply winding 24V at about 60mA.

A custom made transformer would be ideal, and if you have access to winding facilities, a suitable core size would be 75 watts. However, most constructors are not so fortunate, and to have one wound commercially would be very expensive.



The author's unit has the minor components mounted on a 150 x 130mm piece of 0.2" pitch Veroboard, and wired as shown. However some readers may wish to produce a custom PC board for the job.

PARTS LIST

Resistors

R1 27k 1W
R2 510 ohms 5W
R3 1.2k 5W
R4, R5, R6
4.7 ohms 5W
R7 120 ohms 0.5W
R8 180 ohms 0.5W
R9 680 ohms 0.5W
R10 1.5k 0.5W
R11 2.7k 0.5W
R12 5.1k 0.5W
R13 2.2k 0.5W
R14 510 ohms 0.5W
R15 390 ohms 0.5W
R16 1.0k 0.5W
R17, R19
10k 0.5W*
R18 30k 0.5W (33k//330k)*

*For use with 1.0mA FSD meter

Variable Resistors

RV1 1k linear or wirewound
RV2 10k linear or wirewound
RV3 2.5k linear or wirewound

Capacitors

C1, C2
47nF 250VW AC polycarbonate**
C3, C4, C6, C7
47nF 250VW polyester
C5, C24
100uF 200VW electrolytic**
C8 47nF 200VW polyester
C9, C10, C19, C21
47nF 50VW disc ceramic
C11 0.47uF 200VW polyester**
C12, C13, C14
2200uF 35VW electrolytic
C15 10uF 16VW electrolytic
C16 1.0uF 50VW polyester
C17, C23
0.47uF 50VW polyester
C18, C20
100uF 35VW electrolytic
C22 100uF 16VW electrolytic

** Mounted externally to board

Semiconductors

BR1,BR3
1.0A/400V PIV silicon bridge
BR2 6.0A/100V PIV silicon bridge
D1 1.0A/50V PIV silicon diode
ZD1, ZD3, ZD4, ZD5, ZD7
12.0V/1.0W zener diode
ZD2, ZD6, ZD8
10.0V/1.0W zener diode
ZD9 30.0V/1.0W zener diode
VR1 LM350K 1.2-32V 3A TO3 adjustable regulator IC
TR1, TR2
BC557 or equivalent
PNP transistor

Transformers

(All 240V primary)
TR1 110-115V 10 watts*
TR1A 12.6V 3.0A*
TR2 24-25V 5.0W

*Or transformer from old valve-type B&W TV receiver

Hardware

12 x insulated terminals; fuse carrier and 1A Slow-Blow fuse; 2 x small knobs; 1 x pointer knob; 1 x 4 pole, 3-position rotary switch; chassis, panel and case; screws, nuts, bolts etc.

Even to purchase a set of individual 'off the shelf' transformers for the three supplies would cost around $100. Fortunately, inexpensive transformers of 24V or 25V at 5 watt rating and suitable for the bias supply are available commercially.

Transformers suitable for the filament and HT supplies can be salvaged from old TV sets. Many valve equipped monochrome TV receivers (including *EA* projects) used a voltage-doubling HT supply incorporating a transformer delivering very close to 115 volts, which is just what we want.

Furthermore, the filament demand was such that a centre tapped 12.6 volt winding was often necessary — again what is needed.

The current ratings of such a transformer are considerably in excess of this project's requirements, but the additional size is no real problem and operating a transformer at a fraction of its rated current results in less leakage field and induced hum in nearby audio transformers.

Although available from electronics suppliers, the 100uF 200VW chassis-mounted HT filter capacitors in the prototype were also salvaged from a discarded TV receiver. They were made in Australia about 20 years ago and still test 100%. Suitable capacitors were often made in multiple units.

Battery sets generally, and regenerative receivers in particular, are notorious for modulation hum when operated from AC mains. To minimise this, as well as having RF bypass capacitors for each terminal, the mains leads and the three supplies are bypassed to earth, and an earth terminal is provided for interconnection to the receiver's earth.

Construction

The construction and layout are not at all critical. Using a traditional 'inverted tray' chassis and front panel in a simple open backed veneered particle board housing, the prototype is quite compact, measuring 240 x 250 x 205mm overall.

The 2.0mm gauge aluminium alloy chassis is 230 x 190 x 50mm and is bolted to a 215 x 180mm front panel. On top are the transformers, HT capacitors and the filament supply's LM350T regulator IC.

Provided that there is good thermal contact with the chassis, additional heat sinking for the regulator is not essential. To assist heat dissipation, a few ventilation holes should be drilled in the sides and top of the chassis. The front panel of the prototype is made of 5.0mm alloy, but any heavy metal or switchboard Formica could also be used.

When making adjustments, I prefer to be able to keep an eye on temporary receiver connections and consequently all controls and terminals have been mounted on the front panel. But the terminals could be rear mounted if desired.

The type which double as banana plug sockets are handy for the HT and bias supplies, but heavier terminals have been used for the filament supply.

Small knobs have been used to reduce the possibility of inadvertently knocking and upsetting the variable bias controls. Battery valve filaments can be very delicate, and excess voltage can destroy them in a fraction of a second. A good insurance is not to use a knob for the filament control, but to slot the control shaft for screwdriver adjustment.

The prototype meter is a standard 1mA moving coil type, with multiplying resistors mounted on unused tags on the range switch. Similar meters are readily available and inexpensive. Dick Smith Electronics stock a very suitable 200uA universal panel meter with suitable scales and a shunt pack.

In the prototype supply small components are mounted on a 150 x 130mm piece of 0.2" pitch Veroboard, but if desired a PC board can be used.

To prevent heat damage, wire-wound resistor leads should be crimped to provide a couple of millimetres clearance between the bodies and the board. The capacitor bypassing the HT supply to earth is not on the component board, but is wired directly to the HT terminal.

Limitations

No practical supply could cater for every possible situation, and consequently, there are a few minor limitations. Vibrator radios fall into two categories: domestic, drawing up to about three amperes, and car radios requiring six volts at up to eight amperes or 12 volts and drawing as much as four amperes. Domestic vibrator powered receivers are within the capacity of the eliminator's filament supply, but car radios are far beyond the capabilities of an unassisted LM350 regulator.

For 12.0 volt car receivers, an *EA* 'Powermate II' supply (October 1988) would be a much better proposition. Realistically, six volt vibrator car radios are best used in vintage cars with large batteries!

Another type of receiver which cannot be powered by this supply is the 32-volt farm radio, which was designed to be used with DC home lighting plants.

Operating notes

The industry has no standardisation for interconnection of batteries. In some instances B- (HT) and A- were connected together. Others joined B- to A+, and C+ could be connected to either A+ or A-! A few receivers used 180V HT for the output stage, and lack of a suitable transformer has prevented provision of this voltage. Very little practical loss of performance will result from operation at 135 volts, but bias for output stages should be reduced pro rata.

If you are fortunate enough to own a pre-1923 receiver using 5.0-volt, 1.0A-filament UV201 valves, use of this eliminator is not recommended.

The UX and UV201A valves made after 1922 had 0.25 ampere filaments and with one precaution, should not be a problem. These valves have thoriated tungsten filaments, operating at a high temperature. Their cold resistance is very low and if the receiver filament rheostats are fully advanced at switch on, the initial surge of current may shut down the LM350. The remedy is good practice anyway. Always back off the receiver controls before switching on.

If an additional bias output is required, add a duplicate 27V section to the bias supply, but remember that another metering switch position will be necessary.

A hum problem can arise with grid leak detectors. Audio gain from the detector grid to the output stage grid can be anything up to 1000 times, and shielding from the modern environment nil. Furthermore, interstage transformers are sensitive to hum induced from nearby mains transformers. Try to space the power supply a metre or so from this type of receive.

Finally, some warnings. Set up and check the various voltages BEFORE connecting the receiver leads. And never re-arrange connections when the eliminator is operating.

Remember too that the +135V terminal is connected to a 100uF capacitor and can pack a lot of energy if shorted — or if accidentally connected to yourself!