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HIGH-INTENSITY DISCHARGE (HID) SOLID-STATE BALLAST PROGRAM: ENGINEERING DEVELOPMENT REPORT (PHASE II)

R.S. Carlson

December 1983

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Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

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LBL-17196
EEB-L 84-01
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HIGH-INTENSITY DISCHARGE (HID) SOLID-STATE BALLAST PROGRAM: ENGINEERING DEVELOPMENT REPORT (PHASE II)

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DECEMBER 1983

This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Building Energy Research and Development, Buildings Equipment Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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Subcontract No. 4501410

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ABSTRACT (PHASE II)

A high frequency (28-31K Hz) electronic current source (ballast) designed to drive a 200 watt 100 volt sodium vapor gas discharge lamp is described.

A resonant switching power amplifier system utilizing a novel constant power feedback loop is employed to maintain the lamp input power constant within two percent via changes due to lamp aging etc. The lamp input power and therefore the light output is adjustable from 50 to 100 percent of rated power.

A input (electronic filter) inverter, changes the 277 volts alternating voltage input to a regulated direct current (DC) voltage used to power the output stage. The inverter reflects, a essentially unity power factor load to the power input source at all times.

A Phase I report preceded this writing, going into a more complete theory of operation, circuit detail, circuit losses, system specifications, and performance data.

PHASE II FINAL ENGINEERING DEVELOPMENT REPORT

SECTION I GENERAL INTRODUCTION

1-1 As a result of phase I testing, it was indicated that several areas of the electrical parameters as well as a new packaging effort would be required, specifically these task were:

1-2 DYNAMIC OPERATING RANGE

Increase the upper operating range of the ballast from 100 to 150 ohms to maintain full wattage input as the lamp approaches end of life. See attached report "End of Life" lamp test data (fig. 19).

The power output of the output stage of the Phase II ballast is shown in figure 1 (data) and again in figure 2 in graph form. Two curves (figure 2) are shown, the power output (P.O.) versus load impedance open-loop (curve 1) and the P.O. with power feedback applied (curve 2). The open loop plot shows that the power amplifier can supply 200 watts at both ends of the desired load range of 30 and 150 ohms. At the midpoint, 260 watts or 30% additional power is

available. Curve 2 (figure 1) shows the power output with the feedback applied. As can be seen the maximum change in power output over the desired load range is 8.5 watts peak or 4.25%.

1-3 Shown in figure 3 and 4 is data of the Phase I output networks. It is obvious from the open-loop plot (curve 1) that the stage is incapable of delivering the 200 watts required above 90 ohms.

1-4 DIMMING RANGE

Increase the dimming range from (100-70%) to (100-50%) (see figure 7 & 8). An external rehostat may be used, which requires a large maximum value (500K), so as to not load the circuit thereby causing a change in maximum level output. This large valve rehostat produces a very non-linear control with the dimming action occurring all at one end of the pot. The unit is basically designed to work with optimum performance using an Opto-Coupler pulse-width control scheme.

1-5 PACKAGING

Redesign the mechanical package to be more adaptable to commercial fixtures, and to be totally enclosed (versus open U frame construction) to enhance its ability to withstand rough handling (see figure 14 A & B).

1-6 The major change required to accommodate the first two items (1-2 & 1-4) allowed a reduction in the number of large inductors. Further reduction in the part count and volume of the network capacitors, resulted due to circuit change and the direct substitution of series parallel arrangements with single devices of adequate voltage and current rating.

The package was therefore greatly simplified and consist of two printed circuit boards (fig. 15 & 16). One long narrow assembly mounted via 3 screws; with the two power transistor sockets soldered directly into the PCB, along with the protection circuitry (*snubbers). The inductors are mounted in-line directly above the PCB assembly, and were terminated (soldered) directly into the PC board. Two sets of cables also terminated into the PC board and make contact with the larger second PCB, via two female molex connectors.

1-7 STARTING PULSE

Peak starting pulses at or slightly below 2400 volt minimum peak suggested for (60Hz operation), caused no problem, as starting occurs reliably with high frequency operation at voltages of 1500 volts peak.

1-8 LAMP ARC WATTS

The ballasts which were delivered to LBL were first set for equal light output compared to running the lamp at

60Hz using a iron core ballast, and nominal line voltage. This resulted in approximately 180 lamp arc watts or a 10% improvement over the conventional ballast. LBL requested that the ballast be set to 200 lamp arc watts. This resulted in a higher stress figure on the output device and a increase in case temperature. The rise in operating temperature above ambient is approximately 25 to 30°C. Which was found acceptable for a well designed unit for these purposes.

1-9 ACOUSTIC RESONANCES

Arc column flicker due to Acoustic Resonance can produce distortion of the arc column. It was found to exist in lamps from one of the two manufactures of the (200 watt lamps tested) especially when operated at lower lamp arc watt levels. No indication of Acoustic Resonance was observed when using lamps from the other manufacturer whatsoever. (For reference; brand "A").

1-10 A sine wave frequency scan of the lamps after stabilization of the arc, indicated that the major Acoustic Resonance occurred at the following frequencies:

	KHz
BRAND "A"	17-18
BRAND "B"	27-30

Some minor disturbance occurred at higher frequencies with both brands but this was thought not to be significant. The ballast operates at approximately 28Khz at full power, increasing with frequency to 31Khz at 50% lamp powers. This is due mainly to the gas pressure and the mechanical dimensions of the arc cavity and is easily observed.

1-11 These parameters (ARC tube physical dimensions and gas pressure) are not now specified for high frequency and large production variations and differences between manufactures may be a problem with high frequency sine wave excitation. Utilizing a square-wave drive waveform appears to eliminates this problem. The power waveform is constant assuming the transitions (rise and fall time) are rapid. This also offers possible improved lamp life as the current crest-factor is likewise improved.

The difficulty arises in producing the waveform efficiently, and possibly the increased electro magnetic (EMI) radiation due to the square vs. sine waveform.

1-12 LAMP STABILIZATION TIME, FIGURE 11

The time required for the lamp output to reach 63.2 percent of its final output is expressed as the time-constant T.C. The iron-core model used as a comparison

reached 63% of its final value (T.C.) in approximately 5 minutes (see figure 11). With the electronic ballast the T.C. was somewhat shorter 3.5 minutes, the major change occurring in the first two minutes. The electrical parameters current etc. are all well within the manufacturers ratings and no adverse effects have been noted.

SECTION II, CIRCUITRY

2-1 A more detail description of the electrical circuit changes follows:

2-2 INPUT SWITCHING REGULATOR

Reference drawings C500036 and D500038C (Figure's: 17 & 18 Respectively)

The input switching regulator which provides DC to the output power amplifier, originally showed different peculiar effects, causing the main switch transistor Q1 to fail while operating into a short circuit on the original phase I (6) units.

The problem was identified as that of a ground loop in conjunction with the poor current sense response time of the IC regulator control chips.

2-3 When first turned on the lack of charge on the DC filter cap caused excessive voltage across L2 and possible failure of Q1. To overcome this a diode from

the unregulated 24V DC logic power supply was used to establish a (24 VDC) voltage level which allowed the unit to power-up safely.

Using an additional winding on the switching inductor to produce a voltage gate, only allowing the chip to turn on when the inductor current reached zero (see figure 6). (See R19,R23,CR10 and Q3, fig.17). Since the regulator works in the discontinuous mode to provide near unity power-factor (approx. 0.95) no further change or excessive output ripple occurred (see figure 7).

2-4 The input filter inductor L1 was reconfigured to place it before the bridge rectifier. This afforded improved protection against fast (10 microseccond FWHM) line transients to the bridge of up to 6KV. This was a direct results of testing done with LBL on other ballast programs. The ferrite pot core was abandoned for a powered-iron toroid with much higher saturation flux density.

2-5 The positive 24 volt DC control power supply was changed from a regulated to unregulated one to save power. Later it was found to harbor some shortcomings and is covered later in the overview comments.

2-6 OSCILLATOR AND POWER OUTPUT STAGE

Extending the output stage load range (short to open circuit) and the dimming range to 50% proved to be more difficult than first anticipated. The problem was maintaining a safe load line for the resonant switch-mode amplifier Q2 at the high end load impedance (see figures 5, 8 & 9).

2-7 The circuit Q was lowered to flatten the power output curve. It was found earlier on in another development program that reducing the RFC choke L 3 value, so as to make its effect more than just a current source could be helpful. The results were a slight degradation in output current waveform (see figure 10A). The internal DC supply voltage was also reduced. This resulted in slightly higher collector current in Q2 with a slight decrease in efficiency, approximately 2% (see figure 1).

2-8 The peak collector Q2 voltage during start and warm-up reached 950 volts peak dropping back to 800 V.P. after lamp stabilization (see figure 5). Transistors with 1100V minimum breakdown voltage were selected for this function. This presented a higher stress level than previous applied to these devices even though the power supply voltage had been decreased. Higher voltage

devices of reasonable gain and cost were not yet available early in the program.

2-9 Breaking of the load during the lamp warm-up cycle and under high temperature operation caused the peak transient voltage exceeded the 1000 volt level. A peak voltage clamp circuit consisting of diode CR4, capacitor C3, and MOV 1 & 2 (fig. 18) was employed.

2-10 CONTROL LOOP

The constant power output loop control scheme was kept the same, however some changes in the circuit configuration were employed.

2-11 The variable control reference voltage used to reduce lamp power was increased to a higher more manageable level. This was scaled down from the 15 volt regulator via R52, PR-2 and R54 to approximately 3.6 volts at the 200 watt level. Grounding R54 via the external dim connector causes a 50% decrease in power output (see figure 8). The pulse width modulated dim signal
* is integrated via R51 and C21, buffered by the unity-gain configured OP (dual) amplifier IC5 (comprised of pins 5, 6 and 7) and scaled down via
* R49 and R50 for comparison with the output stage collector current in the other half of IC 5 (comprised of pins 1, 2 and 3). The output-stage feedback voltage is derived from that current via

series resistor R55 and integrated by R47 and C22 in IC5. The integrated control voltage (IC5, pin 1) level is applied to the oscillator via R46 and CR16 such that it can only increase the frequency and therefore decrease the output power over a restricted range.

2-12 The oscillator frequency and open-circuit pulse width control function have been separated with IC4 and IC3 respectively.

The (PRF) oscillator frequency and power output control is performed by IC4. The actual pulse width driving the output switch Q2 is determined by the mono-stable IC3, being driven by the above PRF oscillator IC4. The control function is performed in both cases by modifying the voltage of the internal divider via pin 5.

* Each op amp has (3) three terminals a plus input, a negative input , anda output terminal.

2-13 Two potentiometers, are used, PR1 sets the peak power output to 224 watts through a 30 ohm dummy load. This is accomplished by first de-activating the dim level control signal (pin 5) of the oscillator IC4 with a clip lead from the cathode of CR16 to the +15 volt DC supply. Once this is done the clip lead is removed and the load power is reduced to its proper level of 200 watts via adjustment of potentiometer PR-2. The

power output should now remain constant within approximately ±2.5% over a load range of 30 to 150 ohms, which corresponds closely to the lamp resistance change over its useful life span (see figure 1 and 2).

2-14 A small current feed-back transformer T5 is used to sense the external load current rather than a winding on network inductor L4 and its associated high voltage insulation requirements. This is rectified and applied to the base of Q5 which conducts when load current is present. It is necessary to operate with a narrow pulse-width base drive signal when running open-load preventing a destructive load line of Q2 (see figure 9). Q5 being non-conducting at that time allows current via R39, R38 and CR 14 to flow into Pin 5 of IC3 decreasing the pulse width.

2-15 OUTPUT WAVEFORMS

Figure 12 A shows the harmonics and their relative level up to 0.5 Meg Hz typically present in the 28 Khz lamp current waveform at the full power output of 200 watts. These are slightly higher than the Phase I model due to the lower Q of the output network, required to tune over the increased dimming range.

2-16 Figure 12B shows the harmonics present in the input line current of one of the Phase II ballast. The DB levels are (fundamental - 27 DB), (3rd-47DB), (5th-

42.6DB), (7th-50.5DB), (9th-60.1DB) which places the 3rd harmonic content down by (20DB) a factor of 10.

Power factor is the ratio of real power to apparent power. This ratio includes the effects of harmonic components of current and voltage and phase displacement between current and voltage.

2-17 Figure 13 shows the spectrum of the conducted line current present (RFI) in one of the Phase II ballast over the range of 10K Hz to 30 Meg Hz.

SECTION 3 FIELD TEST

3-1 After one years operation, the present experimental ballasts exhibited a higher than anticipated failure rate. The majority of the failures were limited to the two main power switches Q1 and Q2 and diode CR 2 (see drawing C500036). The units were reworked and the following item changed as a result of information learned.

3-2 The problem with the output device was one of insufficient breakdown voltage. The transistor was first replaced with a 1400 volt device. These devices had much lower gain (FB of 2.5), a high saturation voltage drop, and slower switching speed.

The higher saturation voltage caused a further decrease in power regulation of approximately 2-3%, and also in the efficiency.

Unlike more conventional devices, the beta was found to decreased considerably with temperature. When the ballast were hot and the lamp recycled, occasional failures occurred. Upon re-ignition and looking like 5 ohms etc. the devices (Q2) came out of saturation.
A new device with a 1200 volt minimum collector-emitter breakdown and high avalanche-energy capability became available and appears to have solved the problem as it has more than twice the gain (increasing with temperature), lower saturation resistance and higher switching speed. The efficiency figures were restored almost to the previous original values. A series diode and 10 ohm resistor were placed between the base and emitter to limit the reverse voltage swing and prevent tailing on turnoff of Q 2.

3-3 A diode across R51 was added to decrease the charging time of C21 at power-on, reducing load line stress of Q2.

3-4 R34 was increased in value improving the load-current detector switching time and threshold level.

3-5 A simple transistor circuit was added to prevent the possible latch up of the mono-stable IC3 during power up.

3-6 The collector series resistors R26 and R36 in both base driver stages of the power transistors Q1 and Q2 caused discoloration of the PC board especially if left for prolonged time, open-load and high line. These were removed from the PCB and replaced with chassis mounted higher wattage device.

3-7 The switching regulator control chip IC2 was changed to a device with improved performance, especially of the over current detector differential amplifier circuit, and the incorporation of cycle-by-cycle over-current latching.

3-8 The diode CR 2 was found to fail when transistor Q1 failed short, it however was given a heat sink to reduce its operating temperature.

SECTION 4 FUTURE DIRECTION

4-1 Utilize a full-wave current-sense circuit. Half wave is marginal and slow in response time due to the long time constant filter (R39, R48 and C18).

4-2 Use of a SIDAC to replace the SCR 1 and trigger diode CR 15 etc. parts saving.

4-3 Possible use of a class P protector.

4-4 Use of a over-voltage input shut-down detector to reduce effect of transient line voltage surges of long duration (20-MS) causing a increase of L2 peak current and possible saturation.

4-5 Use of a +24 volt boot-strap regulated power supply via a added winding on input SW-Reg inductor L2, assuring constant base dive current, at low and high line voltage for Q1 and Q2.

4-6 Proportional base drive for the switching regulator transistor Q1 as to take advantage of the higher voltage non-darlington transistors without added load on the +24 volt supply. The major drive base power is then derived from the collector current, reducing the +24 current requirements as well as enhancing the switching performance of the switch Q1.

4-7 Use of small power FETS for the output base drivers of Q1 and Q2 and the slow-start discharge circuit to reduce component count.

4-8 Change in ferrite core material for L2, L3, L4 and L5 to H7C1 or H7C4 with lower initial loss and decreasing losses with temperature, reducing operating case temperature rise.

4-9 Higher voltage, high speed transistors are currently in development and are forecasted for delivery in 1984 to further increase reliability or power output.

4-10 The slight noise emanating from the L2 switching regulator can be completely eliminated by using a molypermalloy powered-iron toroid core.

The clay used as a filler in these cores acts to dampen them mechanically to the point where no noise was detectable. The core and winding is however somewhat more costly.

4-11 A further increase in design margin of L2 by reducing the operating qauss level to accommodate larger line voltage surge levels without saturating, as may occur following a line voltage short, overloads, etc. should be further investigated.

4-12 The use of slots in the top cover and the bottom of the box to allow convection of air flow. One unit was so modified and runs-approximately 7-10°C cooler on the side wall the cores are mounted to. The case temperature appears to differ less than 6-7°C over the entire surface.

SECTION 5 CONCLUSION:

5-1 The major objections or shortcomings identified in Phase 1 of the feasibility development program have been identified and solutions have been either implemented or identified. One example is that the time rate of dimming had to be internally limited or else the arc extinguished itself, becoming more critical with extension of the lower end of the range.

5-2 The repackaging of the ballast did much to improve the mechanical integrity of the package. The number of printed circuit boards sub-assemblies were reduced.

5-3 Newer components, specifically the magnetic core materials and power devices (transistors and diodes) promise further to reduce power losses and heat-rise, improving reliability.

5-4 The electronic performance changes required were more difficult and extensive than first thought and resulted in some secondary problems of their own which had to be solved.

5-5 If the program is continued it is strongly recommended that some further engineering be employed before building a larger quantity of test ballast. The major limitation uncovered is that of Acoustic Resonance in lamps. When operating at high frequencies and with the

non-uniformity of the critical parameters physical size and shape between manufactures, usage would be restrict to perhaps two of the three U.S. sources.

A ballast family composed of different wattage lamps could require different operating frequency bands to minimize this effect.

5-6 A method to overcome this limitation using a square-wave current drive has been tested, however will require considerable resources to implement the program. Running the lamps at a higher sine wave frequencies (approx. 100KC), well above the lamp fundamental acoustic resonance mode is being investigated and also appears favorable.

Operating below the fundamental becomes a problem due to excitation via the harmonics of the drive source frequency (see 5-5).

For practical reasons it is desirable the final ballast method chosen should be able to drive lamps from all sources.

FIGURE 1 BALLAST #24

Open Loop Pin at 300V AC	DC +140.0	E OUT	OHMS	P OUT
Line 305V AC (SW Reg Current Limit Jumpered Out)				
244 Watts	140.0	77.5	30.1	200 Watt
270	140.0	92.3	37.5	227
285	139.8	101.7	42.9	241
295	139.7	112.3	50.0	252
302	139.7	124.7	59.8	260
298	139.7	138.8	74.6	258
277	139.7	153.6	98.6	239
225	139.9	167.9	147.4	190
140	140.2	178.9	296	108

Closed Loop: (PR-2) Set 200 watts at 60 ohms*
Line 277V AC (PR-1) Pre-Set to 224 watts at 30 ohms open loop

PIN WATTS	EFF.	140.0	E OUT	OHMS	P OUT WATT
208		140.0	55.4	18.75	163.7
223		140.0	64.5	23.0	180.9
244	82.0%	139.9	77.5	30.1	200.0*
244		139.9	87.1	37.5	202.3
244		139.9	93.4	42.9	203.3
244	83.9%	139.9	101.2	50.0	204.8
245		139.9	111.0	59.8	206.0
245		139.9	124.4	74.6	207.4
245		139.8	143.4	98.6	208.5
232	85.1%	139.8	170.6	147.4	197.5
142		140.2	181.0	296	110.7

The straight line curve segment (curve 3) Figure 2 to the left of the closed curve, shows the power output that would be developed if it were not for the fact the 140 volt DC source is current limited.

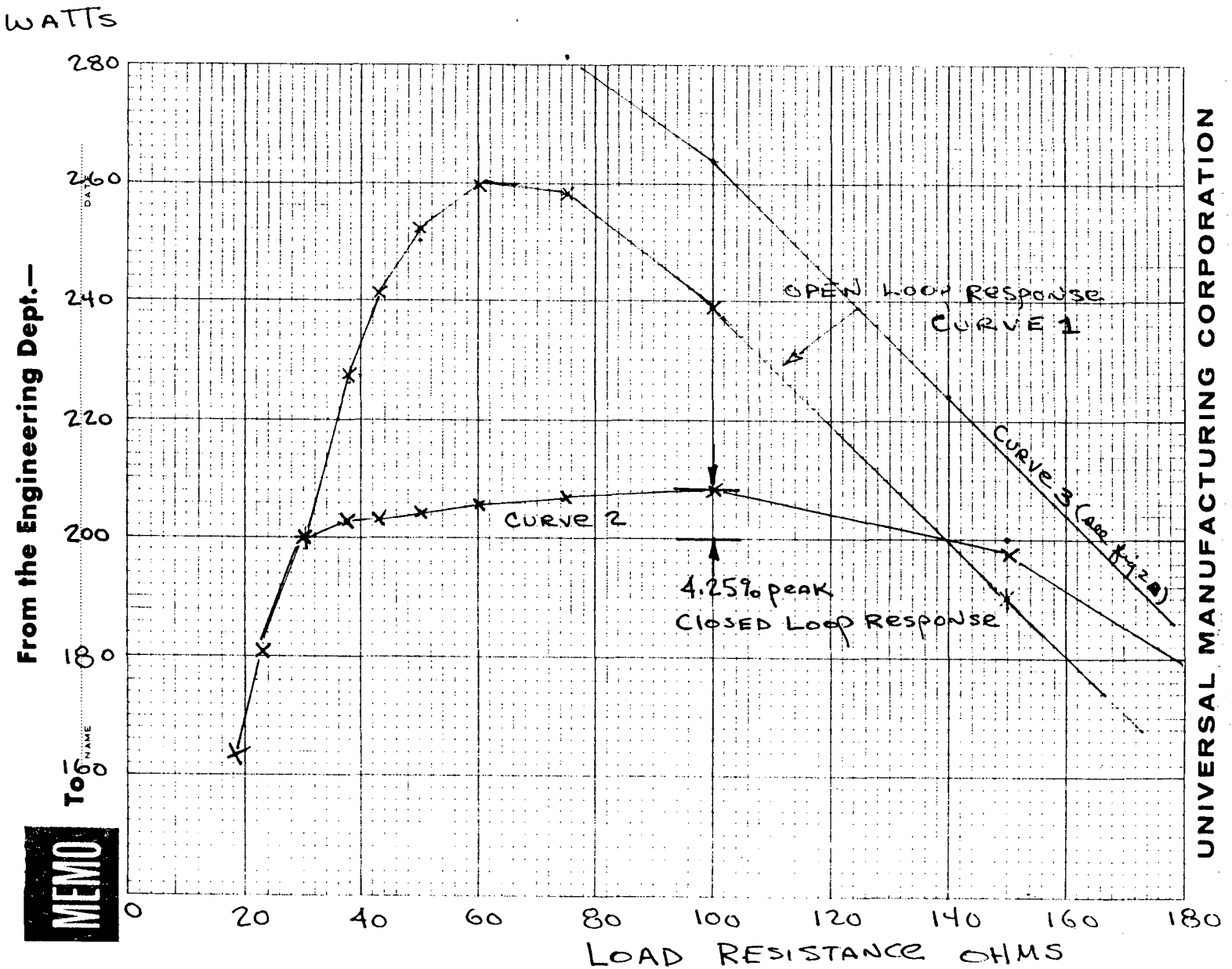

WATTS
280
260
240
220
200
180
160
0
20
40
60
80
100
120
140
160
180
LOAD RESISTANCE OHMS
OPEN LOOP RESPONSE
CURVE 1
CURVE 2
CURVE 3 (Adjusted)
4.25% peak
CLOSED LOOP RESPONSE
From the Engineering Dept.—
To
DATE
NAME
MEMO
UNIVERSAL MANUFACTURING CORPORATION

Figure 2

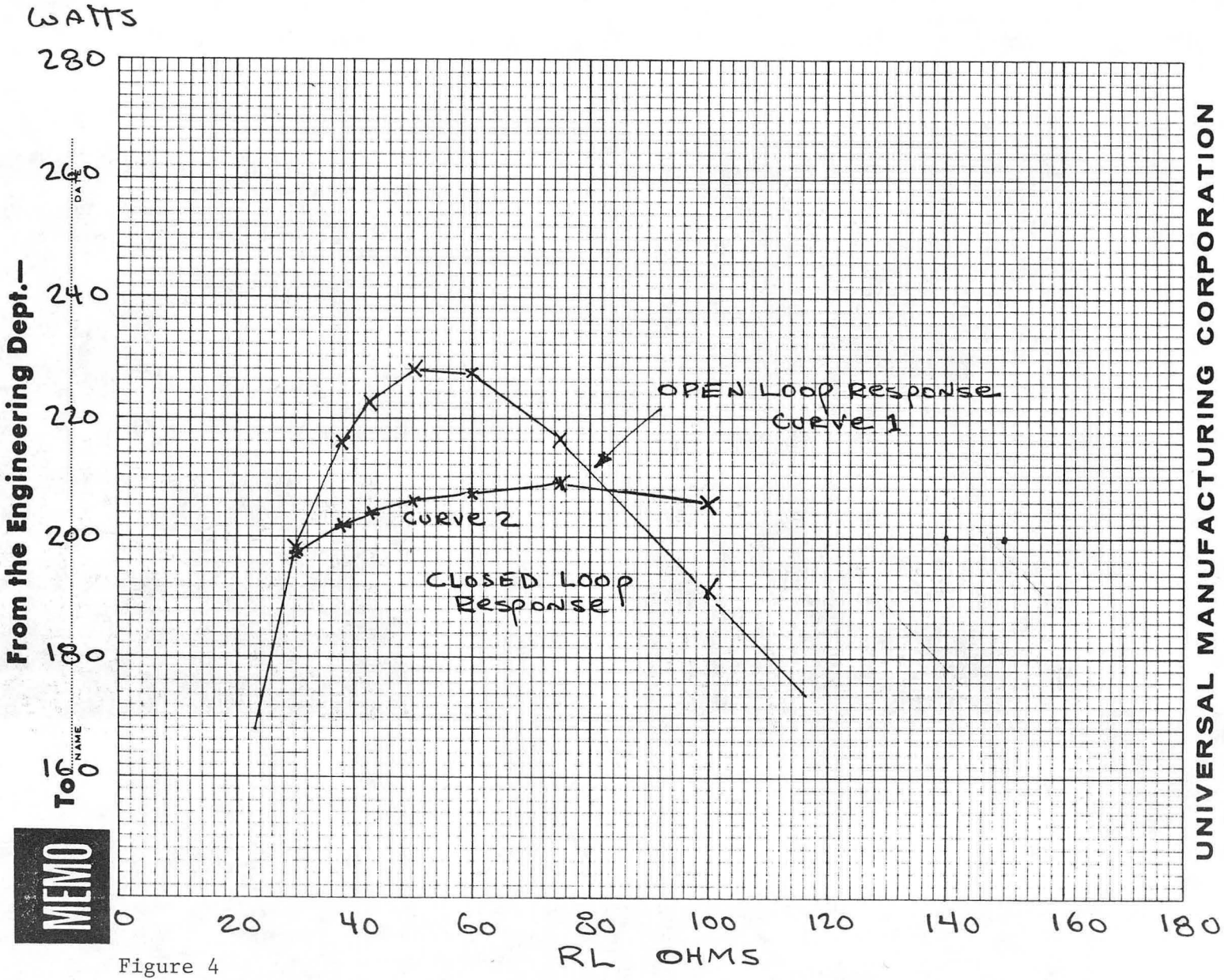
FIGURE 3

POWER OUTPUT (CLOSED-LOOP) VERSUS LOAD RESISTANCE

WATTS INPUT AT 277 VAC	LOAD OHMS	OUTPUT VOLTS RMS	POWER OUTPUT E^2/R=WATTS
250	29.9	76.8	197.6
269	37.3	89.8	216.1
276	42.6	97.6	222.5
279	49.6	106.5	228
275	59.5	116.2	227
260	74.3	126.9	216.4
229	98.8	137.3	190.8

Data Reference: PS Notebook P.S. page 34, 10/10/79

FIGURE 3


WATTS
280
260
240
220
200
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20
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80
100
120
140
160
180
RL OHMS
OPEN LOOP RESPONSE
CURVE 1
CURVE 2
CLOSED LOOP
RESPONSE
MEMO
From the Engineering Dept.—
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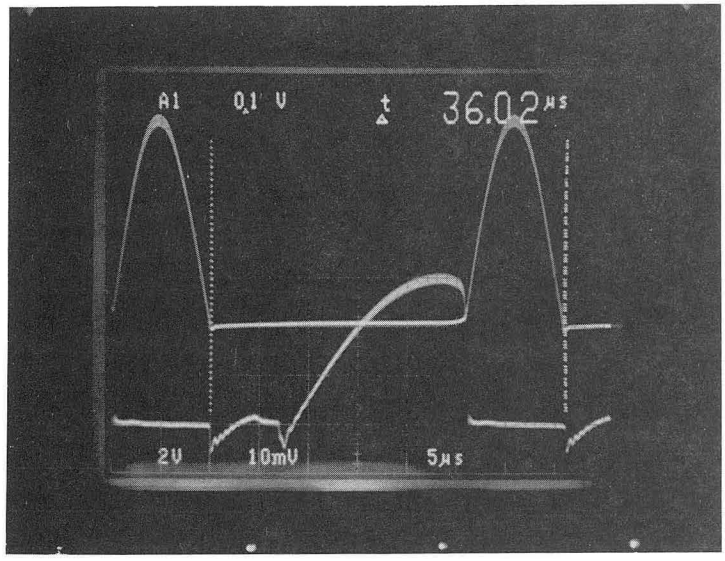
Figure 4

FIGURE 5

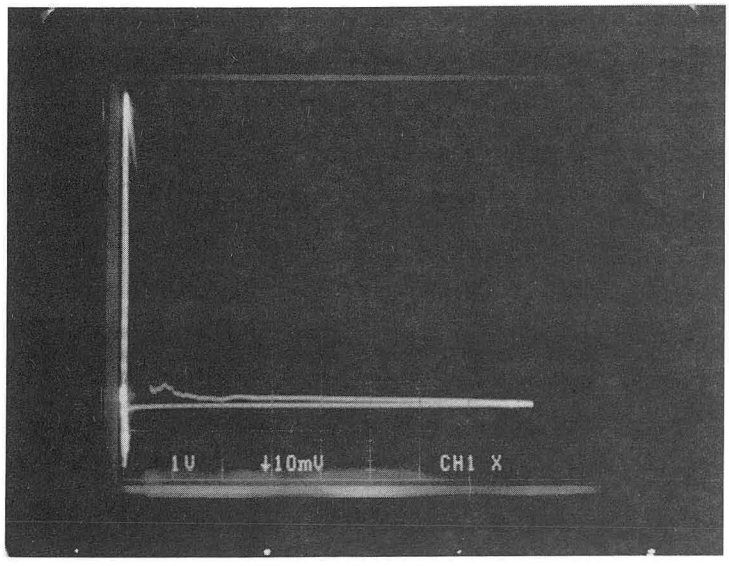
OUTPUT STAGE COLLECTOR WAVE FORMS



A - Upper trace - Q2 collector voltage waveform (200V/cm).

B - Lower trace - Q2 collector current waveform (2A/cm).

NOTE: 30 ohm load or new lamp after warmup.

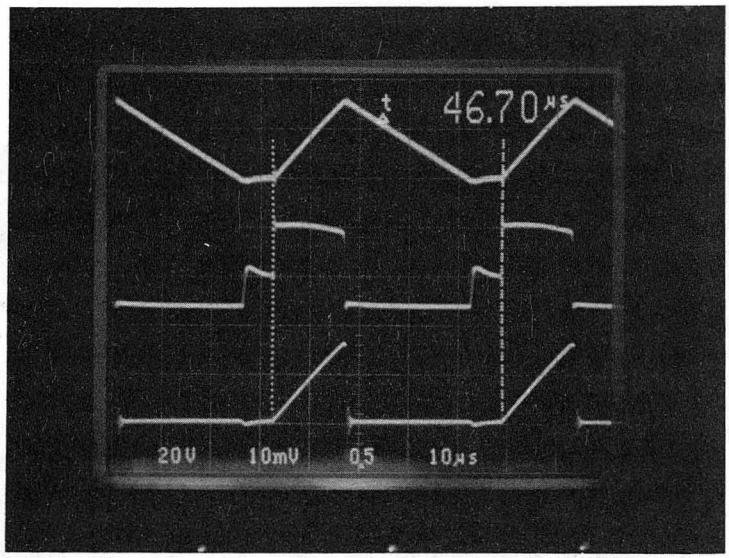


A - Y axis (1 amp/cm). B - X axis (100V/cm).

NOTE: X - Y Q2 loadline.

FIGURE 6

SW REGULATOR L2 WAVEFORMS



A - The top trace is the L2 current (5 amp/cm) showing it remains at zero at the end of each cycle (discontinuous mode).

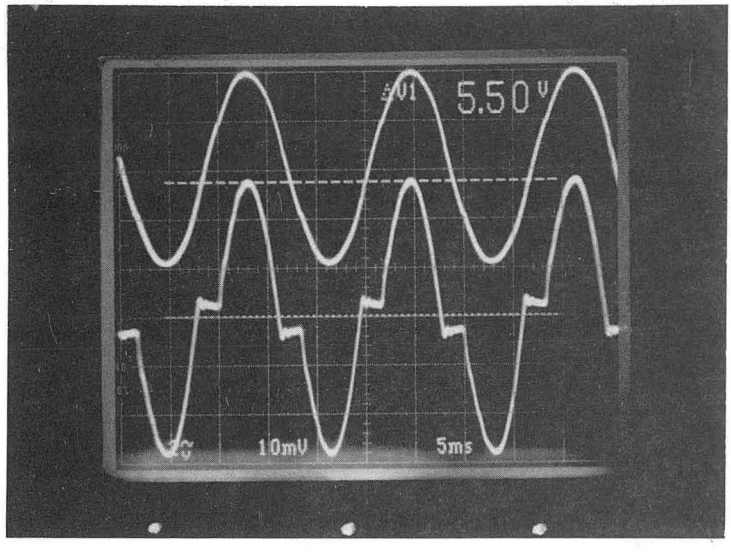
B - The center trace is the feedback winding on L2. 20V/cm.

C - The lower trace is the Q1 collector current (5 amp/cm).

The input power was 227 watts at a line voltage of 277V AC.

FIGURE 7A

INPUT LINE VOLTAGE AND CURRENT



A - The upper trace shows the input line voltage (200V/cm).

B - The lower trace shows the input line current (0.5 amp/cm).

Data taken at 277V AC and 235 watts input.

FIGURE 7 B

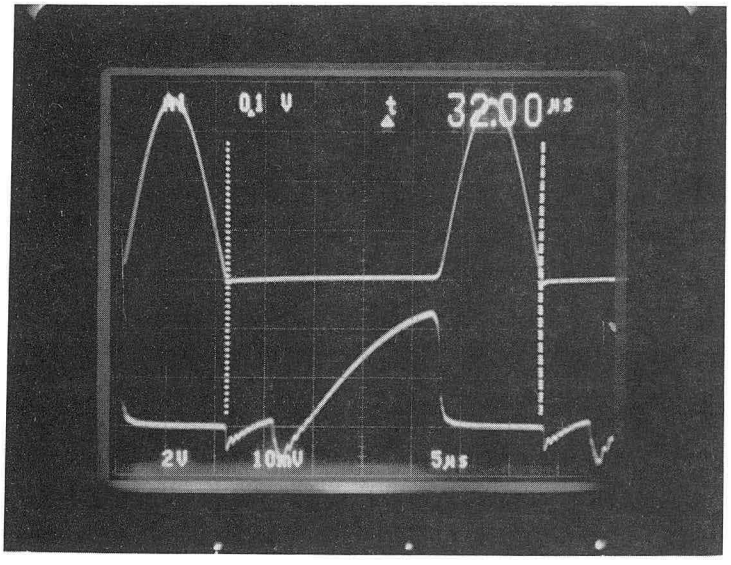
Full Output Power — Load = 30 Ohms

LINE VOLTS	AMPS	VA	WATTS	PF	P OUT	E^2/R	EFF %
250	0.973	243.3	228	0.94	75.3	189	
277	0.894	247.6	234	0.945	75.9	192	82
305	0.828	252.5	239	0.946	76.3	194	
Max Dimming Approximately 50%							
250	0.530	132.5	122	0.921	53.1		
277	0.497	137.7	126	0.915	53.1	94	74.6%
305	0.471	143.6	130	0.905	53.0		

FIGURE 7 B

FIGURE 8A (30 OHM LOAD)

OUTPUT CIRCUIT LOADLINE AT 50% DIM

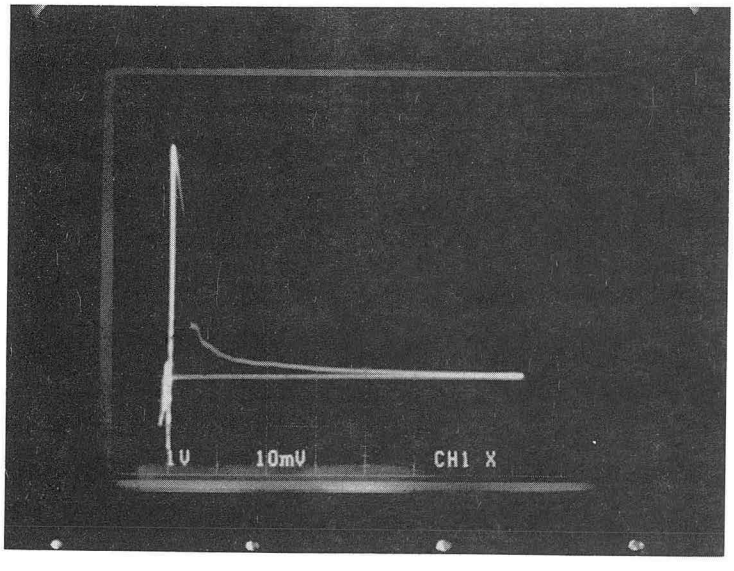


A - Upper trace Q2 collector voltage (200V/cm).

B - Lower trace Q2 collector current (2A/cm).

Input power: 126 watts.

Output: 53.3 volts rms across 30 ohms.

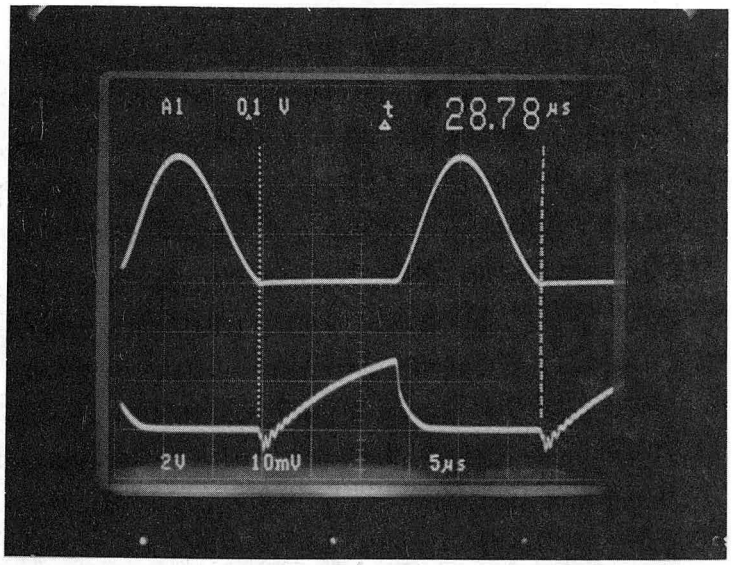


A - Y axis (2 amp/cm). B - X axis (100V/cm).

X - Y Loadline

FIGURE 8B (150 OHM LOADLINE)

OUTPUT CIRCUIT LOADLINE AT 50% DIM

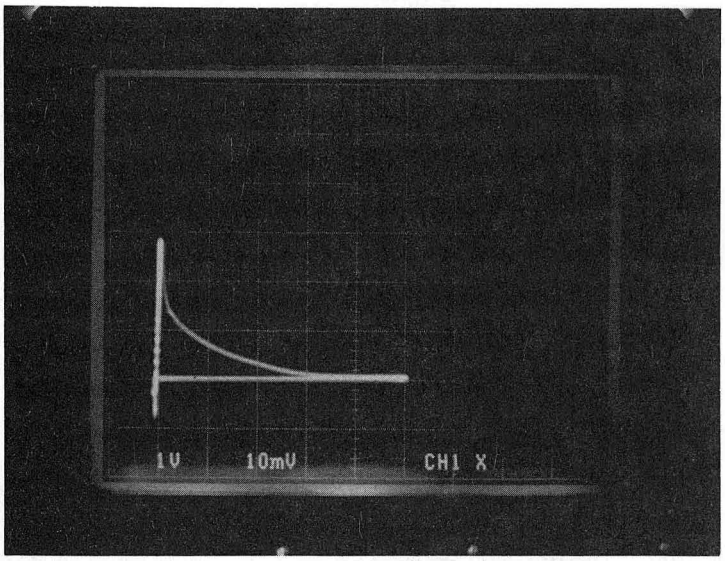


A - Upper trace: Q2 collector voltage (200V/cm).

B - Lower trace: Q2 collector current (2 amp/cm).

Input power: 127 watts.

Output: 122 volts rms across 150 ohms.

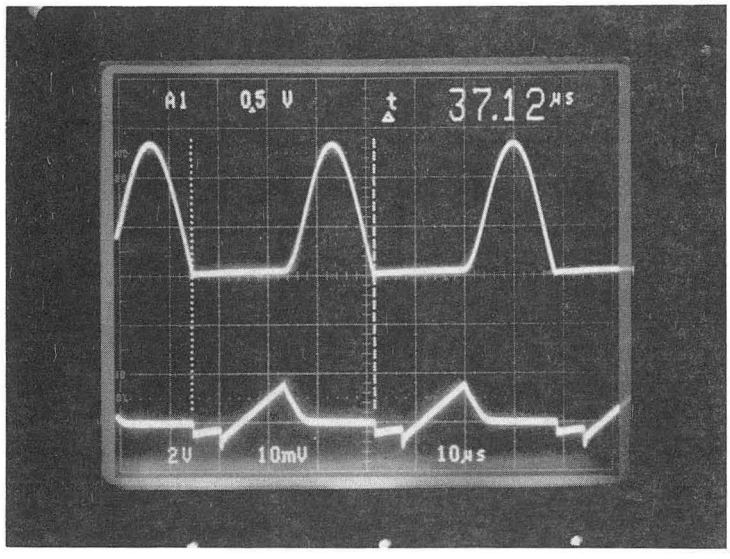


A - X axis (2 amp/cm). B - X axis (100V/cm).

X - Y Loadline

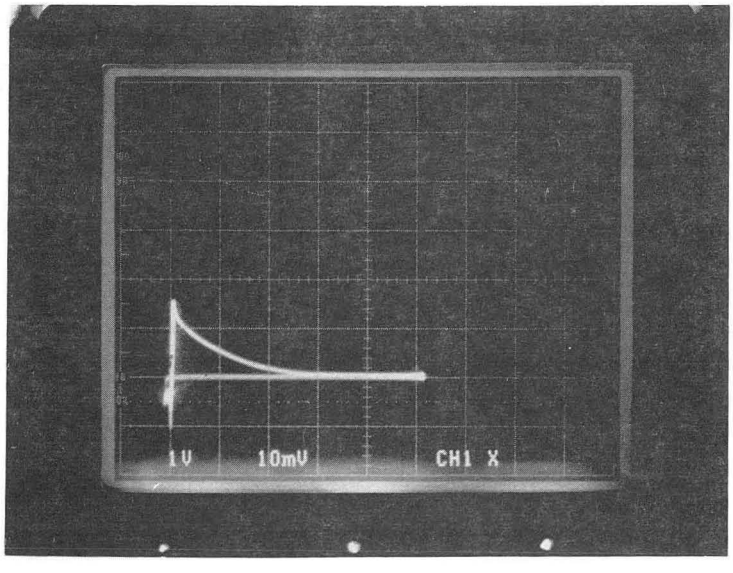
FIGURE 9

OUTPUT STAGE OPEN CIRCUIT LOADLINE



A - Q2 collector voltage (200V/cm).

B - Q2 collector current (2 amp/cm).

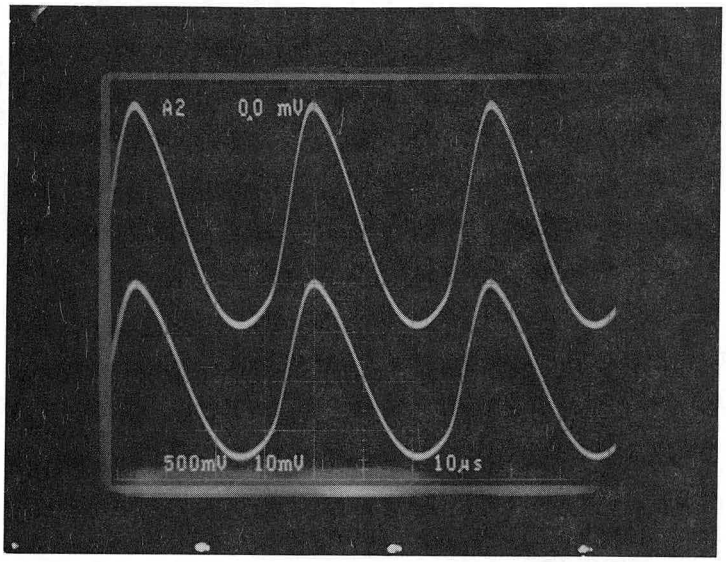


A - Y axis (2 amp/cm).

B - X axis (100V/cm).

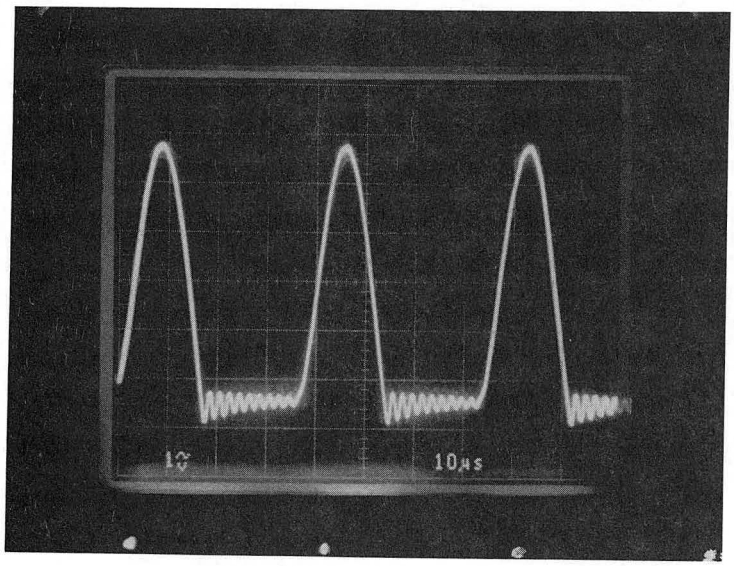
FIGURE 10A

PHASE II OUTPUT CURRENT AND VOLTAGE WAVEFORMS



A - Upper trace, output voltage across 30 ohms (50V/cm).

B - Lower trace, output current thru 30 ohms (2 amp/cm).



A - Open circuit output voltage (100V/cm)
(187V rms)
277V AC, 0.153 amps, 24 watts input.

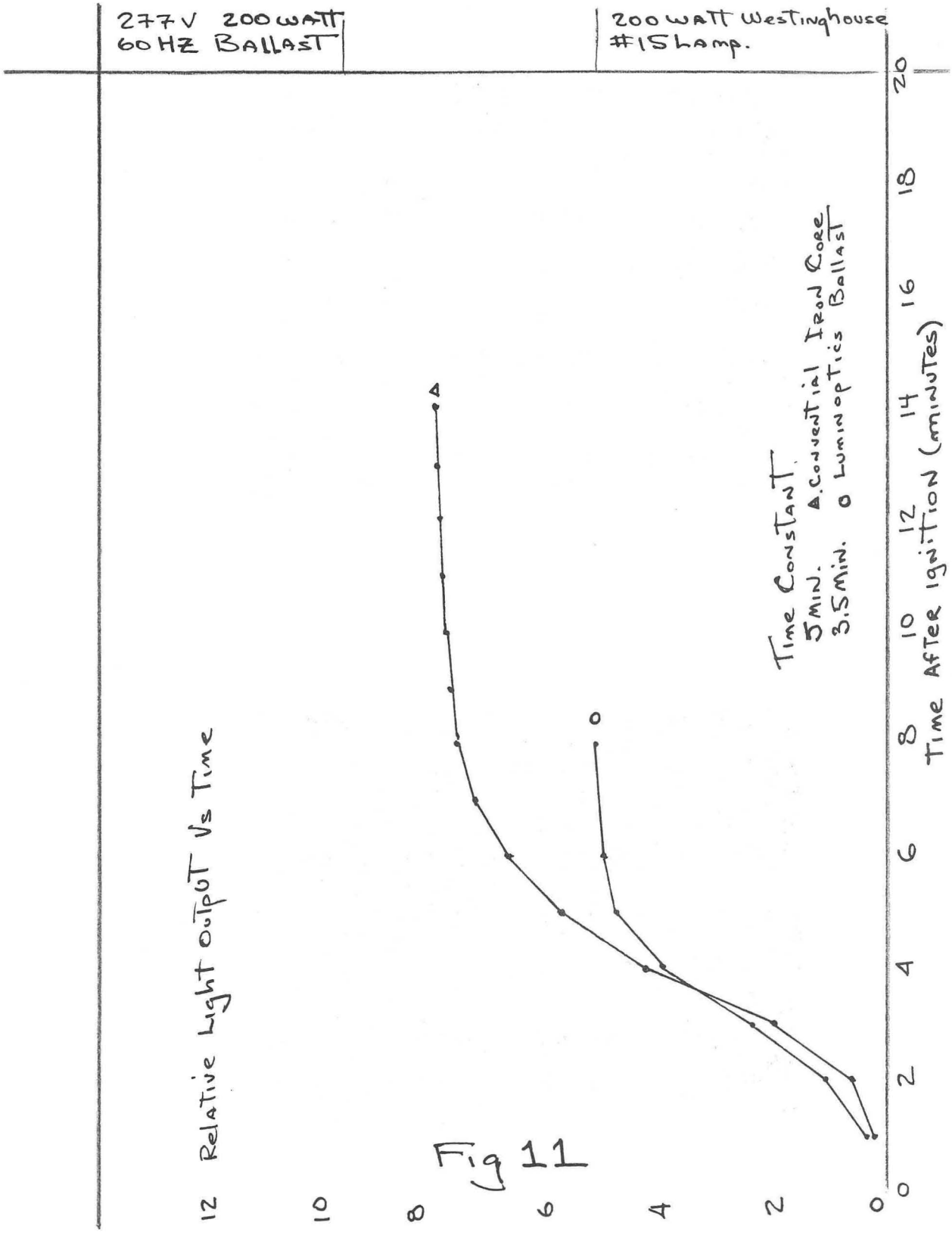

277V 200 WATT
60 HZ BALLAST
200 WATT Westinghouse
#15 Lamp.
Relative Light Output Vs Time
Time After Ignition (minutes)
Time Constant
5 Min. ▲ Convential Iron Core
3.5 Min. o Luminoptics Ballast
0
2
4
6
8
10
12
14
16
18
20

Fig 11

FIGURE 12A

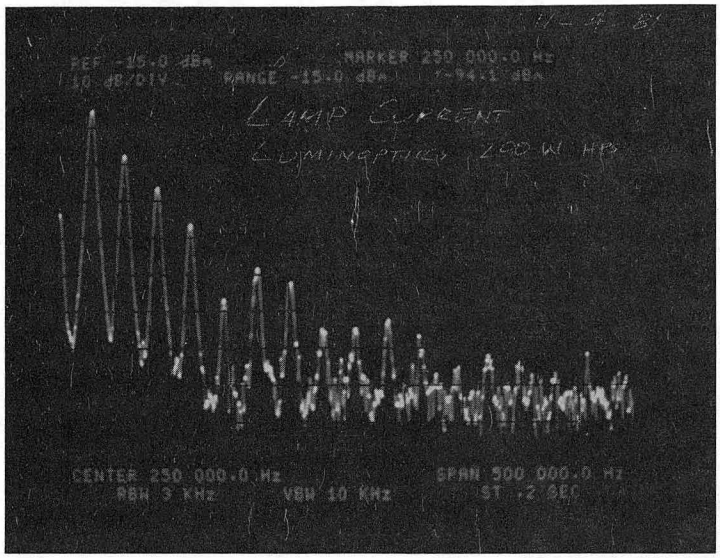


FIGURE 12B

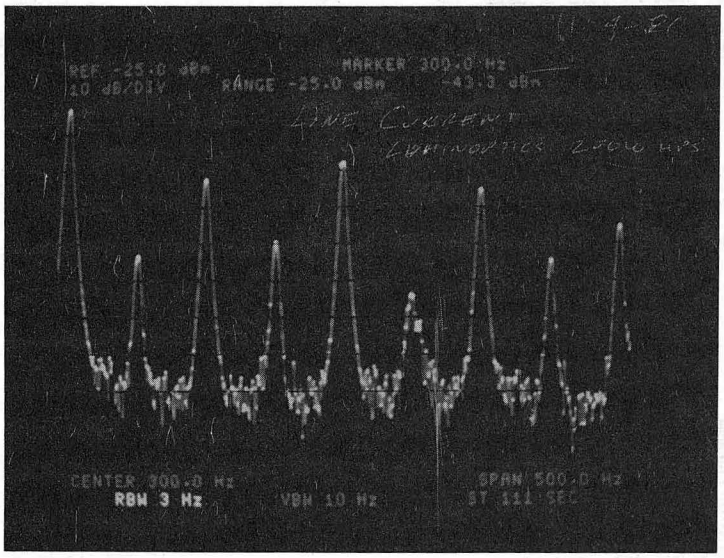
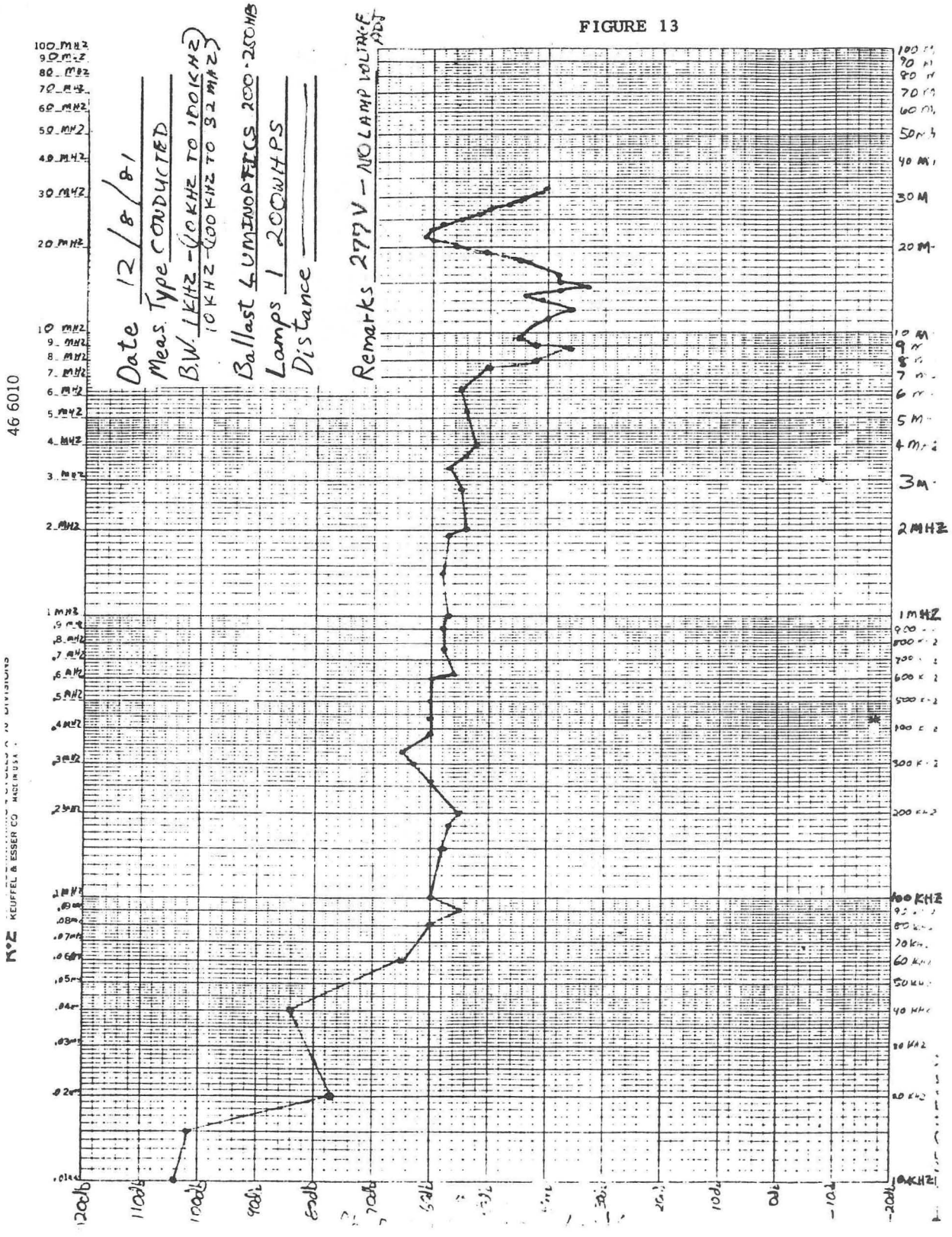


FIGURE 13



46 6010

K+E KEUFFEL & ESSER CO. MADE IN U.S.A.

CONNECTOR	COLOR	
J4	ORANGE	CONTROL SIGNAL
J4	GRAY	CONTROL REF.
J4	VIOLET	+24 VDC
J4	BROWN	+140 VDC
J5	BLUE	LAMP SHELL
J5	RED	LAMP CENTER
J6	WHITE	AC-
J6	BLACK	AC+
J6	GREEN	EARTH

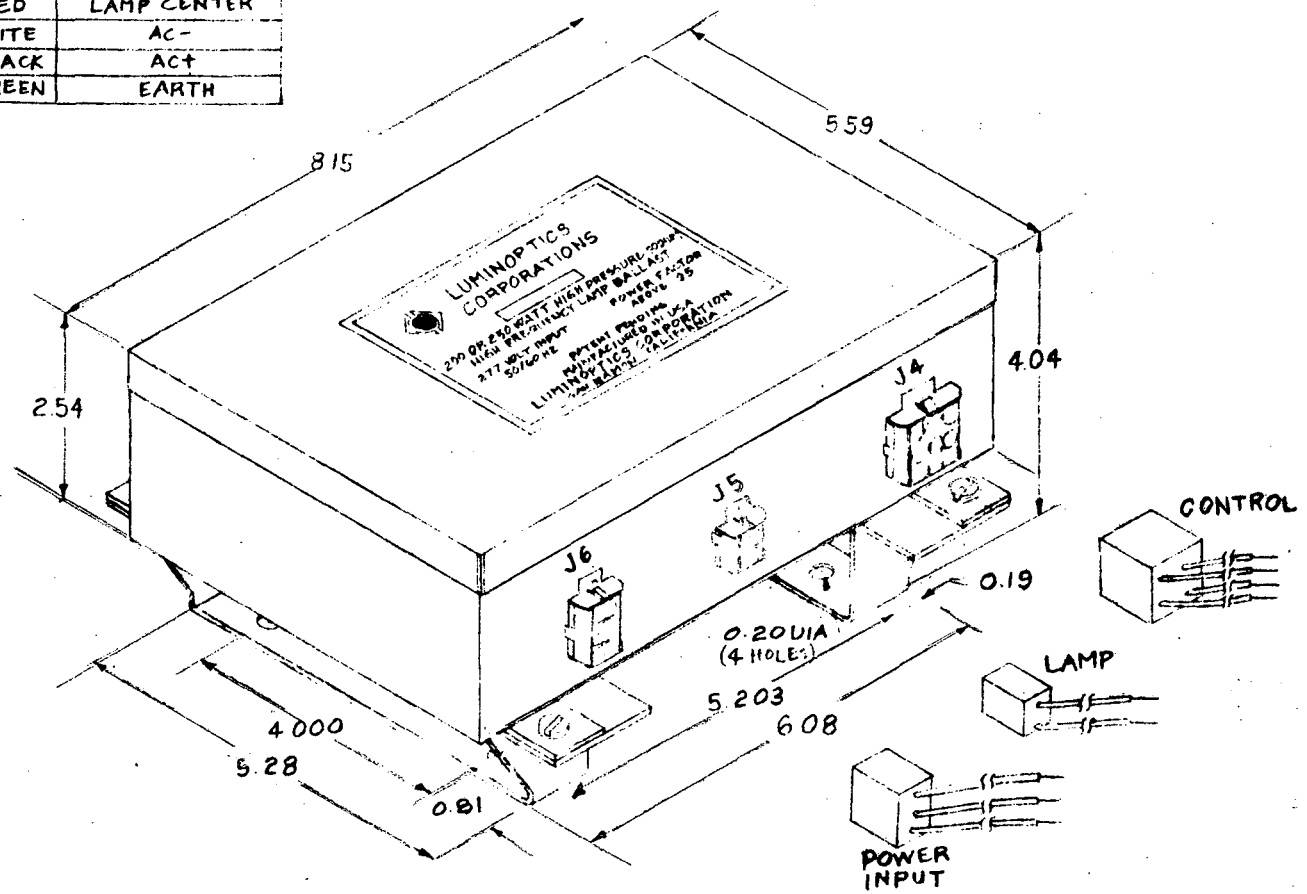


Figure 14A

DRAWN BY: JULITO AYCO APPROVED DWG. NO. 100237 PG. 1 OF 2

TITLE MECHANICAL DRAWING FOR HID BALLAST - ISOMETRIC DATE 11-3-81 SCALE HALF

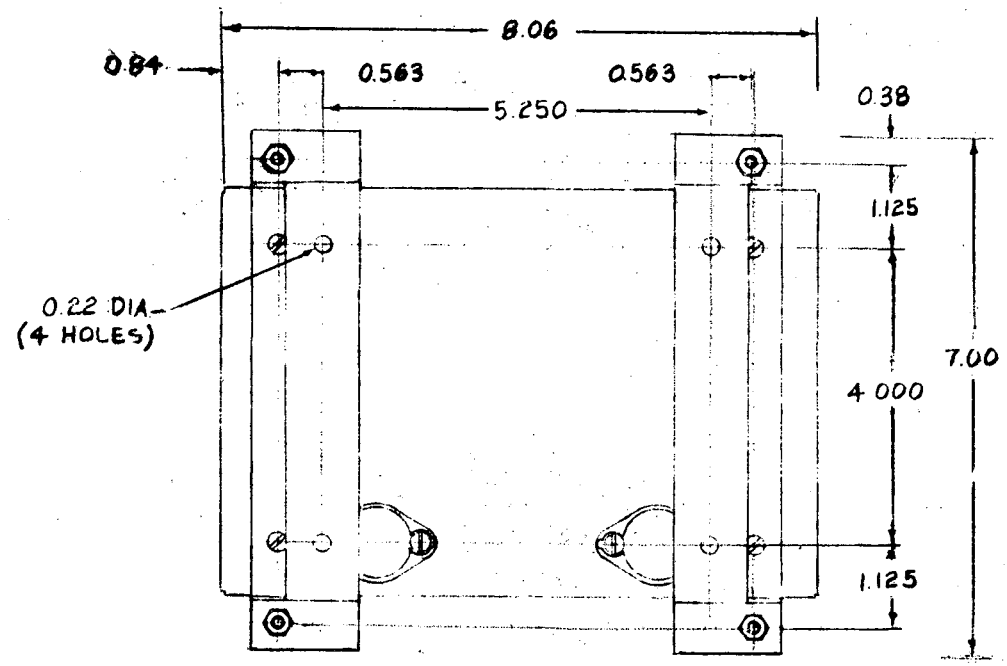


Figure 14B

DRAWN BY JULITO AYCO APPROVED DWG. NO. 100237 PG. 2 OF 2

TITLE MECHANICAL DRAWING FOR HID BALLAST - BOTTOM VIEW DATE 11-3-81 SCALE HALF

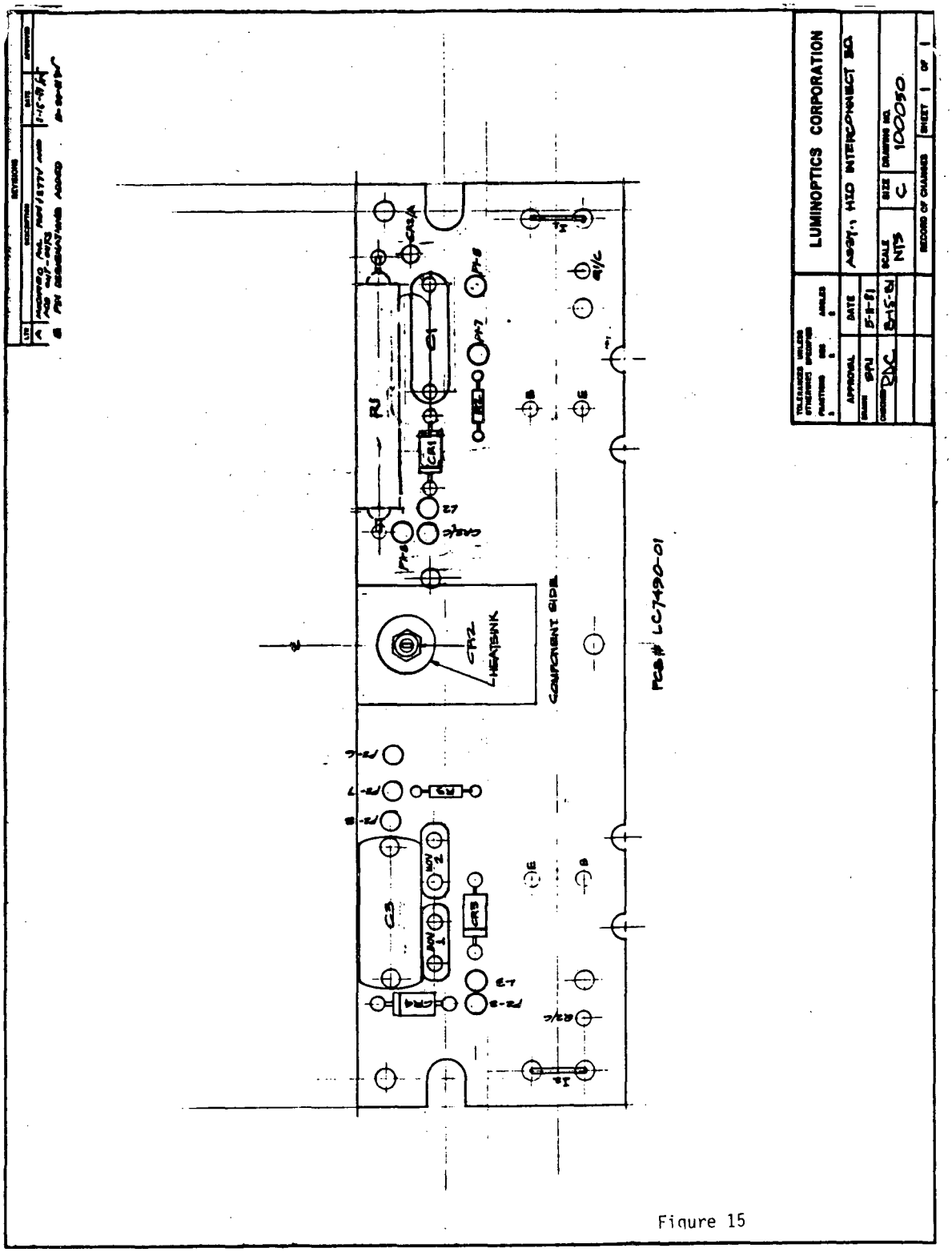

LUMINOPTICS CORPORATION
ASSY., HID INTERCONNECT BD.
SCALE NTS
SIZE C
DRAWING NO. 100050
SHEET 1 OF 1
RECORD OF CHANGES
COMPONENT SIDE
HEATSINK
PCB# LC7490-01

Figure 15

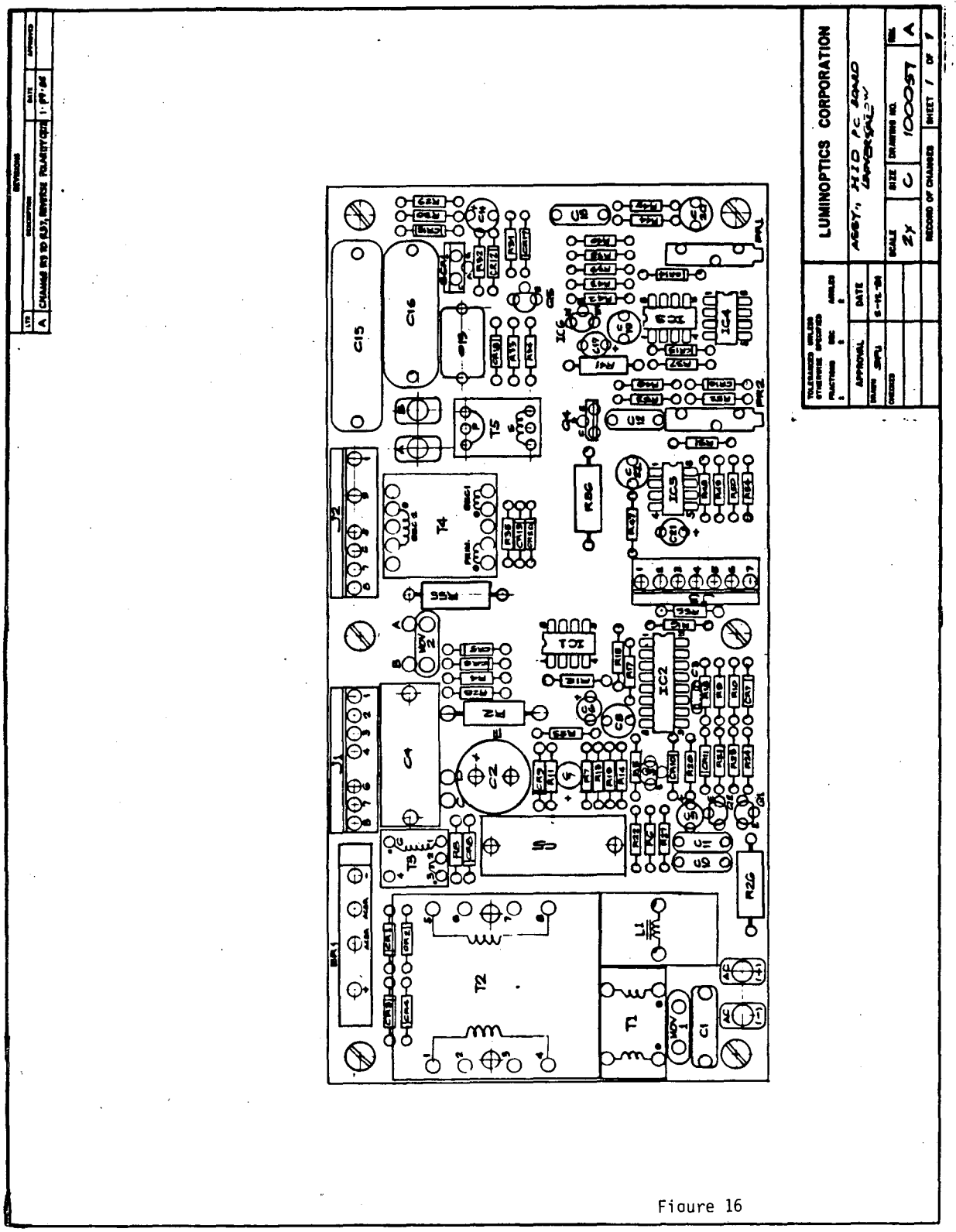
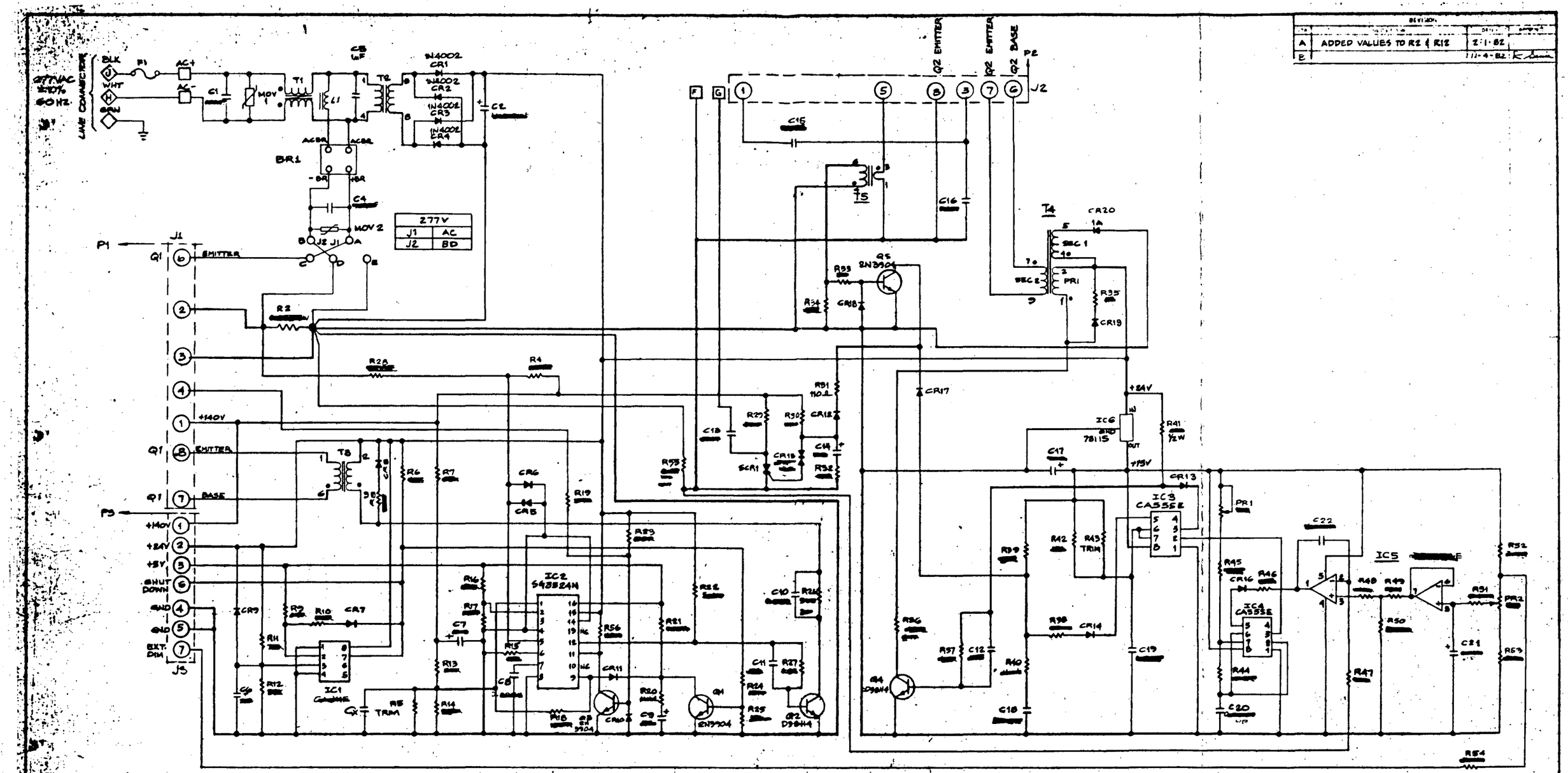

LUMINOPTICS CORPORATION
ASSY., HID PC BOARD
UNIVERSAL
SCALE
2x
SIZE
C
DRAWING NO.
100057
REV.
A
RECORD OF CHANGES
SHEET 1 OF 1
APPROVAL
DATE
REVISIONS
A
CHANGE R3 TO R37, REVERSE POLARITY
C15
C16
T5
T4
J2
J1
C4
C2
C5
T3
T2
T1
L1
C1
IC1
IC2
IC3
IC4
IC5
IC6
R2G
R3G
R5S
BR1

Figure 16



NOTES:

1. RESISTORS ARE IN OHMS 1/4 W UNLESS OTHERWISE NOTED
2. CAPACITORS ARE IN µF. UNLESS OTHERWISE NOTED
3. ALL DIODES ARE 1N4148 UNLESS OTHERWISE NOTED.
4. [X] AMP BLADE TYPE FAST-ON TERMINALS
5. CX- POWER FACTOR ADJ.

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS ± DEC ± ANGLES ±		LUMINOPTICS CORPORATION
APPROVAL	DATE	UNIVERSAL HID
DRAWN SPU	6-18-80	
CHECKED		SCALE NTS · SIZE D · DRAWING NO. 500038 · REV. B
		SHEET 1 OF 1

Figure 17

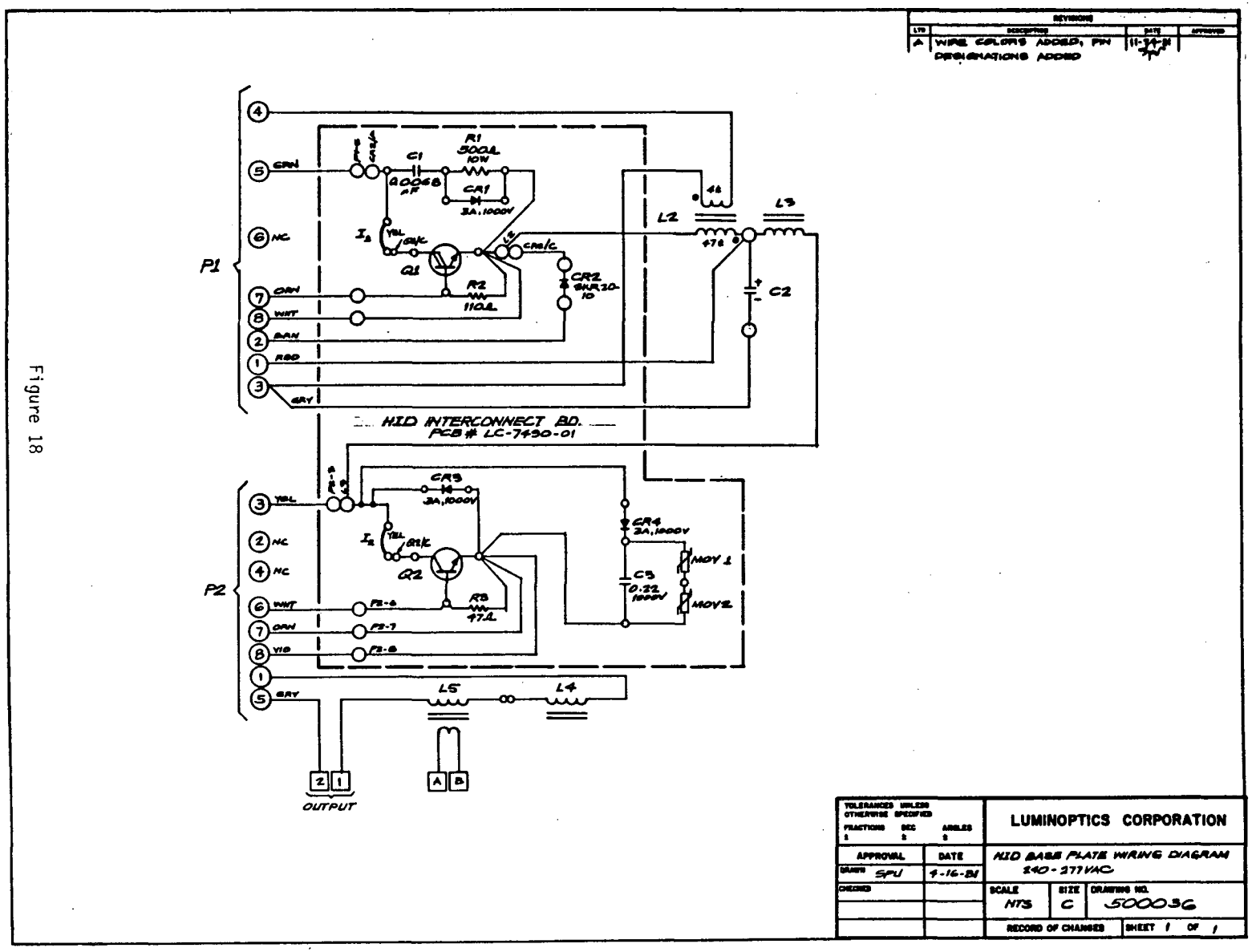


Figure 18

TOLERANCES UNLESS OTHERWISE SPECIFIED		LUMINOPTICS CORPORATION		
APPROVAL	DATE	HID BASE PLATE WIRING DIAGRAM 240-277VAC		
DRAWN SPU	4-16-81			
CHECKED		SCALE NTS	SIZE C	DRAWING NO. 500036
		RECORD OF CHANGES	SHEET 1 OF 1	

END OF LIFE 250W WESTINGHOUSE HPS LAMP TEST

All six (6) of the C250 Watt end of life lamps received from Westinghouse were tested in a standard 250 Watt 120 Volt GE commercial ballast to ascertain their condition. In all cases the lamps lit; their input power increasing to 315 Watts at which time the lamps extinguished, the input power dropped to 15 Watts.

Four of the above lamps were next powered by a 200 Watt Luminoptics Ballast in an attempt to determine what their internal resistance had increased to and to their behavior while powered by a 25KH sine wave. The lamps all lit and remain lit throughout the test, their color however appeared to have shifted toward the red part of the spectrum.

After one (1) hour running time the pertinent parameters are shown

Lamp No.	V	I	Pin	Rint	L.O. Relative
1	143.2	1.200	171.8	119.3	3.50
2	141.5	1.260	177.8	112.0	3.20
3	136.6	1.392	190.2	98.1	4.04
*4	151.0	1.044	157.6	144.6	3.33

*Ballast blew the output transistor just before the one (1) hour reading due to bad load line while operating into a RL of 145 OHMS

The conclusion reached here is that our ballast must be modified if it is allowed to power lamps which have reached an internal impedance in excess of 100 OHMS, or forced to shut down as in the case of the standard ballast. What is not yet known is, does the lamps age (internal resistance increase) and light output vary in the same manner for the two different modes of drive 120 HZ vs 25 KHZ.

Figure 19

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

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