LIGHT TRANSIENT BEHAVIOR OF MERCURY ARC DISCHARGES

by

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INTRODUCTION

The behavior of the light output from mercury arcs utilizing alternating current or pulsed direct current excitation has not been extensively investigated. Loh and Dieke (1947) utilized 60 cycle AC excitation to study the fluctuation of light output of various mixtures of mercury and noble gases. They found that there were strong light intensity surges of short duration at the time of breakdown of the gas. The surges were generally of an oscillatory nature and were not the same for different spectral lines. Barnes (1951) examined mercury and argon mixtures using square wave current excitation. He found that during the increasing current transient the voltage gradient, the power output of the 2537 A line, and the electron temperature, exceeded their normal steady state values. Porter, in unpublished work, found that the percent modulation of the light output of a low pressure, mercury argon, 4 watt, germicidal lamp was a function of the excitation frequency and exhibited a maximum at about 6 Kc. Porter's work was duplicated at this laboratory with essentially the same results.

It is the purpose of this thesis to describe the variation in light output of a mercury arc as a function of the frequency of its AC current source and to relate this behavior to experiments in which the light output of a square wave current excited arc was observed.

APPARATUS

The discharge tube was a modified Sylvania type G4T4/1, 4 watt, germicidal lamp. This tube was opened and an additional quantity of pure mercury was added. The lamp was connected to a vacuum system through a water cooled connection to reduce mercury loss during outgassing. The lamp was then heated to 350° C by an oven for a period of approximately six hours. During this period the filaments were heated by passing a current through them; and for approximately one hour, additional outgassing of the filaments was obtained by maintaining an arc of 50 ma between them. The lamp was then sealed off and examined spectrographicly. There was no indication of gaseous impurities in the mercury vapor even at the cathodes.

Square wave modulation of current through the lamp was obtained by utilizing the lamp as a load for a type 813 vacuum tube. Since the 813 is a pentode type tube, its conduction is relatively independent of plate voltage. Thus it was possible to obtain square wave current pulses through the discharge tube even though its impedance varied during the cycle. Control of the average DC current (I_{ave}) in the discharge tube was accomplished by utilizing voltage dividers on the screen and control grids of the 813 tube such that the bias voltage was continuiously variable between 0 and 90 volts. The screen voltage was variable in steps of 100 V between 0 and 700 V. Current levels up to 250 ma were obtained without exceeding the maximum power limit of the 813 amplifier or its associated power supply.

Drive for the 813 tube was obtained from a low gain broad band preamplifier which was driven by a General Radio type 1210-B sine and square wave generator.

The resultant system was capable of providing a square wave of current, the rise and decay times of which were less than 1 μs.

A schematic of the amplifier and preamplifier are shown in Plates I and II.

Light intensities were determined by first passing the light output of the discharge tube through a Bausch and Lomb grating type #33-86-45-01 500 mm monochromator, the output of which was focused on the cathode of a 1P28 photomultiplier tube. The output of the photomultiplier was presented on a Tektronix oscilloscope. The apparatus used is shown in Plate III and in schematic form in Plate IV.

Calibration trials of the photomultiplier circuit indicated a linear intensity response in the recommended average current region of 0 to .5 ma. Response time of the complete photomultiplier circuit was determined by observing on the oscilloscope the decay of a waveform produced by a narrow noise pulse. The response time was found to be less than .5 μs.

A schematic of the photomultiplier circuit is shown in Plate V.

The power requirements were obtained as follows:

(1) 1000 V, 60 ma, photomultiplier voltage obtained from a General Radio type 673-A regulated power supply.

(2) 300 V and 150 V preamplifier voltages obtained from low voltage conventional type regulated supply constructed at Kansas State College.

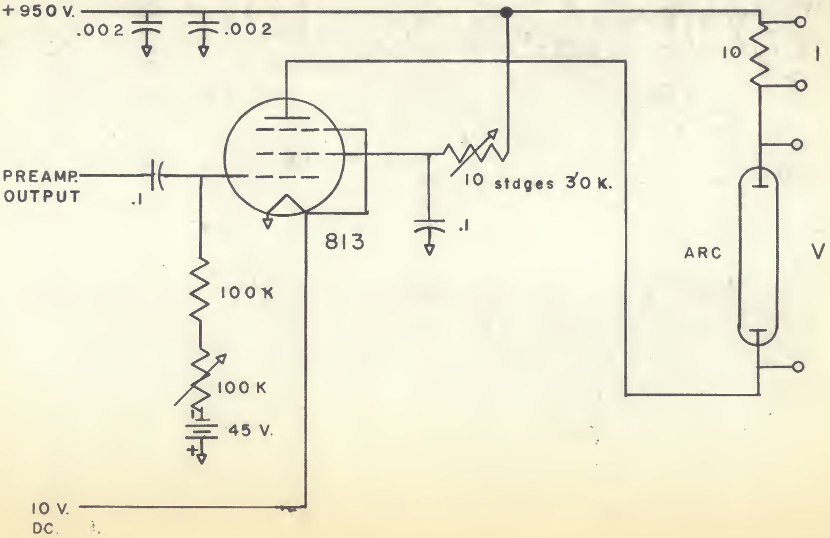
(3) 1000 V, 300 ma, 813 B^+ supply obtained from radar test unit unregulated supply. A conventional type electronic voltage regulator was constructed for this supply.

(4) 10 V, 5 amp., 813 filament supply was obtained from storage batteries.

EXPLANATION OF PLATE I

Schematic of amplifier.

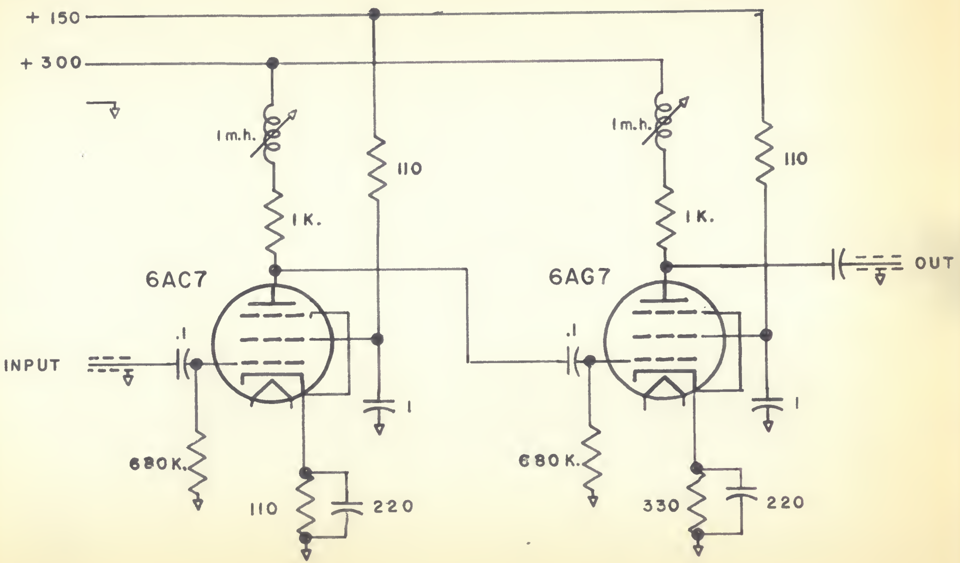
PLATE I


+950 V.
.002
.002
PREAMP. OUTPUT
.1
100 K
100 K
45 V.
813
.1
10 stages 30 K.
10
I
ARC
V
10 V. DC.

EXPLANATION OF PLATE II

Schematic of preamplifier.

PLATE II

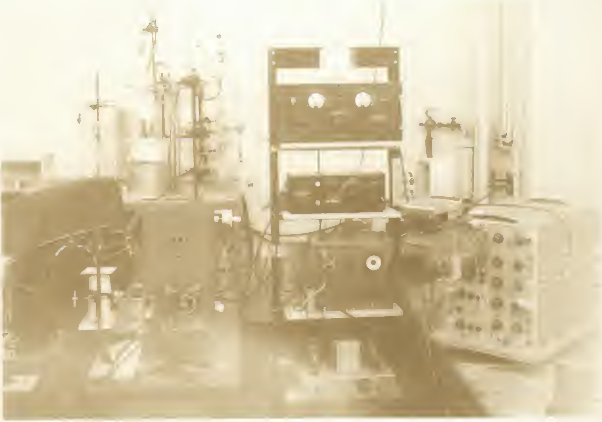

+ 150
+ 300
1 m.h.
110
1 K.
6AC7
.1
INPUT
680K.
110
220
1
1 m.h.
110
1 K.
6AG7
OUT
.1
680 K.
330
220
1

EXPLANATION OF PLATE III

Picture of equipment as used in this experiment. Shown are:

1) Arc and oven assembly.
2) Monochromator.
3) Relay Rack containing amplifier and power supplies.
4) Tektronix 545 oscilloscope equipped with Dumont Polaroid-Land Camera.
5) Vacuum system for lamp preparation.

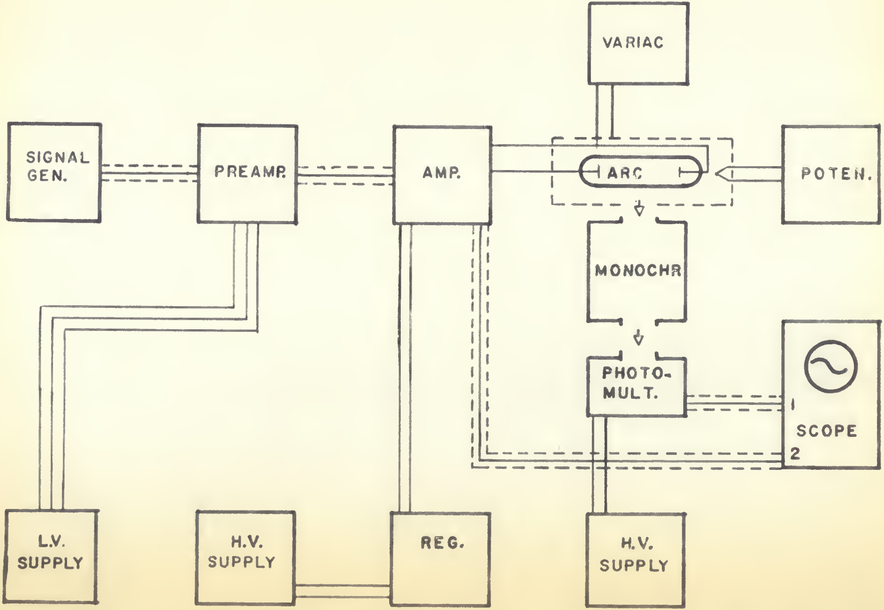
PLATE III



EXPLANATION OF PLATE IV

Block Diagram of equipment as utilized in both square wave and sine wave experiments.

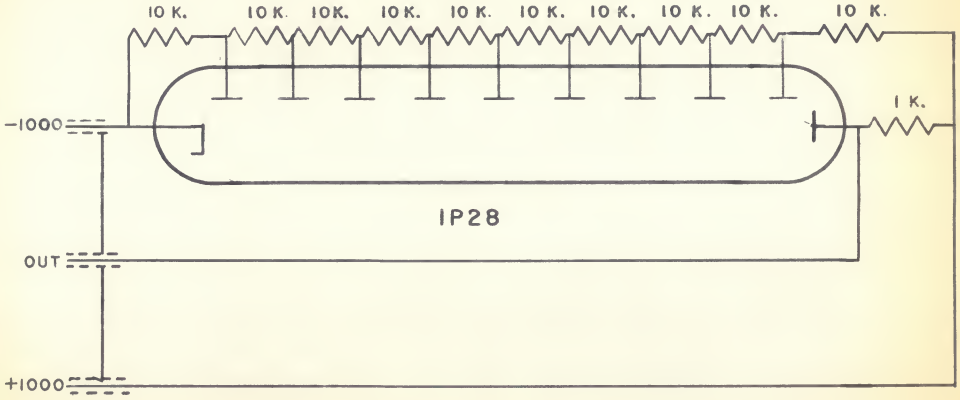
PLATE IV


VARIAC
SIGNAL GEN.
PREAMP.
AMP.
ARC
POTEN.
MONOCHR
PHOTO-MULT.
SCOPE
1
2
L.V. SUPPLY
H.V. SUPPLY
REG.
H.V. SUPPLY

EXPLANATION OF PLATE V

Schematic of photomultiplier tube circuit.

PLATE V



Mercury vapor pressure in the discharge tube was controlled by placing the lamp in an electric oven. A $1\frac{1}{2}$ inch diameter brass cylinder penetrated one side of the oven; and the open end of the cylinder was placed adjacent to the collimator lens of the monochromator, thus providing a large aperture with small heat loss. Temperature of the oven was determined by a Chromel Alumel thermocouple and a Leed's and Northrup potentiometer. A Variac in the oven supply line was used for controlling oven current and temperature. The oven assembly is, also, shown in Plate III.

All waveforms were presented and all current and voltage measurements were made on a Tektronix type 545 oscilloscope, utilizing a dual-channel input unit.

Photographic record of waveforms were made with a Dumont type 302 Polaroid-Land oscilloscope camera.

The waveform of the current through the discharge tube was obtained from a 10 ohm resistor in series with the tube. The voltage drop across this resistor was presented to one channel of the oscilloscope.

Voltage measurements across the tube were measured in the same manner; but in this case, the potential was measured from cathode to anode. The current and voltage monitoring points are shown in Plate II.

PROCEDURE AND RESULTS

The temperature of the oven was maintained at 300° C at which the vapor pressure of mercury is 246.8 mm of mercury.

The output of the signal generator was set at 3000 cycles square wave operation. From observation of the waveforms on the oscilloscope, the time between transients was sufficient for the tube to return to a steady state operation.

The output of the signal generator was increased until the percent modulation of current was 50 percent where percent modulation is defined as follows:

$$\% \text{ Mod} = \frac{I_{max.} - I_{min.}}{2\, I_{ave.}} \times 100$$

The currents were determined by their corresponding deflections on the oscilloscope.

Plate VI indicates current and voltage waveforms. It can be seen that the rise and decay time of the current waveform is less than 1 μsec.

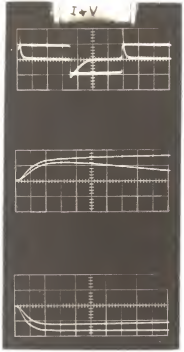
Plates VII - VIII - IX indicate light output waveforms for various spectral lines. All pictures are in the following order: 1) complete waveforms 2) increasing current transient, and 3) decreasing current transient. When the spectral line was of sufficient intensity, the monochromator slits were opened until the deflection of the trace during the high current steady state condition was .1 volt. The maximum of the light output waveform associated with the increasing current transient (L_{ICT}) and the decreasing current transient (L_{DCT}) are tabulated in Table 1. The maximum values are measured from the lowest grid line which in all pictures is the zero light output line.

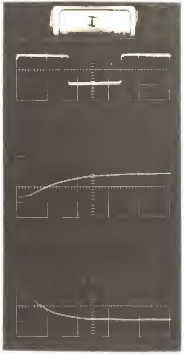
EXPLANATION OF PLATE VI

Current (I) and voltage (V) waveforms associated with a square wave excited mercury arc. Zero line for pictures I and V is the bottom grid line. Picture I + V does not have a zero reference line. The three waveforms appearing on each picture are in the following order: 1) complete waveform (CW); 2) waveform during increasing current transient (ICT); 3) waveform during decreasing current transient (DCT). Ordinates and abscissa are as tabulated below.

Subject	Waveform	Abscissa μs/division	Ordinate
I	CW	50	50 ma/div.
	ICT	.2	50 ma/div.
	DCT	.2	50 ma/div.
V	CW	50	200V/div.
	ICT	2	200V/div.
	DCT	10	50V/div.
I + V	CW		
	Current	50	50 ma/div.
	Voltage	50	200V/div.
	ICT		
	Current	.5	50 ma/div.
	Voltage	.5	100V/div.
	DCT		
	Current	.5	50 ma/div.
	Voltage	.5	100V/div.

PLATE VI



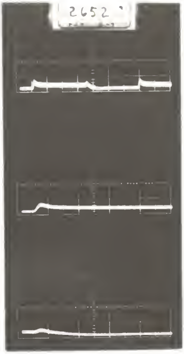


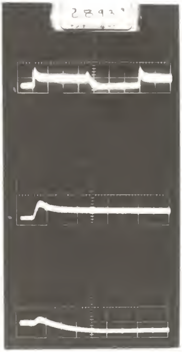
EXPLANATION OF PLATE VII

Light output waveforms of various spectral lines of a square wave excited mercury arc. Zero light input is the bottom grid line. The ordinates are in volts/$_{cm}$ which was proportional to light intensities. The abscissa are in time units as tabulated below. The three waveforms shown in each picture are as follows: 1) complete waveform; 2) light output waveform associated with the increasing current transient (L_{ICT}); 3) light output waveform associated with the decreasing current transient (L_{DCT}). All pictures except those denoted by (*) were taken utilizing a high current steady state deflection of .1 volt.

Line in Å	Waveform	Abscissa in μs/$_{division}$	Ordinate in volts/$_{div.}$
2437	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
2652*	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
2752*	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
2893*	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
2967	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
3021	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05

PLATE VII



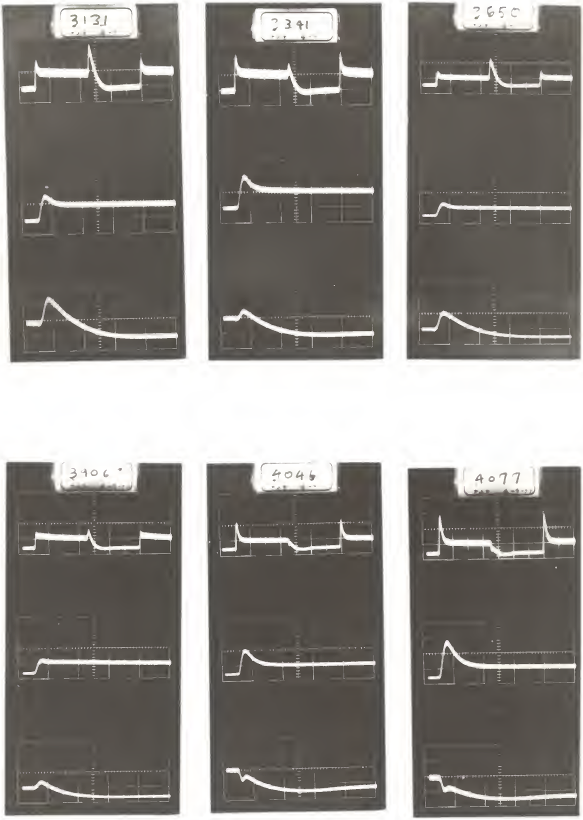


EXPLANATION OF PLATE VIII

Light output waveforms of various spectral lines. See Plate VII.

Line in A	Waveform	Abscissa in $\mu s/_{division}$	Ordinate in $volts/_{division}$
3131	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
3341	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
3650	CW	50	.1
	L_{ICT}	10	.1
	L_{DCT}	10	.1
3906*	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
4046	CW	50	.1
	L_{ICT}	10	.1
	L_{DCT}	10	.05
4077	CW	50	.1
	L_{ICT}	10	.1
	L_{DCT}	10	.05

PLATE VIII

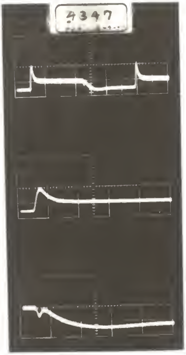


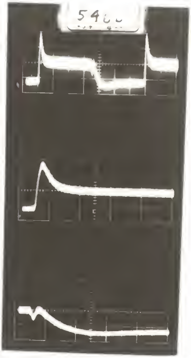
EXPLANATION OF PLATE IX

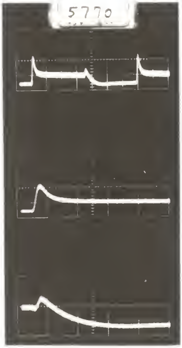
Light output waveforms of various spectral lines. (See Plate VII)

Lines in A	Waveform	Abscissa in µs/division	Ordinate in volts/division
4347	CW	50	.1
	L_{ICT}	10	.1
	L_{DCT}	10	.05
5460	CW	50	.05
	L_{ICT}	10	.05
	L_{DCT}	10	.05
5770	CW	50	.1
	L_{ICT}	10	.1
	L_{DCT}	10	.05
5790	CW	50	.1
	L_{ICT}	10	.1
	L_{DCT}	10	.05

PLATE IX







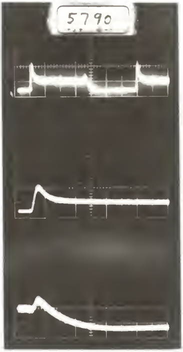


Table 1. Maximum deflections associated with light transients.

Line	L_{ICT}	L_{DCT}	Remarks
2537	.19	0	
2652*			too weak to make measurement practical.
2752*			
2893*			
2967	.14	.19	
3021	.17	.16	
3131	.135	.185	
3341	.16	.13	
3650	.14	.22	
3906*			too weak.
4046	.21	.085	dip before rise
4077	.29	.075	dip before rise
4347	.2	.1	dip before rise
5460	.2	.115	dip before rise
5770	.23	.135	
5790	.23	.14	

Plate X indicates light output waveforms associated with the decreasing current transient. A fast sweep speed was used in these pictures to attain the greatest possible resolution. No attempt was made to maintain a zero level or a particular steady state value.

Plate XI indicates the change in the percent light modulation with respect to the frequency of the excitation source. The excitation utilized was a 50 percent sine wave modulated 100 ma current.

DISCUSSION

General

From the pictures of the voltage waveform during a square pulse of current the following observations may be deduced:

(1) The impedance of the discharge remained relatively constant

EXPLANATION OF PLATE X

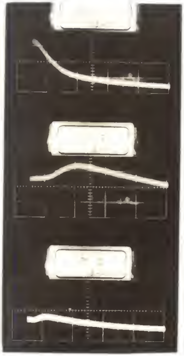
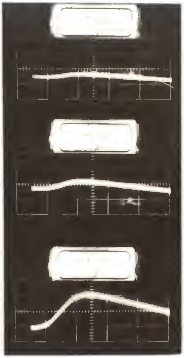
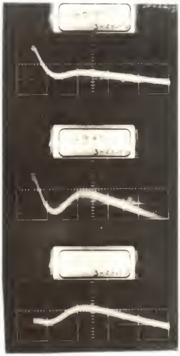
Light output waveforms of various spectral lines associated with the decreasing current transient.

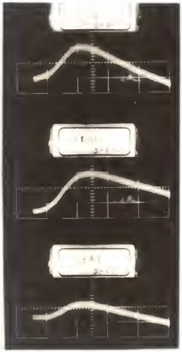
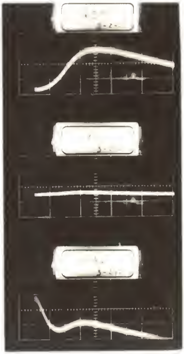
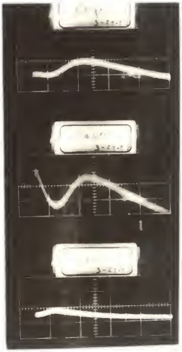
a) Absicissa - time - .2 $\mu s/_{div.}$; with the exception of the 2752 A and the $3906^{(2)}$ A lines are .5 $\mu s/_{div.}$

b) Ordinate - .05 $V/_{div.}$

c) No zero reference line.

PLATE X

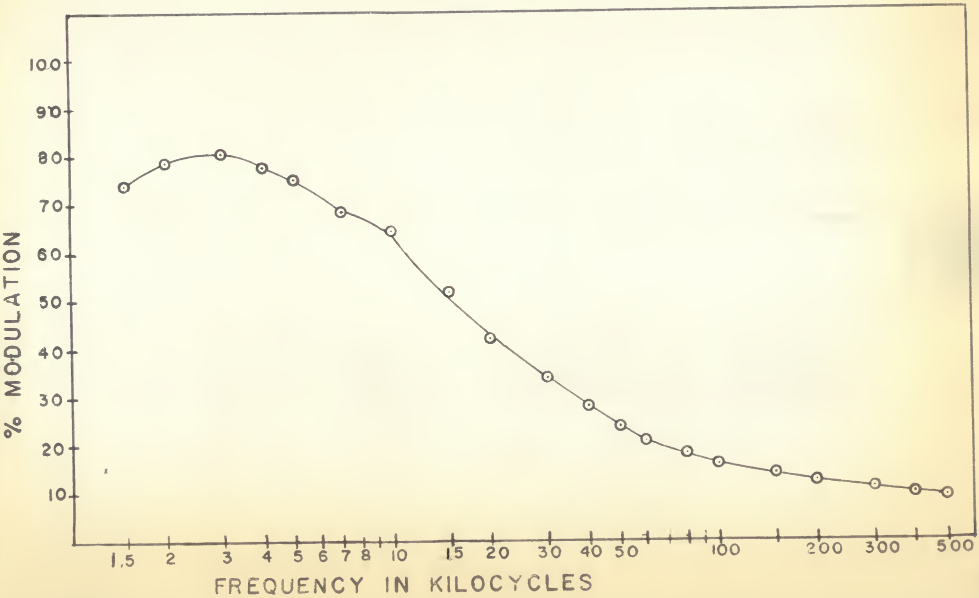




EXPLANATION OF PLATE XI

Percent modulation of light output of 2537 A line as a function of excitation frequency.

PLATE XI


% MODULATION
100
90
80
70
60
50
40
30
20
10
1.5
2
3
4
5
6
7
8
10
15
20
30
40
50
100
200
300
500
FREQUENCY IN KILOCYCLES

during the initial 1 μs increasing transient of current. The impedance then decreased to a normal steady state value as the ion densities assumed their normal value for steady state conduction.

(2) The time required for the discharge to assume its steady state character was greater for the case of high to low current than for the low to high current portion of the cycle. These values were,

Increasing current	12 μs.
Decreasing current	70 μs.

This result was to be expected since during the high current period, ion densities were being increased by electron bombardment; while in the low current portion of the cycle, the ion densities must be decreased by the slower process of diffusion to the tube walls.

From the pictures of light output the following effects were noted:

(1) There was a steady state light output proportional to the current through the discharge tube.

(2) There were transient phenomena in light output occurring at the time of sharply changing current but having a longer duration.

(3) The light output waveform resembled the voltage waveform during the transients, and the current waveform during the steady state portion of the cycle with the exception of the increasing light transient during the time of decreasing current and voltage.

(4) The transient behavior of light output was a function of the particular spectrum line being observed.

Increasing Current Transient

All light waveforms after the increasing current transient exhibited a light output in excess of their normal steady state values for a period of 20 to 30 µs. The amplitude and the duration of this transient increase depended on the spectral wave length being observed, but the time of occurrence of the maximum was the same in all cases. The maximum of the light transient occurred approximately 4 µs after the initial point of current increase.

It was observed that the voltage and current obtained a maximum value in .8 µs so that there was a delay in maximum light output as compared to the time of maximum power input.

Decreasing Current Transient

All waveforms of spectral lines of Table 1 with the exception of 2537 A line exhibited an increasing light output with decreasing current and voltage transients. The magnitude and the duration of this light transient varied between spectrum lines, but the duration generally did not exceed 20 µs.

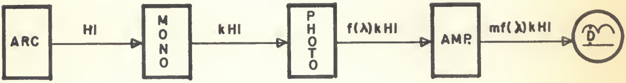
The maximum amplitude of this transient occurred at 7 ± 1 µs after the initial current decreased. Pictures of the transients using a fast sweep speed appear in Plate X. Although it seemed that there was some variation of the maximum point for various spectral lines, the noise level of the photomultiplier circuit and some variation in pulse shape made doubtful any measurement to an accuracy greater than 1 us. Further study using specialized photomultiplier techniques will be required to determine if an actual time variation exists.

The waveforms of the light transients were observed to be non-symmetrical about their maximum. The slope of the increasing light portion of the transient were greater than that of the decreasing.

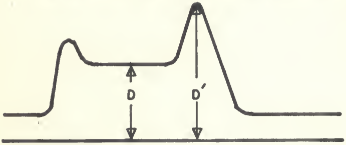
Another point of difference between the waveforms for different spectral lines was the behavior of the light output in the first 3 us following the decrease in current. In this interval there was observed a variation in slope for the different lines. Examples of lines which showed a positive slope are the 3131 and the 2967 lines while the 5460, 4347, 4077 and 4046, A lines exhibited a negative slope. The magnitude of this slope can be seen to be slightly greater than the slope of the increasing portion of the waveform. In this connection, it was noted that the rate of decrease of light for the above lines during the 3 µs interval was approximately twice the rate of decrease of the 2537 A line. The relatively slow rate of decrease for the 2537 A line was to be expected since the majority of all electrons in excited states must make this transition to return to the ground state. Other lines than the above had small negative slopes; however, all lines with wave lengths less than 4077 A had positive slopes.

An analysis of the pictures shown in Plates VII - VIII - IX indicates that absorption in the arc may have modified the light transient waveforms.

Consider the following schematic representing the transformation of the spectral lines energy into an oscilloscopic deflection. The effect of each piece of apparatus is indicated symbollically by the factor multiplying the input energy.



Assume, also, a simplified waveform to appear as follows:



Where:

I = Internal intensity of arc source (absorption neglected)

H = Transmission coefficient (determined by absorption)

k = Optical gain (proportional to slit width of monochromator)

$f(\lambda)$ = Multiplier, determined by spectral response of photomultiplier tube

m = Amplifier gain

D = Observed deflection

For simplicity the waveform will be described at only the following two points: 1) Steady state condition, which is represented by unprimed symbols. 2) Maximum value of transient, represented by primed symbols.

Consider two different spectrum lines λ_1 and λ_2, for example the 5460 and the 4047 originating from the 7^3S_1 level. Then from the diagrams it can be seen that:

$$D_1 = m_1 k_1 H_1 I_1 f(\lambda_1) \tag{1}$$

$$D_2 = m_2 k_2 H_2 I_2 f(\lambda_2) \tag{2}$$

$$D_1' = m_1' k_1' H_1' I_1' f(\lambda_1)' \tag{3}$$

$$D_2' = m_2' k_2' H_2' I_2' f(\lambda_2)' \tag{4}$$

However, in the above, a number of the terms are equal.

$$m_1 = m_2 = m_1' = m_2' \tag{5}$$

$$k_1 = k_1' \; ; \; k_2 = k_2' \tag{6}$$

$$f(\lambda_1) = f(\lambda_1)' \tag{7}$$

$$f(\lambda_2) = f(\lambda_2)' \tag{8}$$

Consider the following ratios:

$$\frac{D_1'}{D_2'} = \frac{m_1' k_1' I_1' f(\lambda_1)'}{m_2' k_2' H_2' I_2' f(\lambda_2)'} = \frac{k_1' H_1' I_1' f(\lambda_1)'}{k_2' H_2' I_2' f(\lambda_2)'} \tag{9}$$

$$\frac{D_1}{D_2} = \frac{m_1 k_1 H_1 I_1 f(\lambda_1)}{m_2 k_2 H_2 I_2 f(\lambda_2)} = \frac{k_1 H_1 I_1 f(\lambda_1)}{k_2 H_2 I_2 f(\lambda_2)} \tag{10}$$

But in the pictures shown in Plates VII - VIII - IX, D_1 was made equal to D_2 by varying k.

Thus from eq. (10):

$$\frac{k_1\, f(\lambda_1)}{k_2\, f(\lambda_2)} = \frac{H_2\, I_2}{H_1\, I_1} \qquad (11)$$

And in eq. (9):

$$\frac{D'_1}{D'_2} = \frac{H_2\, I_2}{H_1\, I_1} \cdot \frac{H'_1\, I'_1}{H'_2\, I'_2} = \frac{H_2}{H_1} \cdot \frac{H'_1}{H'_2} \cdot \frac{I_2}{I_1} \cdot \frac{I'_1}{I'_2} \qquad (12)$$

From the pictures it can be senn that:

$$D'_1 \neq D'_2$$

Therefore, at least one of the following equations representing inequalities must hold,

$$\frac{H_2}{H_1} \neq \frac{H'_2}{H'_1} \qquad (13)$$

or

$$\frac{I_2}{I_1} \neq \frac{I'_2}{I'_1} \qquad (14)$$

Since in the example chosen both transitions orginate from the same state, it may be reasonable to assume that the observed $D'_1 \neq D'_2$ was due to $\frac{H_2}{H_1} \neq \frac{H'_2}{H'_1}$. The most probable factor which could produce such a result is a variation in the population ratios of the final states of the transitions represented.

Although insufficient data are available at the present time to formulate a theory which will account for the light transients following the decreasing current portion of the cycle, a tentative hypothesis might be as follows: Barnes has shown on a somewhat longer time scale that the variation in electron temperature in a square wave excited plasma has a waveform closely resembling the waveform of the 2537 A line. Unfortunately the time resolution of the equipment he used was of the order of 10 milliseconds; and, thus, his results cannot be directly applied to the microsecond phenomena described in this paper.

The sudden decrease of current through the discharge tube leaves the plasma with excessively high ion densities. This effect is shown in the potential curves in which the time to return to a steady state condition is approximately 70 μs.

If the average energy of the electrons does drop in the interval following decrease of current, then it follows that the plasma would be in a condition of relatively high ion density, but low electron energy.

Normally, in Hg arc discharges, ionization is a two step process; the electrons excite a Hg atom to its 6^3P levels and by a second collision ionize it. Thus if the average electron energy decreased, it would then be insufficient to cause transition from the ground state to the 6^3P levels, resulting in a decrease in intensity of the 2537 A line output.

Even though the electrons have insufficient energy to cause 2537 A excitation, they could still be expected to cause lower energy transitions from the 6^3P levels to higher levels.

Since the 6^3P_2 and 6^3P_0 levels are metastable with an average life time of the order of 10^{-4} seconds, a high population of these levels would exist for the 30 us transient condition following the current decrease. Therefore, considerable excitation to higher levels from the metastable levels could occur with resultant light emission.

A secondary effect must be postulated to predict the actual variation of intensities of this transient with respect to observed steady state values. Under steady state conditions, the 6^3P levels are populated in the increasing order of P_1, P_0, P_2 with light transitions which end on the most populated levels being reabsorbed the most. In the transient condition, the metastable levels are quickly depopulated, thus, making the intensities of lines ending on these levels larger compared with steady state conditions.

Both the excitation and reabsorption processes that have been described would be rapidly terminated by the loss of excitated atoms to the ground state. Thus the observed light output would appear as a transient spike terminating in a "steady state" condition.

Change of Modulation with Frequency

As shown in Plate XI the percent light modulation for the spectral 2537 A line was maximum at about 3 Kc. and then decreased exponentially. This can be related to the transient effects as follows: At very low frequencies the slope of the current sine curve was not great enough for short time light transients to appear. With increasing frequency the slope became great enough for transients to form, thus increasing the percent light modulation observed. If the frequency of the current source was increased beyond 3 Kc. the following effects were noted:

The voltage waveform approached a square wave, indicating that the impedance of the lamp and its ion density were relatively constant.

In the frequency range from 3 to 4 Kc., the light transients exhibited a very slight decrease in amplitude; but the major change in the waveform with increasing frequency was a decrease of the time in which the arc was in a steady state condition.

For frequencies above 6 Kc., a true steady state level was not observed. Intersection of the increasing and decreasing transients was associated with a rapid decrease in the amplitude of the light transients and a small decrease in the magnitude of their slopes.

Further increase in frequency above 10 Kc. produced earlier intersecting of the exponential increasing light portion of the cycle with the exponential decreasing portion. The resultant effect of this earlier intersection was to produce a modified saw tooth waveform and reduce the amplitude of the light variation.

The curve of percent modulation thus exhibits a maximum. It should be noted that there are some deviations from these general trends due to plasma oscillations. A particularly noticeable deviation was observed at 14 Kc. Others were observed at frequencies below 3 Kc.

CONCLUSIONS

A summary of the important results of this preliminary investigation of light transient effects is as follows:

1) Associated with rapidly changing currents in a Hg arc were high intensity light surges.

2) The amplitude and duration of the light surges were dependent upon the spectral line being observed.

3) All spectral lines with the exception of the 2537 A line exhibited a high intensity surge for both increasing and decreasing current transients.

4) The 2537 A line exhibited an increasing transient surge associated with increasing current but had no increasing light transient associated with decreasing current.

5) The time of occurrence of the surge maximum appeared to be the same for all spectral lines.

6) The surge maxima associated with increasing and decreasing current occurred at 4 and 7 μs respectively after the initiating current transient.

7) The light surges were not symmetrical about their maxima. The rate of increase in all cases was greater than the rate of decrease.

8) Surge formation was dependent on the frequency of the exciting current source. If the frequency of excitation was sufficiently high so

that no true steady state condition would exist, the surge amplitudes were greatly reduced.

9) The amplitudes of the light surges were probably modified by absorption.

10) If absorption did occur, the ratio of the absorption coefficients of any two spectral lines was not the same during the transient as compared to the steady state condition.

The work described in this paper suggests further experiments designed to investigate the method of formation of the light surges. Included among these experiments should be:

1) Absorption measurements (techniques using a second DC source appear in the literature).

2) Experiments to determine if the magnitudes and time of occurrence of the light surges are position dependent (techniques similar to those used for investigating moving striations could be used).

3) Experiments designed to determine rapid variations in ion densities and electron temperature.

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LIGHT TRANSIENT BEHAVIOR OF MERCURY ARC DISCHARGES

by

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It is the purpose of this thesis to describe the variation in light output of a mercury arc as a function of the frequency of its AC current source and to relate this behavior to experiments in which the light output of a square wave excited arc was observed.

A mercury arc at a vapor pressure of 246.8 mm of Hg was excited by a variable frequency current source.

The light output was dispersed by a monochromator, detected by a photomultiplier, and observed on an oscilloscope.

Studies were made of the light output of various spectral lines when the arc was excited with a 50 percent square wave modulated 100 ma current.

Studies were also made, utilizing sine wave excitation, of the variation in the percent modulation of the light output of the 2537 A line as a function of the frequency of the excitation source.

Utilizing sine wave excitation it was observed that the percent modulation of light output was maximum at 3 Kc and decreased exponentially for frequencies greater than 10 Kc.

The following phenomena were observed utilizing square wave excitation:

1) Associated with rapidly changing currents in a Hg arc were high intensity light surges.

2) The amplitude and duration of the light surges were dependent upon the spectral line being observed.

3) All spectral lines with the exception of the 2537 A line exhibited a high intensity surge for both increasing and decreasing current transients.

4) The 2537 A line exhibited an increasing transient surge associated with increasing current but had no increasing light transient associated with decreasing current.

5) The time of occurrence of the surge maximum appeared to be the same for all spectral lines.

6) The surge maxima associated with increasing and decreasing current occurred at 4 and 7 μsec respectively after the initiating current transient.

7) The light surges were not symmetrical about their maxima. The rate of increase in all cases was greater than the rate of decrease.

8) Surge formation was dependent on the frequency of the exciting current source. If the frequency of excitation was sufficiently high so that no true steady state condition would exist, the surge amplitudes were greatly reduced.

9) The amplitudes of the light surges were probably modified by absorption or, in some cases, by lack of it.

10) If absorption did occur, the ratio of the absorption coefficients of any two spectral lines was not the same during the transient as compared to the steady state condition.