

HAROLD E. EDGERTON

PAPERS

MC 25

Series III

Laboratory Notebooks

Number 16

Dated Feb. 17, 1945 to Mar. 30, 1946

Massachusetts Institute of Technology

Room 4-117

S-103. S-105

COMPUTATION BOOK

NAME	Number
HAROLD E. EDGERTON	16

Course.....

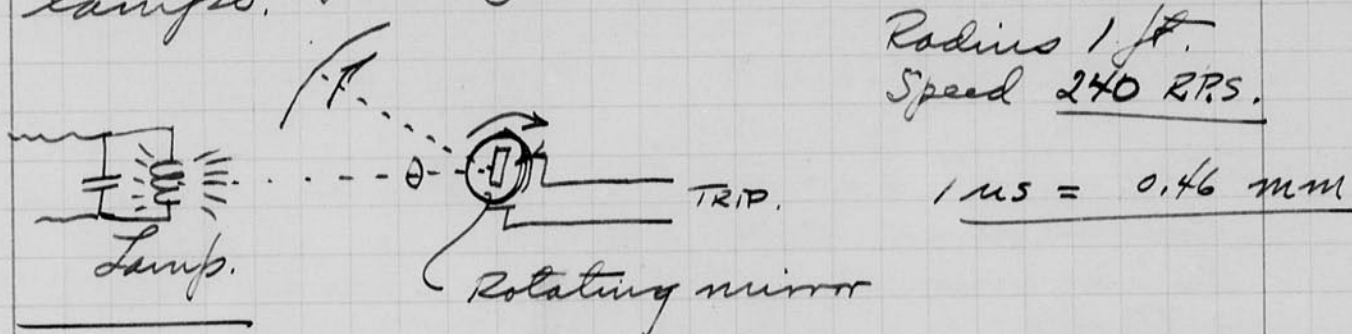
Used from FEB 17 1945, to MAR 30 1946.

Feb. 17, 1945 M.I.T.
Harold Edgerton

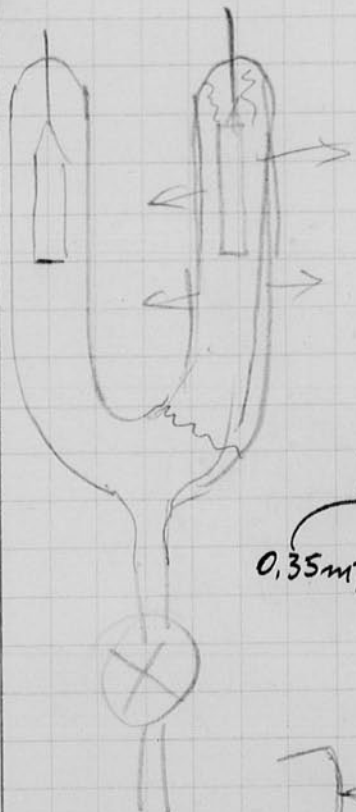
Most of my time is now spent on a project at Bedford field where an A26c plane is being fitted with a flash unit (2400 mf 4000V) and a radar plus other navigational devices. Baystow and Mc Roberts are working with Roythem on the design and manufacture of the flash unit.

Capt Roll and three soldiers from U.F. are learning the radar equipment.

For the last weeks or so some experiments have been made to measure the true duration of the flashes from short duration lamps.



a V shaped pyrex lamp was repumped and filled with argon at 25# sq inch. It exploded when flashed with 1/3 mf at 8000 ± volts.



A second tube was pumped and flashed ok at 9000 volts 1/3 mf. Duration is short. Same trailer.

1. 9000 V 1/3 mf U ↓ 30# sq in argon.

2. 9000 V 1/3 mf ↓ " " "

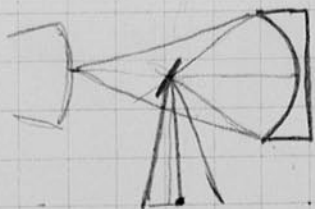
3. 14000 V .05 mf C " " "


0.046 mf

Spot on cathode.

#3 phot is much dimmer than #2 and 1. ? why.

0.35 mf.



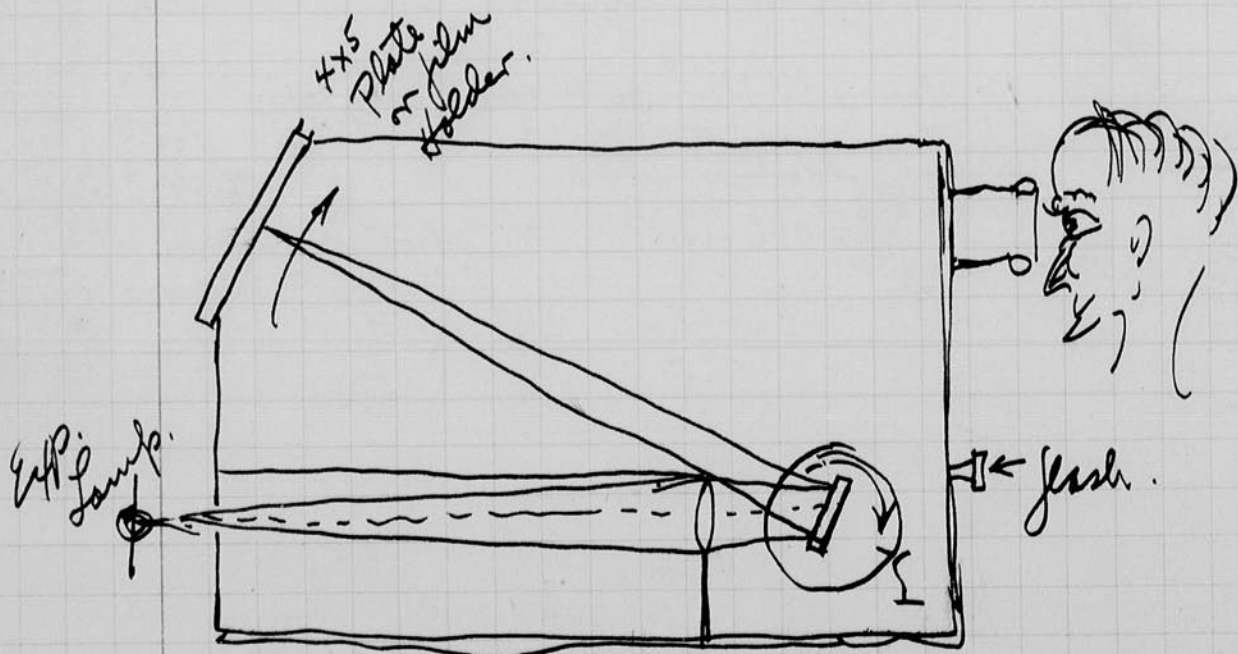
4. 8200 V. 15# 1/4 inch argon tube  1/3 mt
 5. 10,000 " " " " 3 exposures
 Some self flashing at 10,000 volts.

5

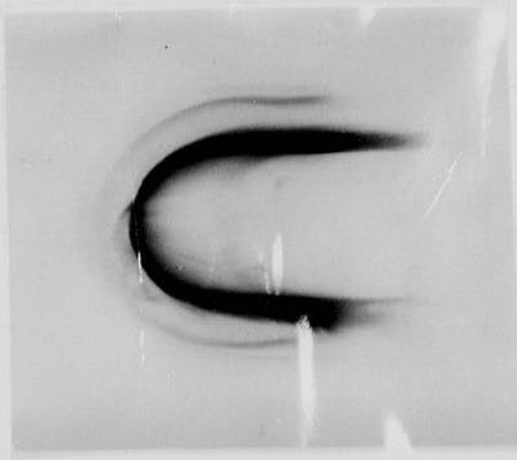
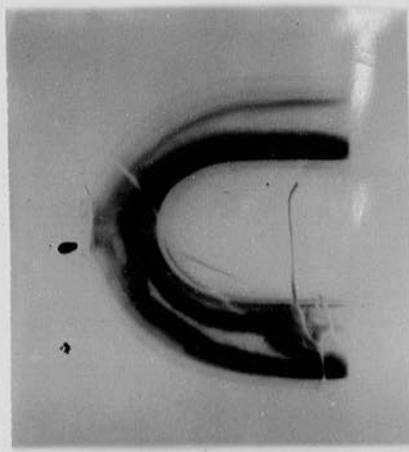
Feb 20 1945

6. 10,000 30# 1/4 inch argon 1/3 mt. "
 7. 7600? Old microflash lamp. 1/3 mt.
 8. 7600 30# 1/4 inch argon 1/3 mt microflash lamp.
 9. 7600 " " " " " " " " atmosphere
 10. 7600 " pres argon 1/3 mt + .5 Same tube as shot 4.
 This tube self flashes about 14,000 volts

11. Tube run with ~~2~~³ mt at 6000 or 7000 volts - Blow up
 flashed ok at 4000 first.
 The tube broke along the space opposite the
 cathode. Usually the arc formed on this
 surface, for example see shot 6.



Argon tube 30 lbs per sq inch
240 R.P.S. 1 ft radius



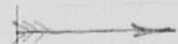
1. 9000V $\frac{1}{3}$ mf



2. 9000V $\frac{1}{3}$ mf



3. 14,000V .05mf



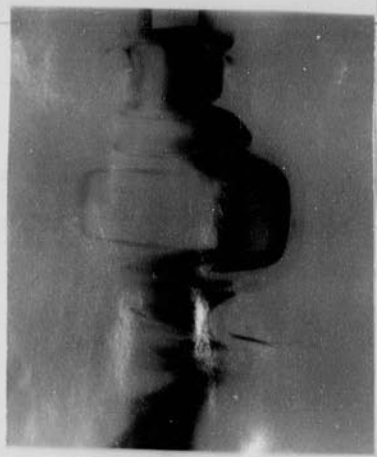
0 10 50 100 microseconds

4

8200 V .35 mf 2 atmos.

?

4



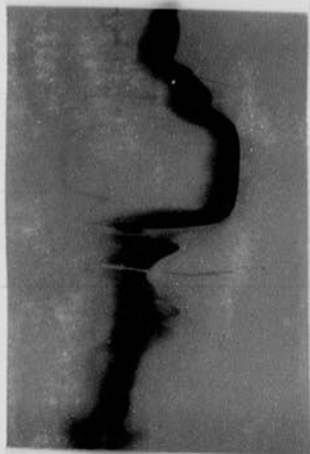
5



10,000 V
.35 mf
2 atmos

6

10000V
.35mf
3 atmos

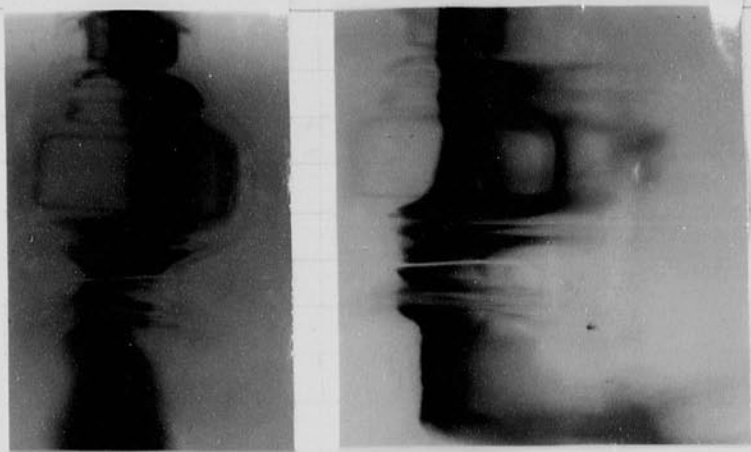


7

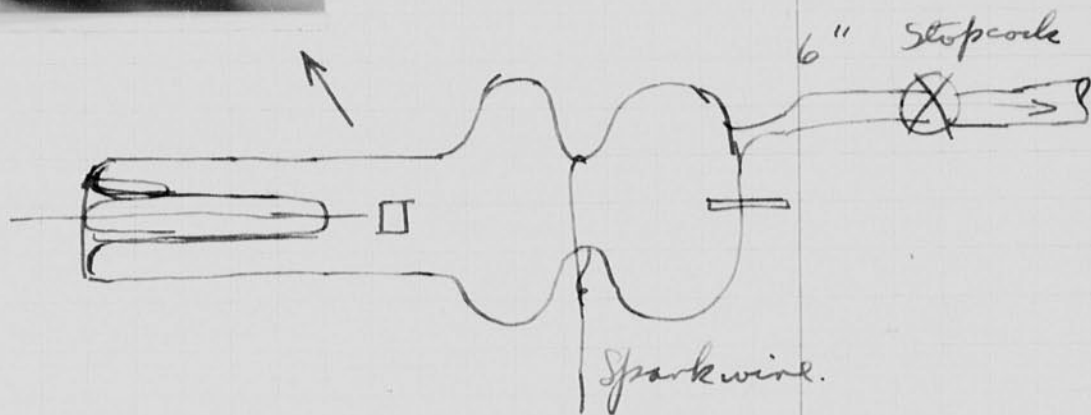


Hygrade microflash
7600V 0.35 mf

10

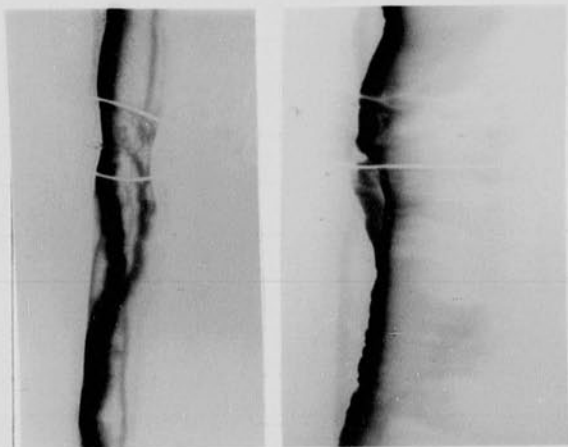


1 atmosphere argon
7600 v
0.85 mf.



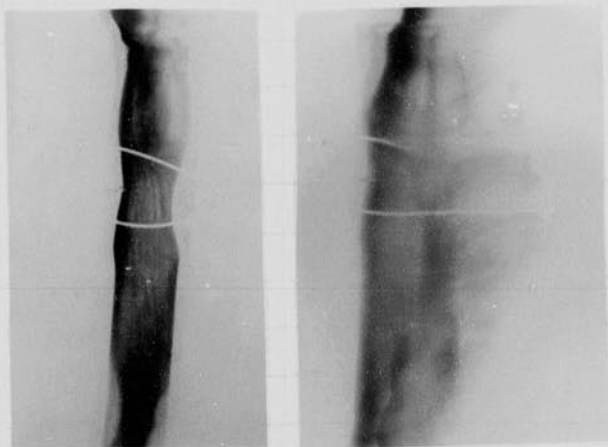
11

8



3 atmospheres argon
7600 v 0.35 mf
microflash tube.

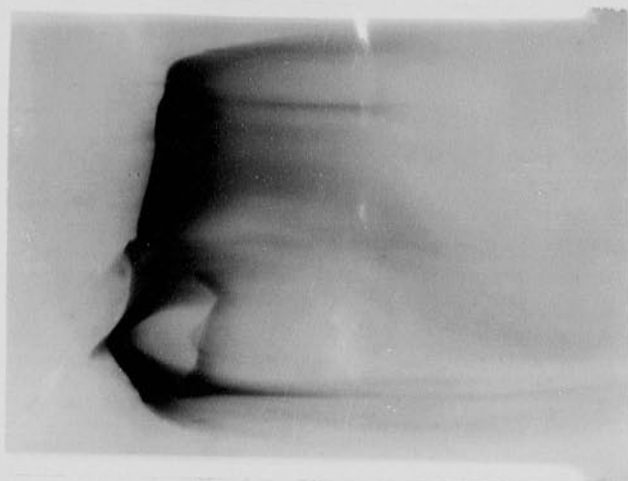
9



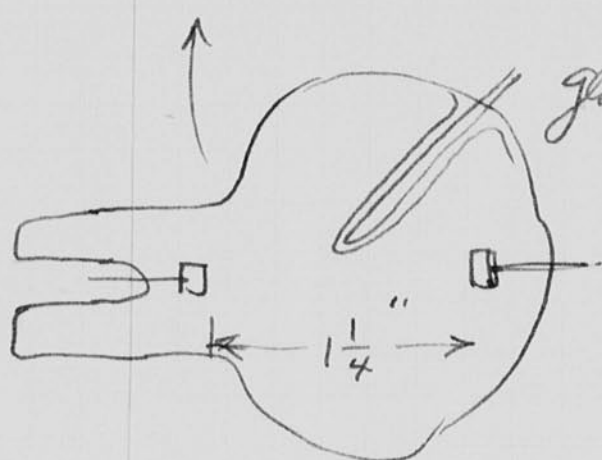
— 1 atmosphere
7600 v 0.35 mf.
→ Same tube

Feb. 26, 1945
 David S. Edgerly

Starter

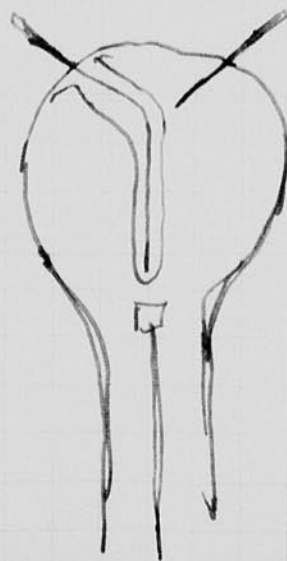
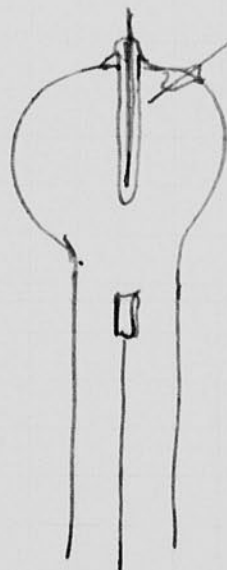
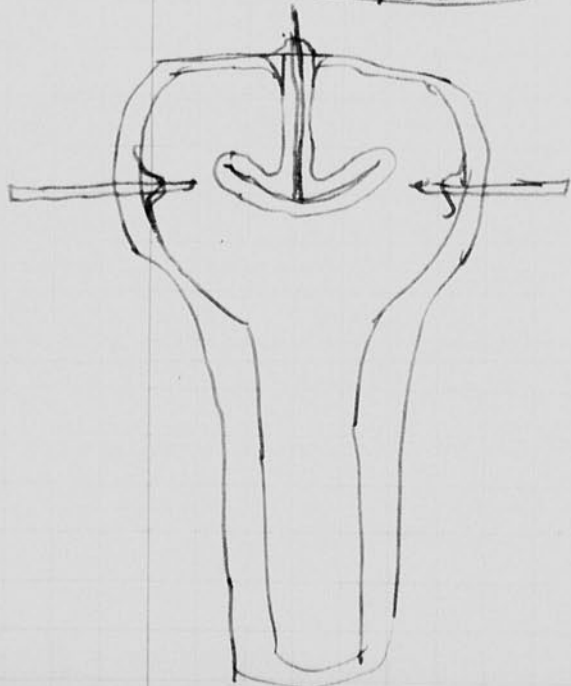
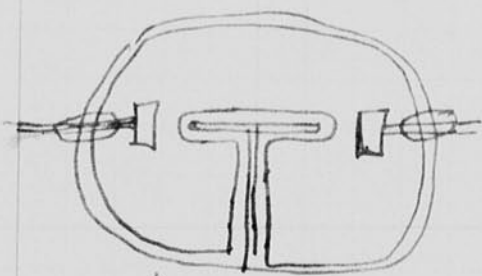


$\frac{1}{3}$ mf
 9000 - 10000 v.
 15 # per sq inch
 2 atmos.
 Argon.



Glass covered starter electrode.

Note short flash where arc strikes the glass starter.



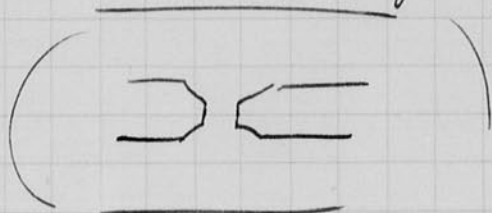
March 1 1945
 M.I.T. Caput
 Harold E. Edgerton.

Work is going fine on the A26 airplane that is at Bedford for night photography. The radar dome has been put on the bottom over the hole left by the rear turret. Ready this week for flight. Prof Copper checked air forces.

Two K-19 cameras have been mounted in the nose at an 18° angle with each other. Synchronizers have been put in the shutters for the electric flash.

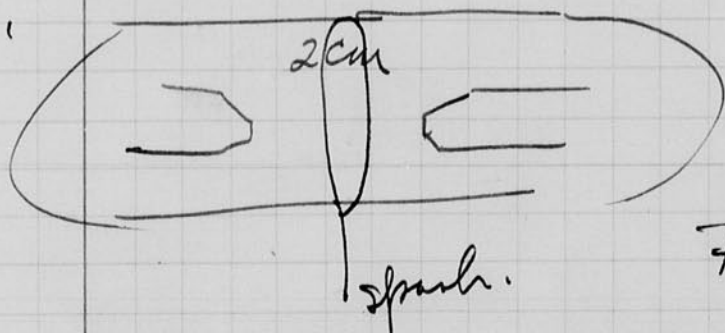
The reflector for the flash equipment is in the tail giving about 50 ft between the lamp and camera.

Mar 2. Argon gap tube.



$3/16$ " gap Argon 30 # $1/2$ inch
 Sparks over at 7000 volts by
 self.

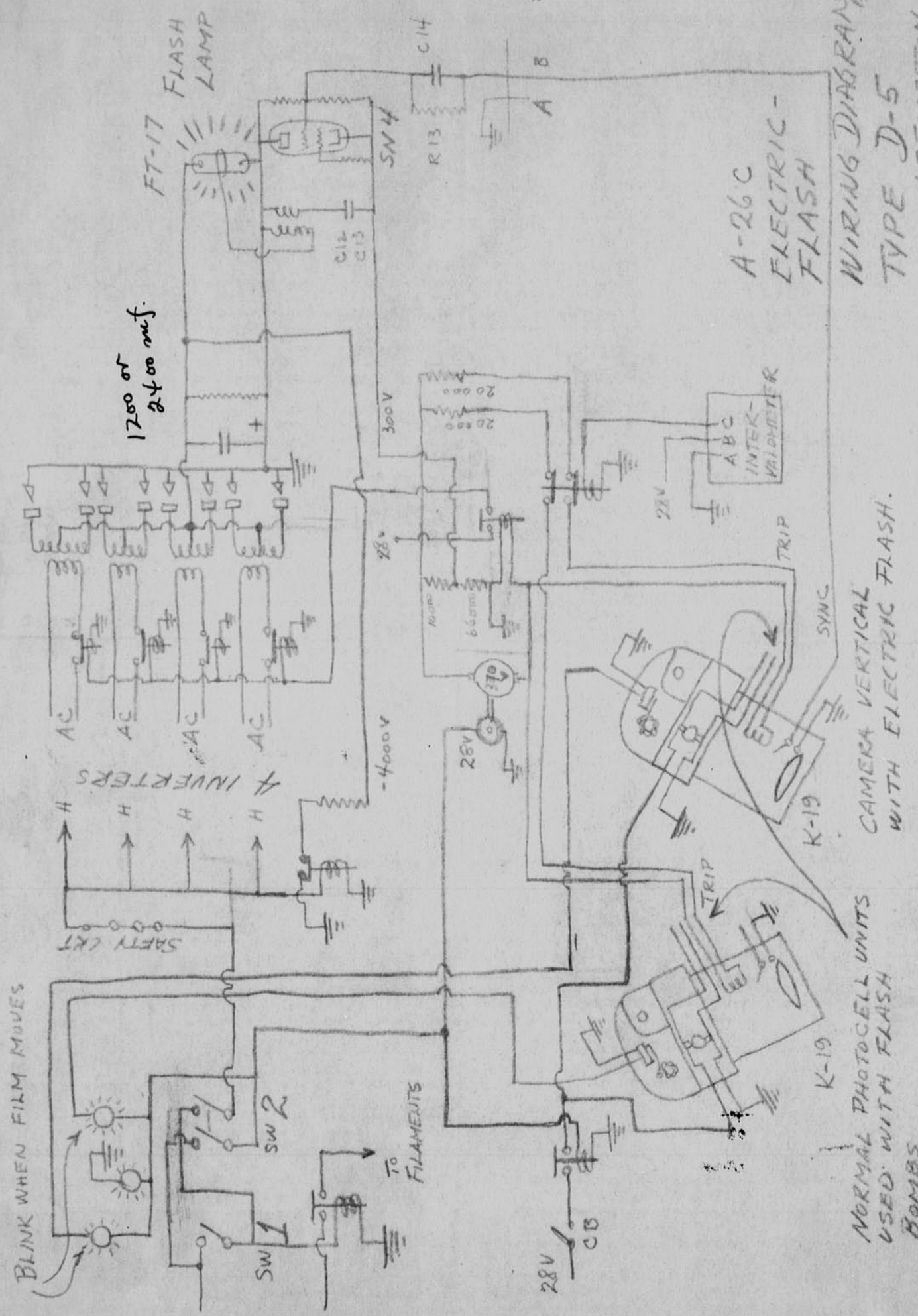
Controls ok with external ~~gap~~ spark.



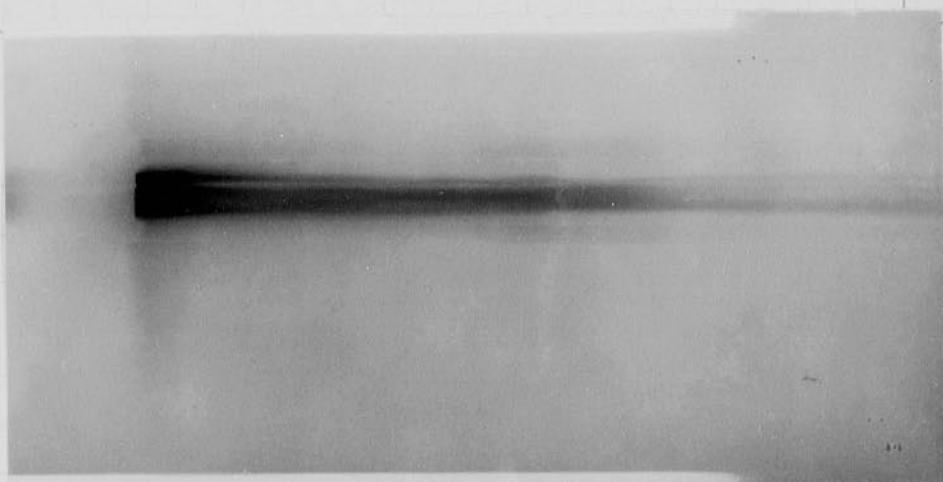
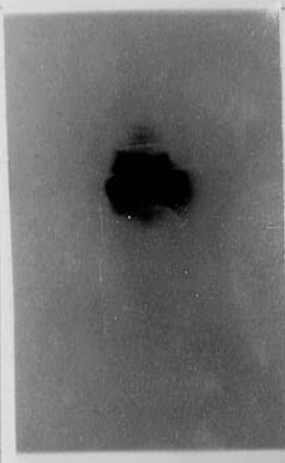
Sealed off stopcock at 45 # $1/2$ in
 flashes ok at 5000 to 10,000 volts

Photo taken. Long trailers.

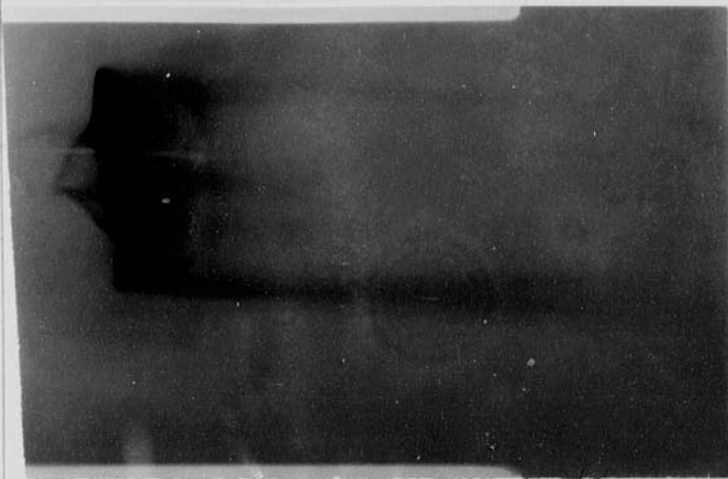
$3/16$ " gap tube re pumped and filled with 45 #
 $1/3$ mf 10,000 volt shows 100 ~~ms~~ + trailers!



MIT
 H. E. EDGERTON
 FEB. 23, 1945.



$\phi 7$
 $3/16''$
 gap tube
 argon
 45 # sg inch
 $1/3$ mt
 10,000 v.



2cm gap
 argon 40 # sg inch.
 $1/3$ mt 10,000 v.



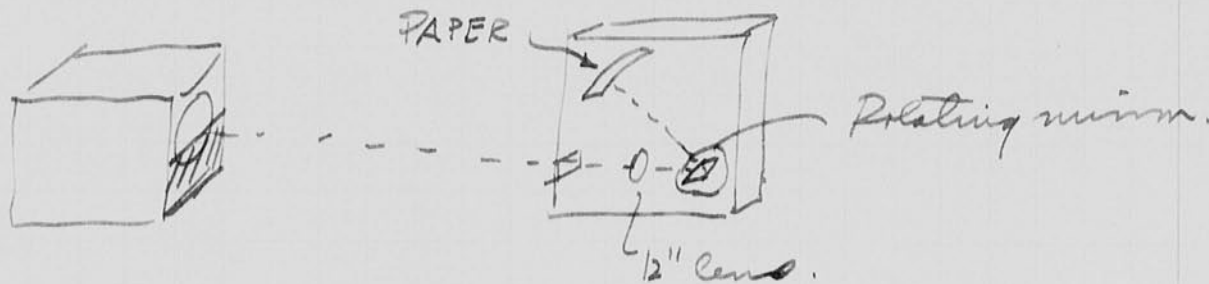
For this shot the camera mirror
 motor was not up to speed.

0 50 100
 microseconds

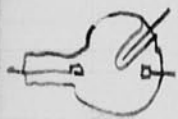
March 4 1945
 M.I.T. H.E. Edgerton

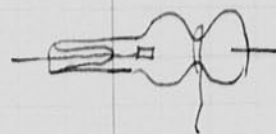
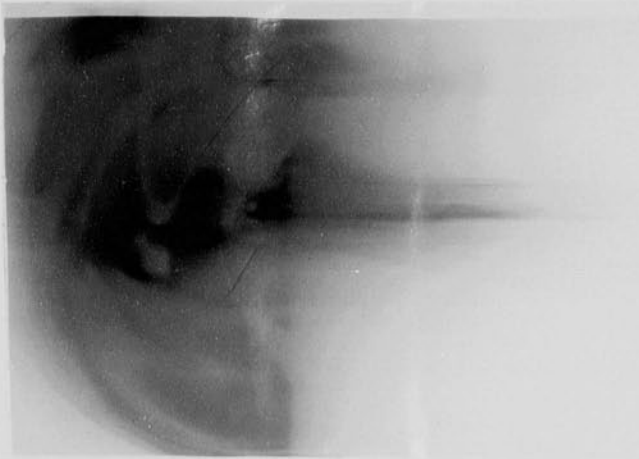
The lens in the rotating mirror camera was changed to an $f9\ 12''$. Now the subject is 1 meter from the front plate of the box. A 4:1 reduction of the tube image is photoed.

A series of tests were made with the G.R. ~~gun~~ second unit as shown below



See
 Hynde
 ref. table





Tube sketched above repumped - filled with 1 cm Hydrogen, then 15 # of inch argon.

Photo also taken with 1 atm by opening stop cock trailer is much less with 1 cm Hydrogen. About same with 1 and 2 atm.

Repumped 5 cm H₂ + 15 # of inch argon.

Would not start on GR w/ f lens it

Reduced press to 1 atm - still no reliable operation. One photo taken - excessive time delay.

Tried again - delay > 200 us since photo was not on the film.

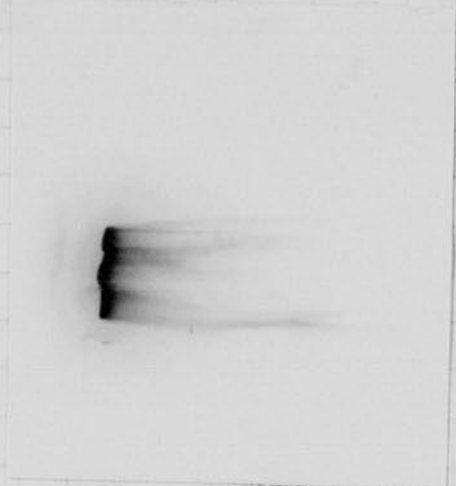
Repumped 2 cm H₂ + 15 # of inch argon.

Repumped 2 cm H₂ + 1 atmosphere argon - sealed off.

Similar test ~~made~~ made with a dition 2.5. Large delay in starting more than 400 microseconds! Condenser voltage increased to 7000 - 10000 volts. Delay about 200 u.s.!



Hygrade microflash lamp
across $\frac{1}{3}$ mt condenser - 8000 volts
Still and moving pictures on the
same film. 15 ~~micro~~ ~~for~~ ~~micro~~ ~~sec~~
delay in start.



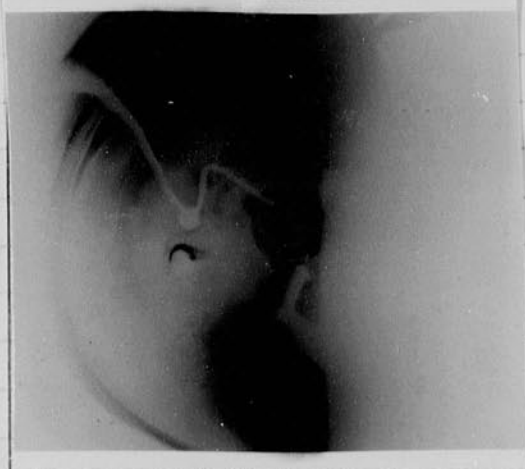
Gap tube. page 11 & 13
2 cm H_2 and 1 atmosphere
of argon.



Arditron tube.
← $\frac{1}{2}$ speed (7200 rpm)
of mirror.

0 100 200 45 .

Same tube as page 11.



Standing still.

8000 volts
1/3 mt in
the G.R.
microsecond
flash unit.



2 cm Hydrogen
2 atmospheres Argon.

0 50 100 MICROSECONDS.

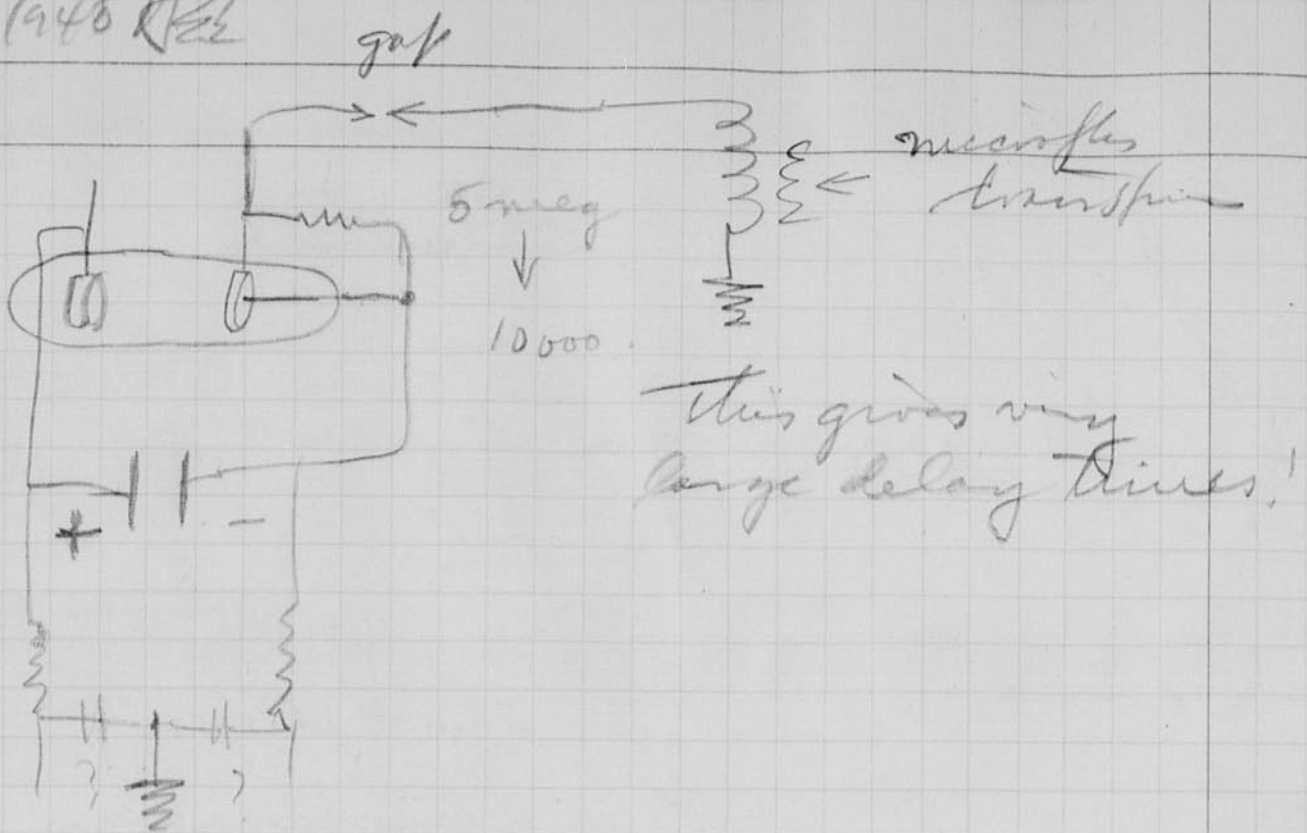


{ 2 cm Hydrogen
{ 2 atmos Argon
reduced to
1 atmosphere.

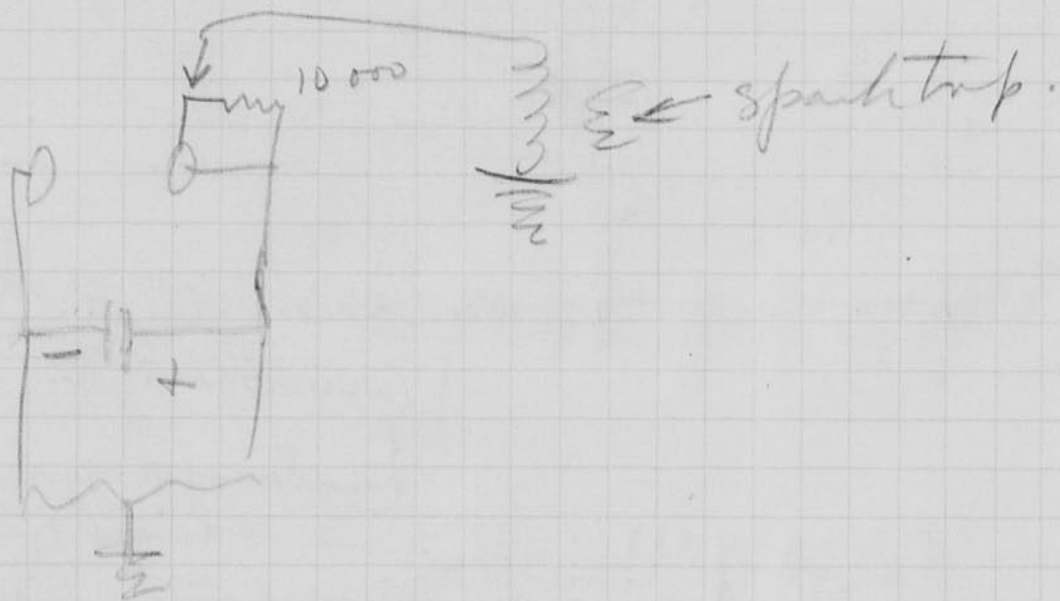



2 cm H₂
1 atmosphere Argon.

14 Mar 5 1948 KEE



This gives very large delay times!



- | | | | | |
|---|---------|--------------------|-------|--|
| 1 | 240 n/m | 9000V | .35 w | Ar-Ne flash & glow |
| 2 | " | 7000 | .35 | ⊕ 1 atm argon |
| 3 | " | 9000
↓
10000 | " |  3 cm Ne
15# spind. Ar.
Starts at 6000V
ok at 10,000V. |

4 " " Press reduced to 1 atm
flashed twice. then held
glow at 7000V very dim.

March 11 1945
 MIT Cant. Mass
 Harold Edgerton.

The struggle this week has been with the A 26 flash plane which should have been ready to go on Monday last. The radar dome installation took until Thursday. Then the inspection was done by M.I.T. and by the army. On Friday two flights were made by Capt. Atkins of W.F. The reflector and radar dome worked ok at 300 mph.

Difficulty was experienced in the air with the bomb bay doors which could not be closed due to trouble in the hydraulic system. A new Regulator was flown in from Rome yesterday and a crew is working on the plane now at Bedford.

Capt Roll returned ~~last~~ yesterday from W.F. Capt Olsen was here the past two weeks.



ARD
 ①
 9000V
 .35

3.

3

M.I.T.
March 14 1945

David S. Egerton

The first night photo flight with A26C no. 576 was made last night about 9 pm. Atkins pilot.

The air speed is 250 mph with 1950 RPM and 32 inches manifold pressure.

Photos were taken over Bedford at 1000, 2000, 3000, 4000 and 5000. Also Boston at 5000 and 3500. Interval 6 sec. The pack unit is called D-5. It has 2 banks of 12 condensers each (100 mf) giving a total of 2400 mf. Four Deland inverters (1500 watt each) are used for power. The charging time is about four seconds.

Trouble was experienced last night before take off due to the strobotron failing to fire because of darkness.

A film magazine at the end of the roll caused the case drive of the camera to break. Apparently the paper and film joint was too thick to pass through the magazine.

Capt Roll arrived Mar 10 from W.F.
Capt Olson returned Mar 13. at 4 pm to W.F.

March 23 1945 9:30 pm.
Bedford Mass Airfield
David Edgerton.

17

Major Kenyon and Walt Haylbaker are making prints of negatives taken in and around Boston on Sunday night March 18, 1945.

The negatives show the need for blanking the fog due to the beam. Fred Barlow suggests a plate of glass with a yellow density surface of variable density so that the hot spot will be absorbed.

The 50 degree lamp may help this condition since the beam spreads some. We plan to try this on the next night flight.

We were in Dayton over the weekend. Left on Friday night about 8 pm. Took pictures over New York then at Dayton with the camera at 18° from vertical. Saw Baisky Saturday morning with Kenyon, Alpin, Jones etc. Discussed flash photography at length. Baisky is out of the photo lab at the present.

An eight inch lens is coming for use as a wide angle lens. f 4. It will be coated and tried with a 50 degree reflector and lamp.

April 4, 1945.

Went to Washington Sunday Mar. 25, in A26C no 43-22576 with atkin pilot Kenyon, ~~the~~ Baker, and Oeschleage. Plane and equipment was inspected at Bolling field by army, navy marine, and British. Retd to Boston via Newark, Mar. 26. where we saw Becker and Brattain.

Mar 27 - Rain - no flight

Flew Baker's camera Mar 28

" " " Mar 29.

Mar 30

Mar. 31

Weather.?

Flew 4800 mf.

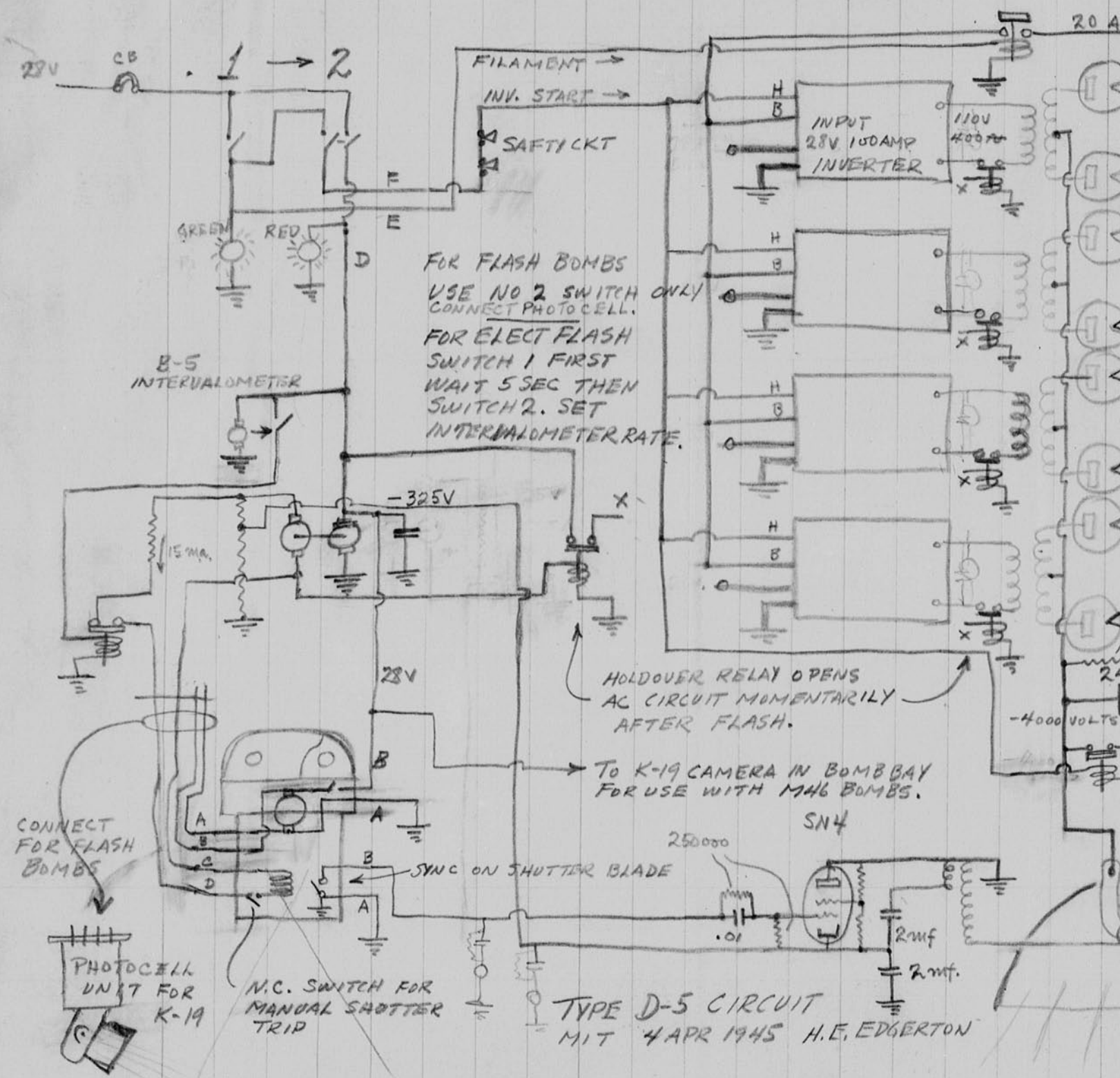
Apr 1. front wheel trouble.

April 2 Plane grounded.

Apr 3. Plane in hangar.

McCledden and Baker Apr 4.

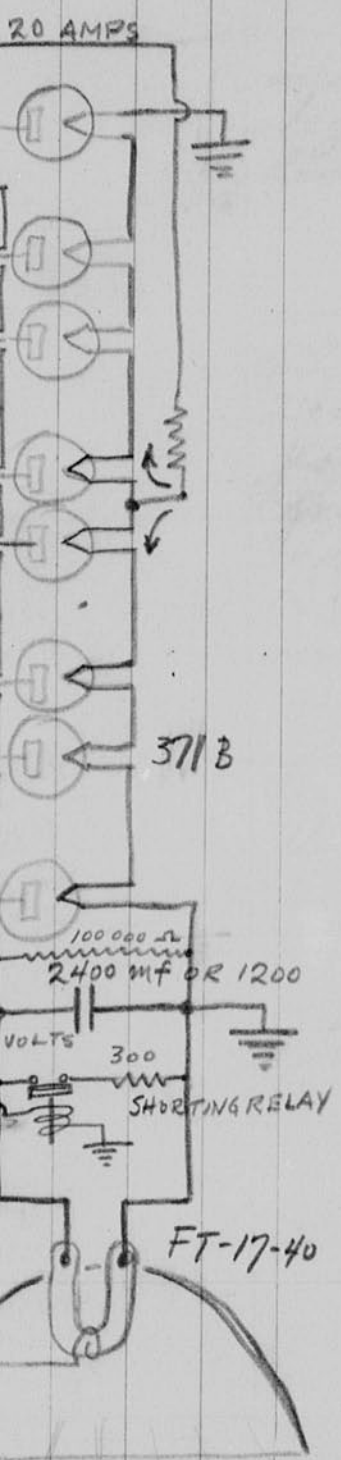
Butler came to M.I.T. for conference with Huff Davenport, Thompson, Hazen, etc. on 584.



April 14, 1945

M.I.T. 4-117

Daniel Edgerton.



Apr. 12 I took the photocell meter to G.R. Co
 constructed it to Watkins and Easton.
 then a letter proposing that the
 be manufactured.

Most of my time is spent at Bedford
 working with the A26C plane no.
 76 which has a D-5 flash unit
 4000 volts + second interval between
 Since Monday the plane has been
 led to cure a trouble with the
 heel which once in a while refuses
 down except when an emergency
 pulled.

Problems have been experienced with
 ar, K band, due to loose wires etc.
 being fixed now.

April 14, 1945

M.I.T. 4-117

David Edgerton.

19

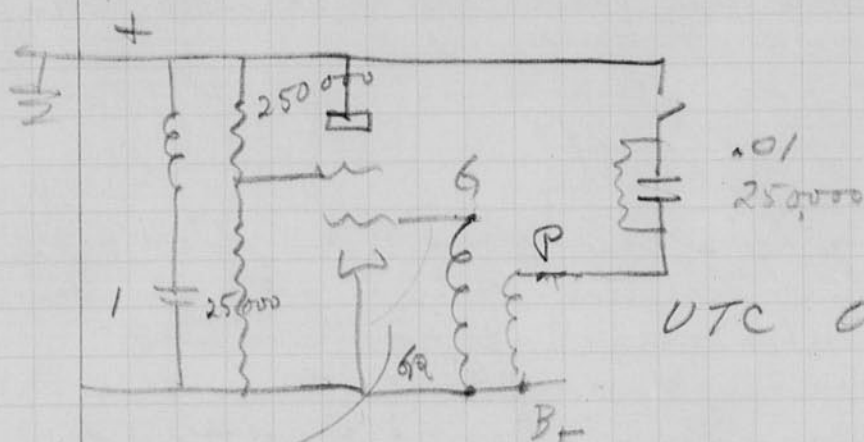
On Apr. 12 I took the photocell meter to G.R. Co and demonstrated it to Wilkins and Easton. I gave them a letter proposing that the device be manufactured.

Most of my time is spent at Bedford airport working with the A26C plane no. 43-22576 which has a D-5 flash unit 2400 mf 4000 volts 4 second interval between flashes. Since Monday the plane has been grounded to cure a trouble with the nose wheel which once in a while refuses to come down except when an emergency wire is pulled.

Difficulties have been experienced with the radar, K band, due to loose wires etc. This is being fixed now.

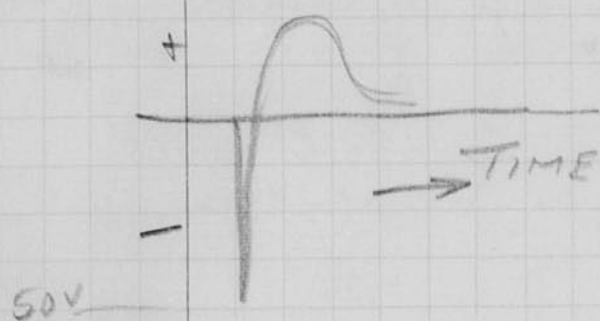
H. J. Edgerton & Mc Roberts
April 18 1945

Strobe firing circuit



UTC 0-15 small transformer.

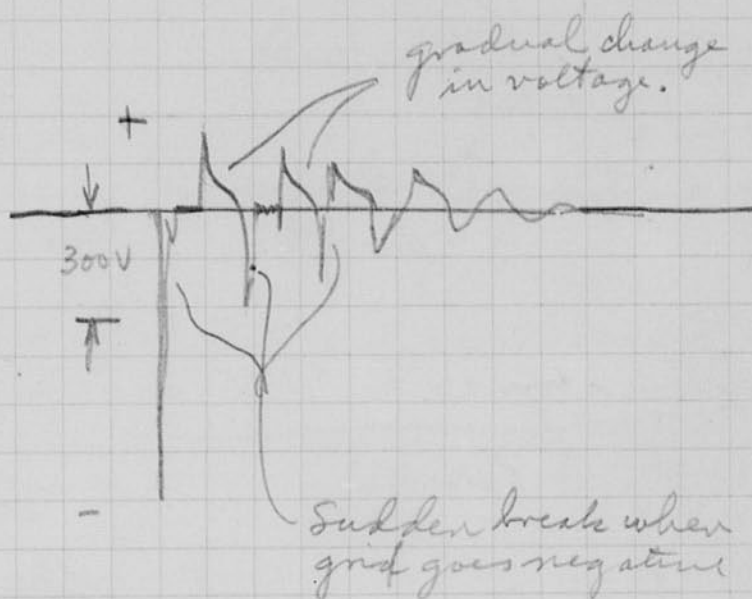
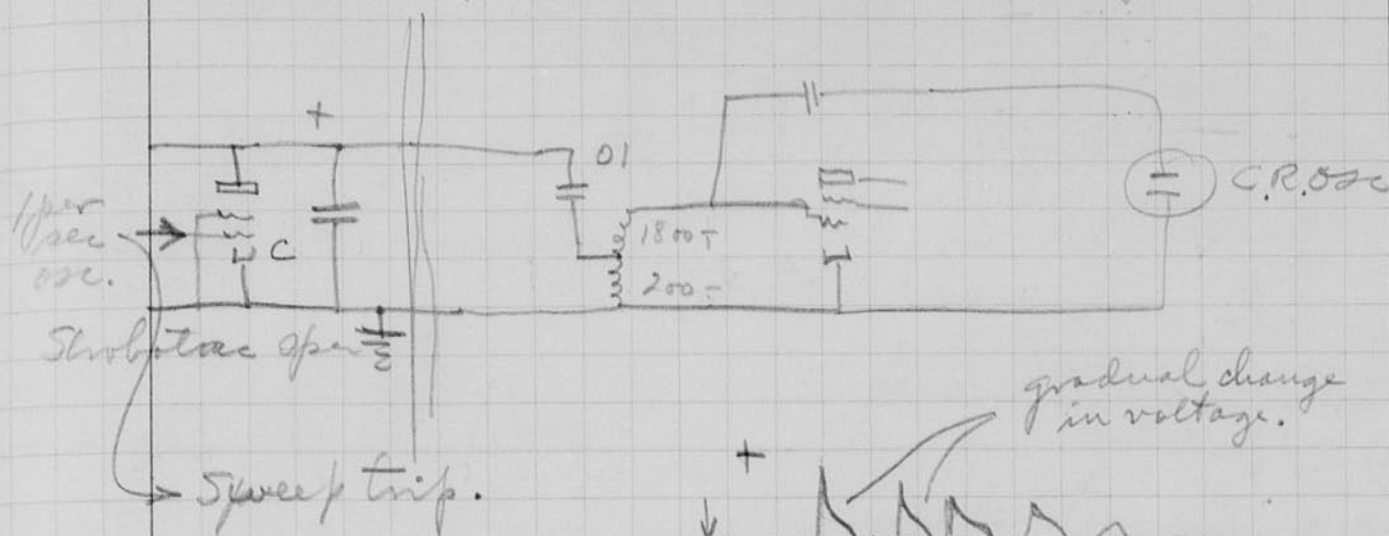
CR meas. of cathode to grid.



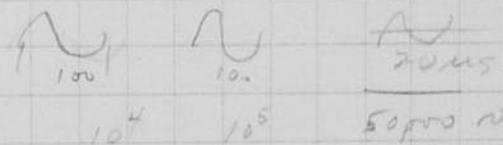
osc. of circuit when
switch is closed with
stroboscope in socket.

Osc tests of Strob trip circuits

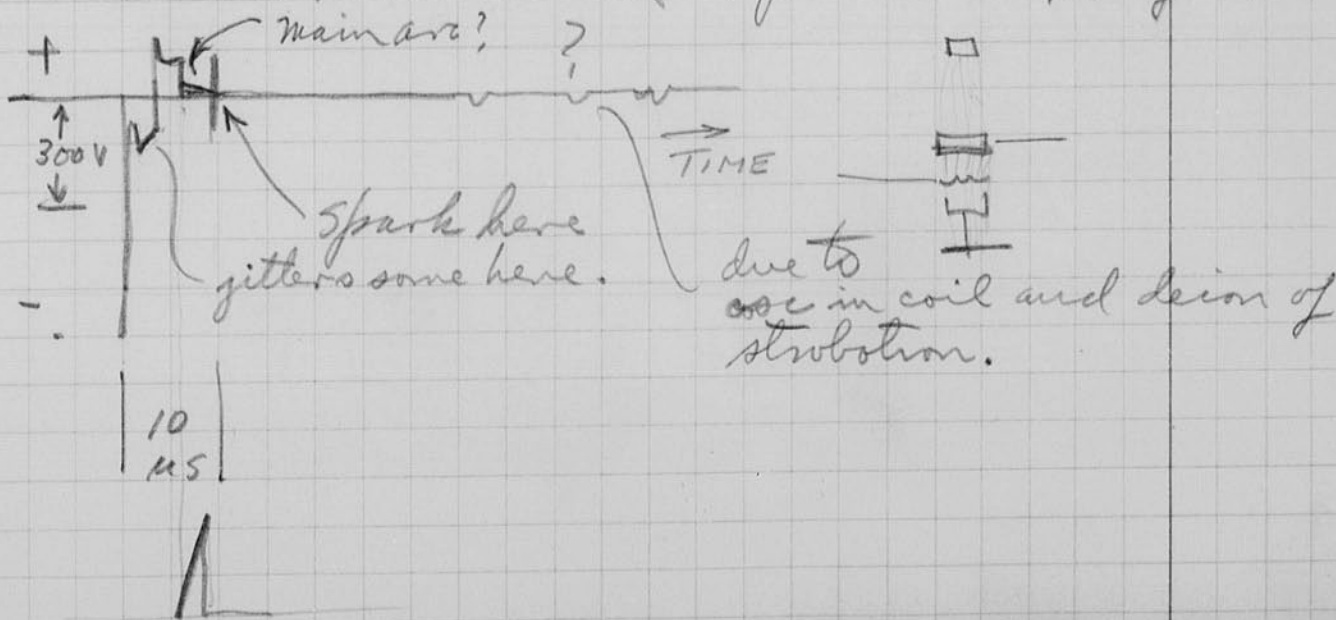
W.F. oscillograph connected as used by Newton Feldman.



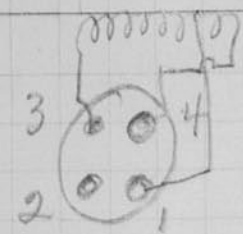
With tube out of the socket, the voltage is a damped sinusoid with a peak volts about double that of the first peak when the tube is in the socket. 4 cycles to 1/2 value, 45,000 cycles.



Strobatron next connected to power supply 325V 7000ohm 1.mf.

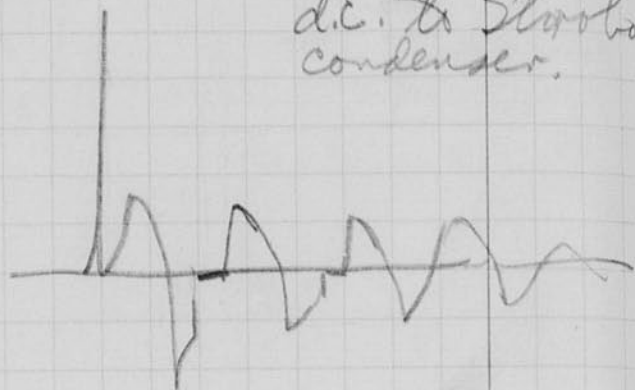
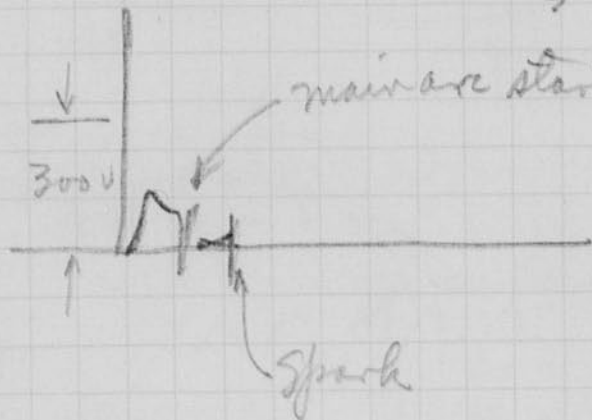
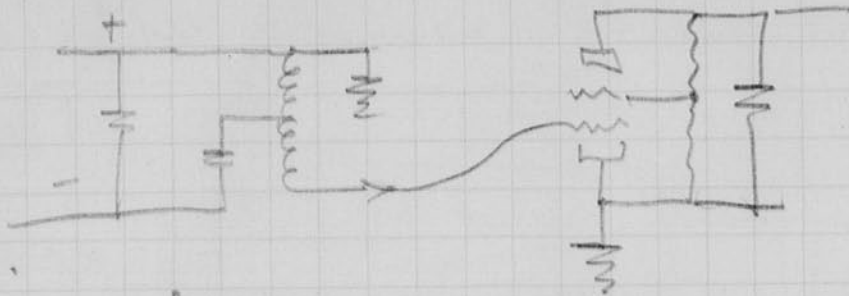


Positive surge



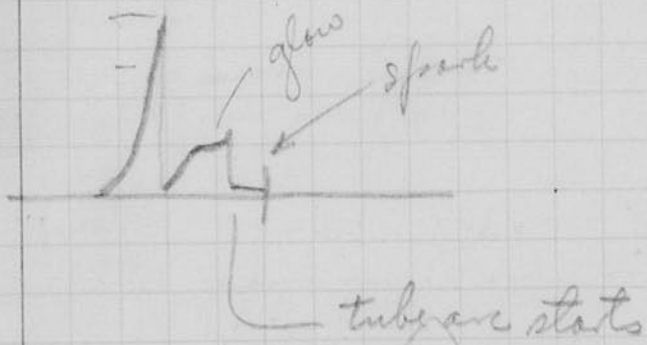
Bottom view.

U8185
33 wire.

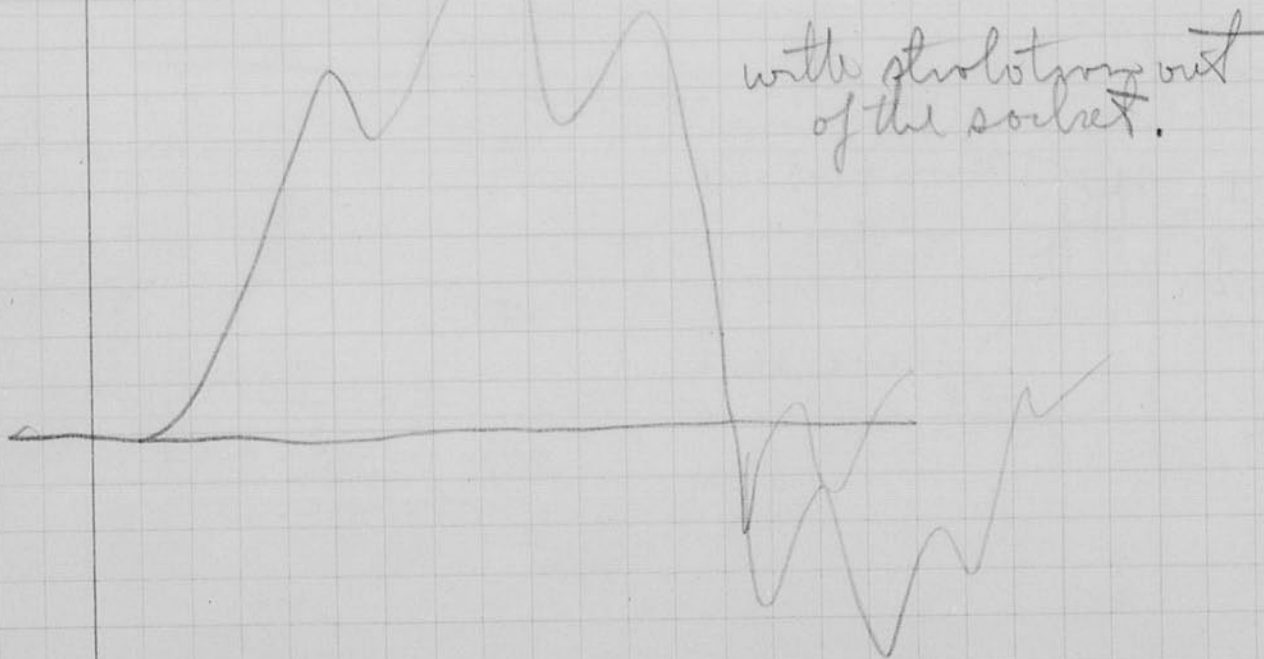


with out
d.c. to Strobe
condenser.

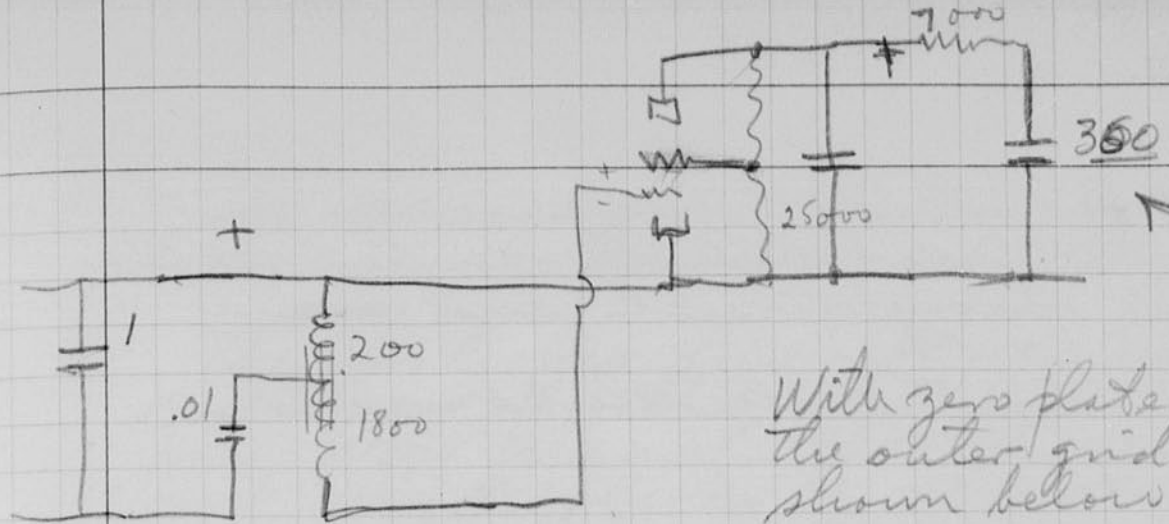
Audiotransformer. U.T.C. 0-15



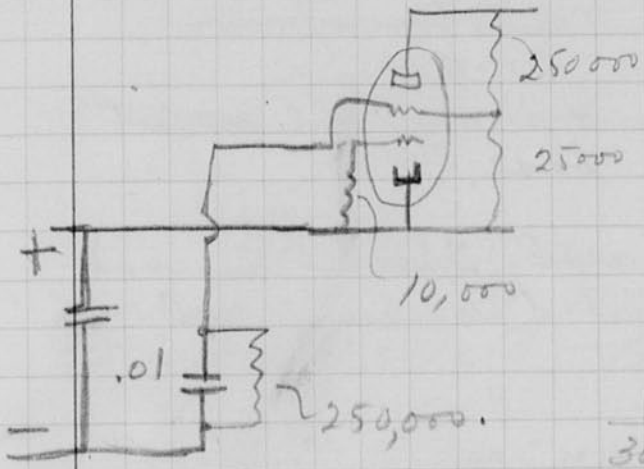
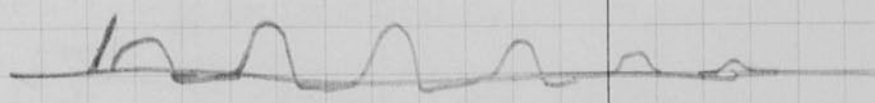
Slower rise
of grid voltage.
Trip voltage is lower,
An. 01 condenser was put
across the secondary
which resulted in a
still lower firing voltage



with strobe out
of the socket.

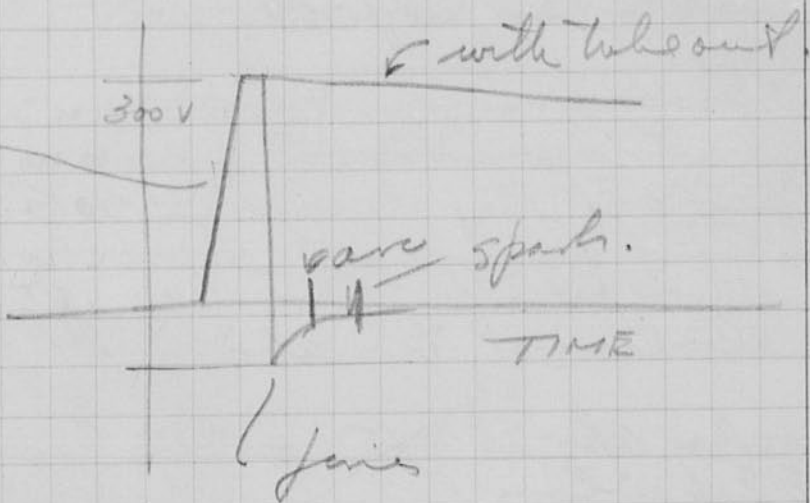
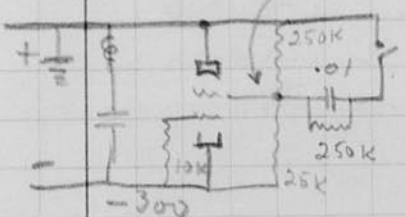


With zero plate volts, the outer grid voltage is shown below.



might be partly pickup.

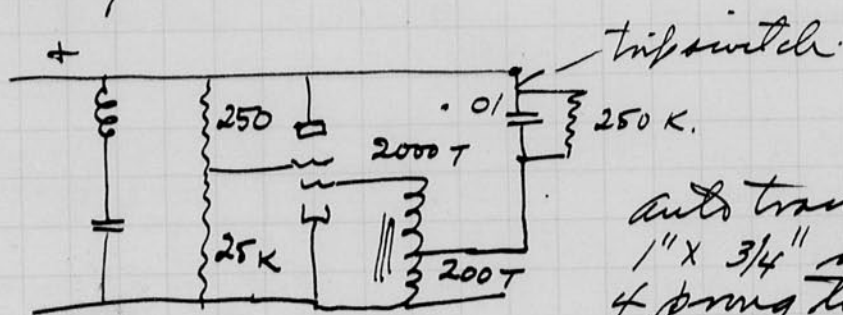
D-5 as first used.



April 23, 1945
David Edgerton

Worked with stroboscope circuits last week with Mac Roberts. He ran tests in the dark on many circuits and many tubes.

The circuit finally selected was the following.



auto transformer
1" x 3/4" in a
4 prong tube ~~base~~
base.

C.W. Duncan, E.T. Scott and Speak arrived Sat morning the 21st. Visited Duncan and went to Bedford field.

Yesterday went with Duncan to Bedford field to witness the A26 with a 584 test. Did not fly due to a 50 m.p.h. wind. Tried again at 4 pm with Duncan at Roberts. No results due to electrical trouble on the plane.

Wednesday Apr 25 1945 on the Federal to Washington.
David Edgerton

Mr. Halen of Electronics was in Boston today to discuss the beacon case.

On Monday the 584 test was run with the A26C using a beacon. The results were not so good.

Two photos were made of Fitchburg, resulting in an error in range of about 1 or 2 miles. We had difficulty in holding the plane into the target at that distance, about 25 miles.

Two runs were made over Concord from the town to the West Concord traffic circle.

The first was fine. It was run from East to West. The second was run from West to East. It started late and was displaced to the south of the target. The road was in the edge of the first photo of the series.

Pictures were taken at 5000 ft with 2400 m f 4000 volts at 6 sec. Negatives printed ok but they were very flat.

The picture sequences do not check the flight paths as drawn by the 504. This should be checked.

The plane is now being painted black before being returned to W. F. It then goes to Orlando.



meeting
 of
 W. F. Dwyer
 3/20/54

May 10 1945
Orlando Florida
Orange Court Hotel.

With Harper as pilot I left Bedford in A 26 48-22576 on April 30 about noon. We stopped over in Rochester for five hours while I saw some people at Eastman Kodak. Took off about seven for Cleveland, but finding a storm there we left for Dayton. I took the night train to Cleveland where I met Grier and saw people at the General Electric Co. I went to Dayton on the night train, arranged for Harper to fly B76 to Washington leaving about 8 pm.

May 3 was bad for weather in Washington. I visited Mary Ellen and her family in Chevy Chase.

Took off with Starnum and Butler on the 4th for Orlando, stop-over at Dohlgren and Florence S.C.

flight to
Tampa
and Miami

→ May 5 nothing accomplished due to people being away. May 6. - Sunday.
May 7. flight to Tampa and Eglin field. Left plane at Kissimmee field for maintenance.

May 7 Monday - conf with Lt Col Guerry. plane being accepted.

May 8. Visited Kissimmee - plane not in condition.

May 9. Flight in apt to Jacksonville also flight at night with two photo runs at 2000 and 3000 ft. The low run involved an 18 degree turn during the photo run.

today I was at Kissimmee all day working on the films and prints.

May 18 1945

MIT Camb. Mass.

J.G. Egerton. Left Orlando on Monday the 14 for Washington in the A26 no 576 with Starnum, McClelland, Butler and the crew chief. Three hours to Washington 770 miles.

on the 15 we visited the O.C.R. where I went with Kennedy, McCoy, to see Gen McClelland about APO 34 sets for ~~reconnaissance~~ use. In the aft I was at a conference with the Navy Dept on the TBM/F flash unit. This is to be designed to operate at 1000 ft at 2 second intervals.

after numerous conferences upon my return to Boston the tentative arrangement will be

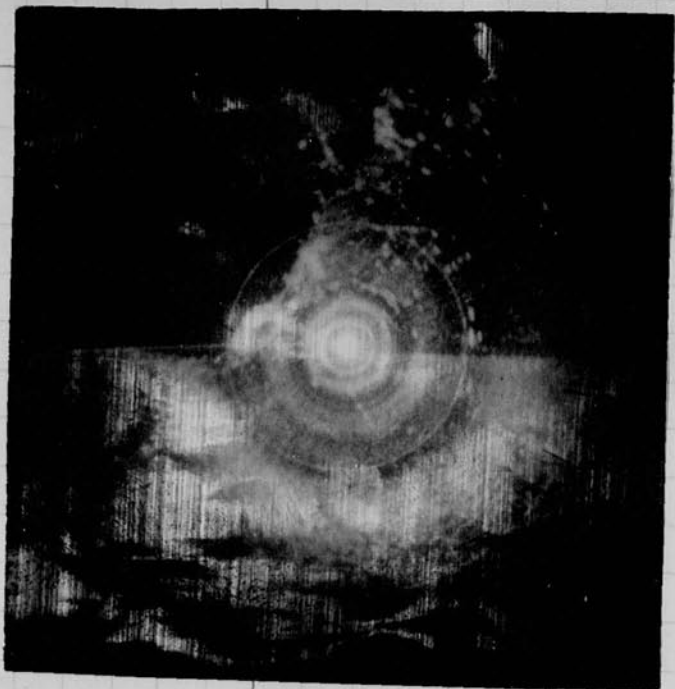
2 - Navy Bendix inverters 800-D-1

6 - Condensers 80 mf 4000 v G.E. type.

2 - FT-24 lamps will be used in small reflectors if the 24 lamp will take the power from 3 condensers. The lamp will carry the average power, but there is some question about its ability to withstand the flash from three condensers.

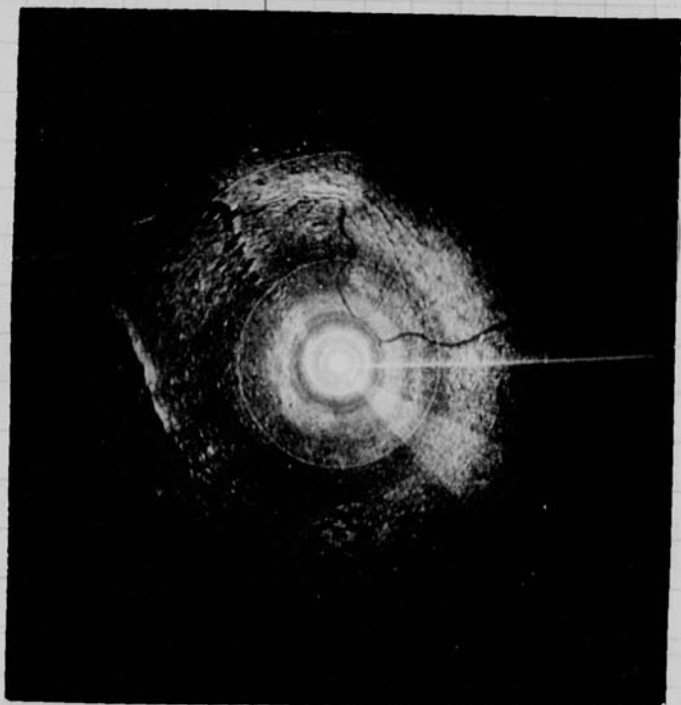
An FT-17 tube will be used if the FT24 is not able to stand the flash.

I visited the Bell Lab at Whippany N.J. on the morning of May 15 and then returned by train to Boston.



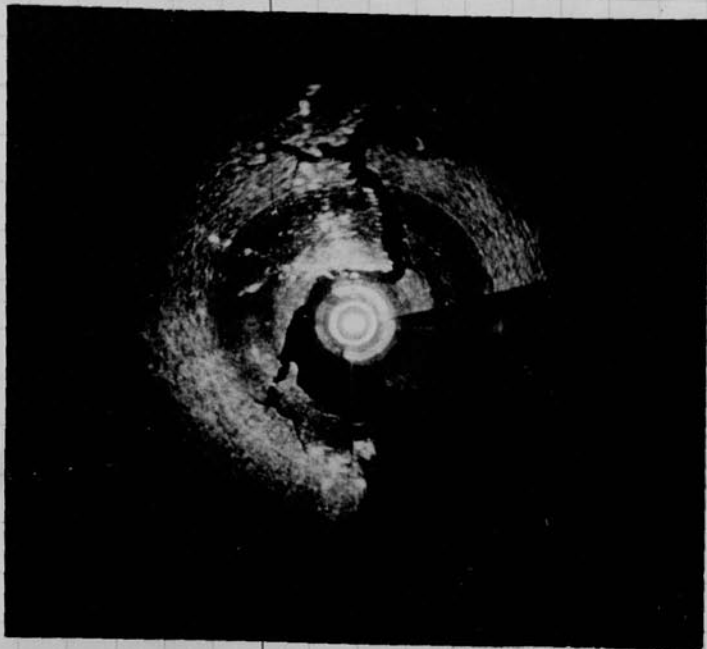
APS-1-K. May 1945.

BUFFALO NY.



POTOMAC Riv

HARDERS FERRY



JACKSONVILLE FLA.

Notebook # 16

Filming and Separation Record

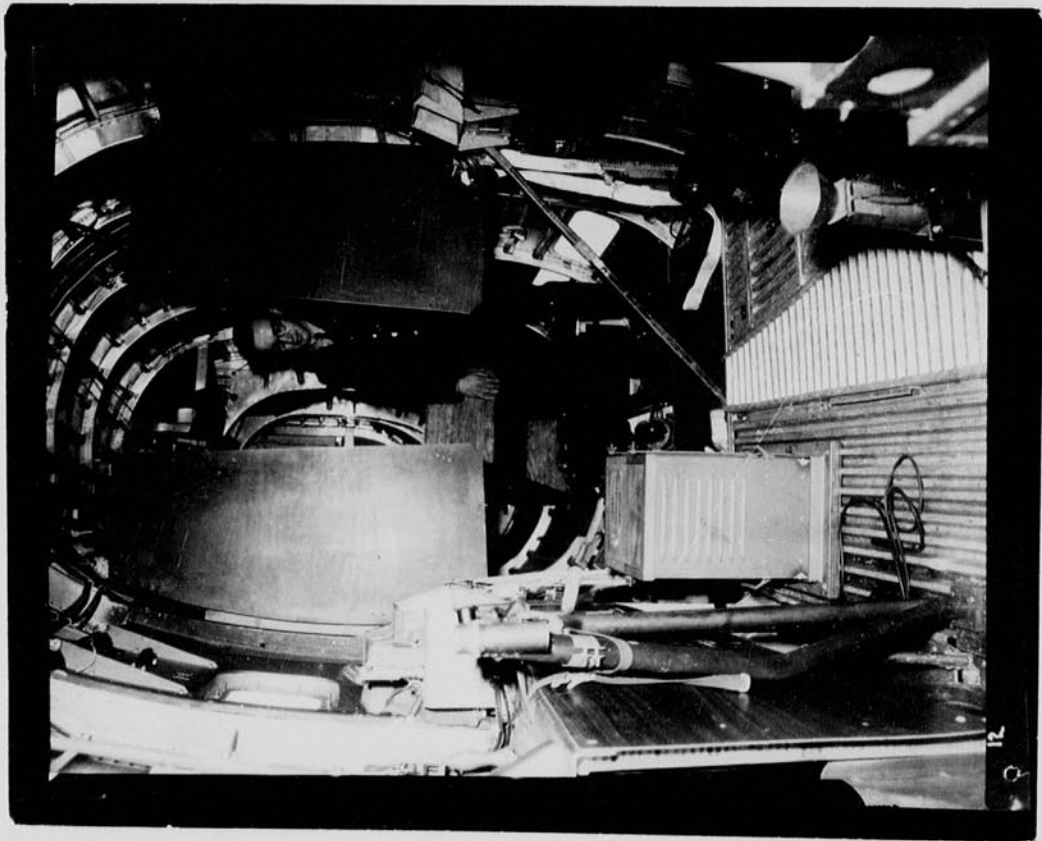
1 unmounted photograph(s)

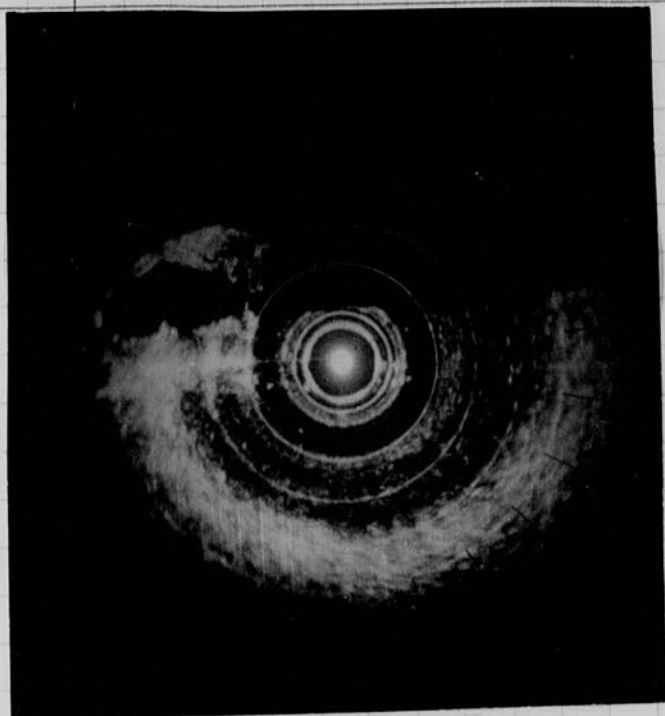
___ negative strip(s)

___ unmounted page(s)
(notes, drawings, letters, etc.)

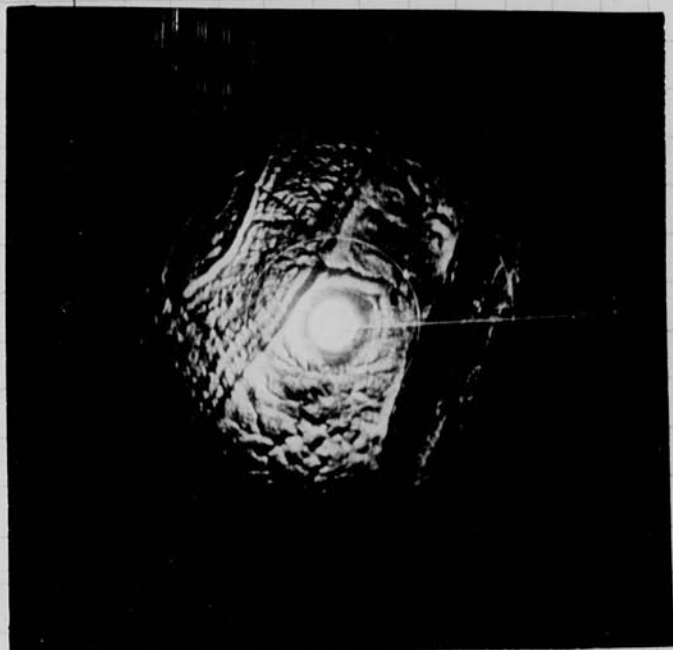
was/were filmed where originally located between page 28 and 29.

Item(s) now housed in accompanying folder.





ERIE PA

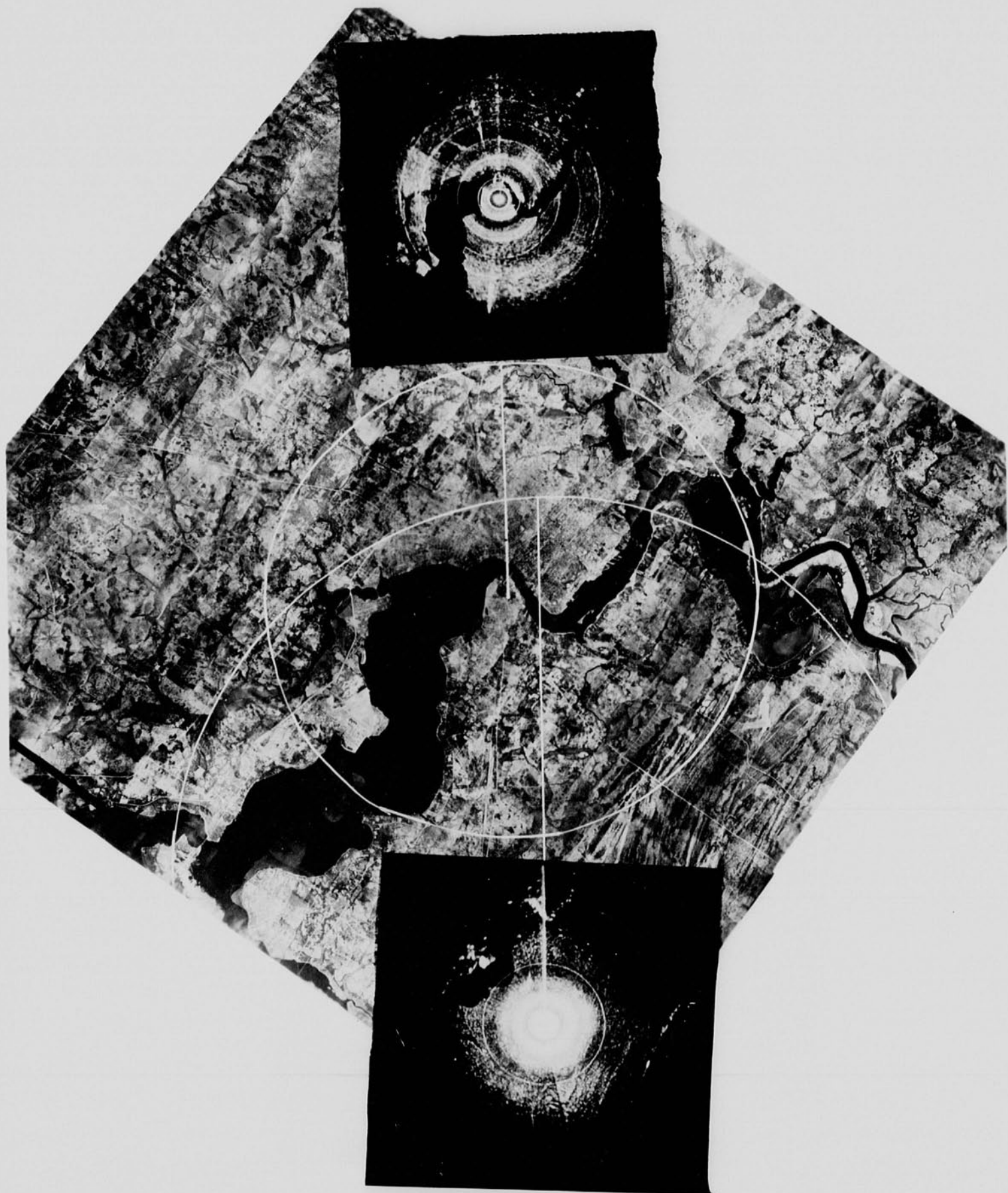


MIS IN PA



COASTLINE

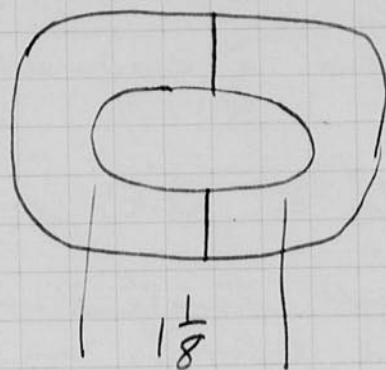
SC. OR FLA.



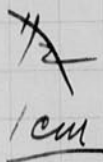
May 26 1945 MIT

David Egerton

Series coil for starting movie lamp.
from Bernshausen.



2 mil silicon
steel
core



20 turns #18 wire solid = ^{0.004}~~0.004~~ henry. $Q = 2$

6 " #18 stranded = ^{0.001}~~0.001~~ henry. $Q = \approx 1$

as measured on 1000 cycle bridge.

Harold Edgerton
May 28, 1945 M.I.T.

Exposure meter measurement
of shutter time.

The meter must be read twice
for measuring time. The first
reading is made with a
load resistor and a constant
light.

$$V_{\text{calibration}} = V_c \cong IR$$

The shutter is next tested with
a capacitor in the photo cell circuit
giving a reading ∞

$$V_{\text{shutter}} \cong \frac{1}{C} \int_0^T I dt \cong \frac{IT}{C}$$

then the shutter time T is

$$T = \frac{V_{\text{shutter}}}{V_{\text{calibration}}} \frac{1}{RC}$$

if $T = 0.01$ seconds

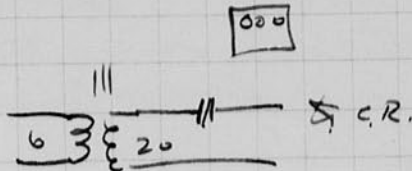
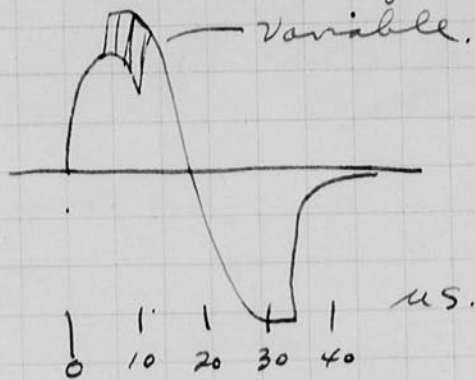
then $R = 10^4$ sec with a cap of $C = 10^{-6}$ farads.

$R = 10^6$ ohms	for 1.0 sec
10^5	0.1
10^4	0.01
10^3	.001

Test of coil page 31.

6 to 20 turns.

$7/8 = 300$ volts?



amp. of signal = $1\frac{1}{8}$ inches.

2 - 20

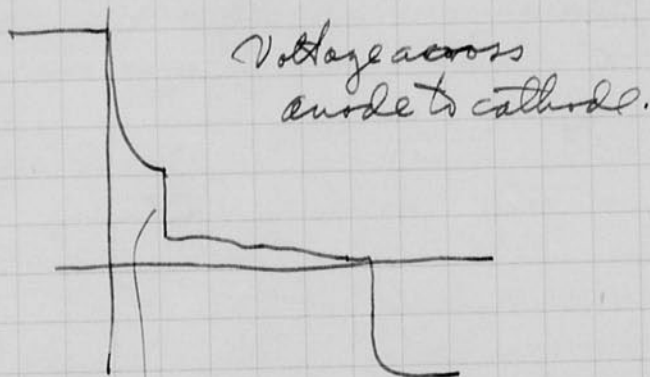
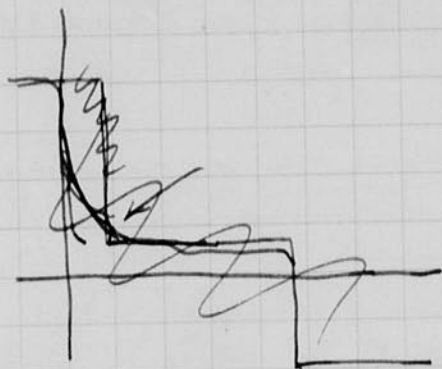
= $2\frac{1}{4}$ inches.

1 - 20

= 3 approx.

10 us total.

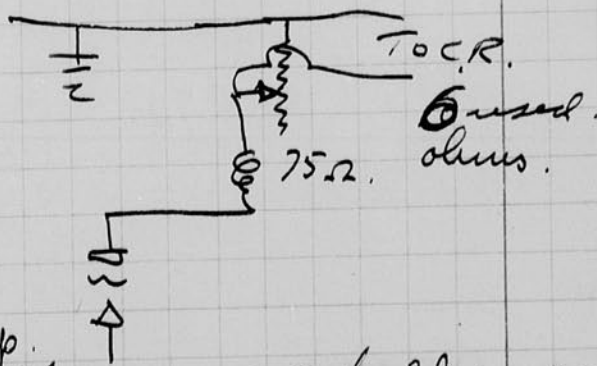
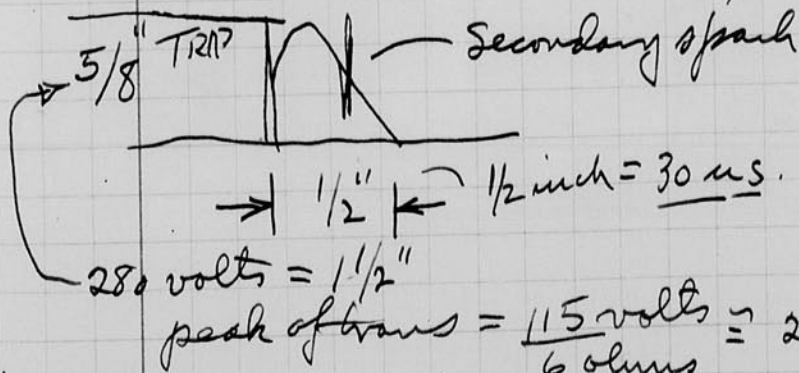
$$RC = 10^{-5} \quad R = \frac{10^{-5}}{1 \times 10^{-6}} = 10 \text{ ohms.}$$



Sudden breakdown.

CR 3.5KV on dial.

521 Movie spark FG-67 thyatron.
.07 mH into coil.



with 20 turn coil on silicon core the FG-67 holds over 6 ohms
the current in the first surge was > 40 or 60 amps.

Experiment to show influence of
sil steel core in series with movie lamp.

Peak current with out = $5/8$ "

" " with coil = $3/8$ "

this is a 20 turn coil with 10 on
each leg of the lamination.

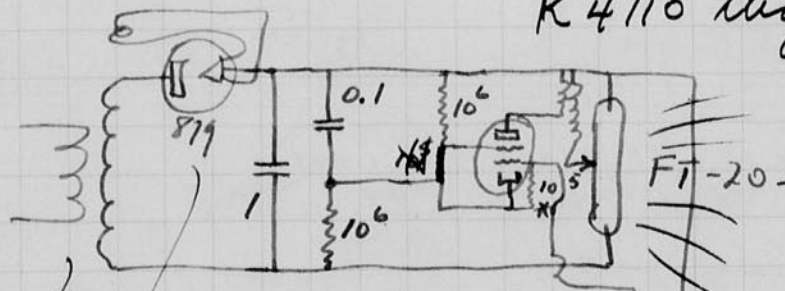
May 31 1945 Duncan C.S. of the RAE arrived May 28
from Toronto and plans to leave tonight for
Ottawa.

June 1 1945. Discussed dark-starting of stroboscopy
with Nottingham several days ago. He
suggested 5% thorium in cathodes of
stroboscopy tubes to give some dark
emission.

I worked with Wilkins on a contactor
stroboscope for loom observation. We used
the stroboscopy R 4110 which is rated 1000
volts. I had some self flashing so
reduced the plate voltage to 750.
Capacity of 0.1 μ f gave enough spark
to trip a stroboscopy but not enough
for a FT-20.

Had a conf with Sinclair, Nottingham
and Wilkins about the integrating
exposure meter. It was suggested
that Nottingham and I work on the
project on a royalty basis, $2\frac{1}{2}\%$
each.

R 4110 thyatron.



RK R 72

Raytheon

V 4576 B.

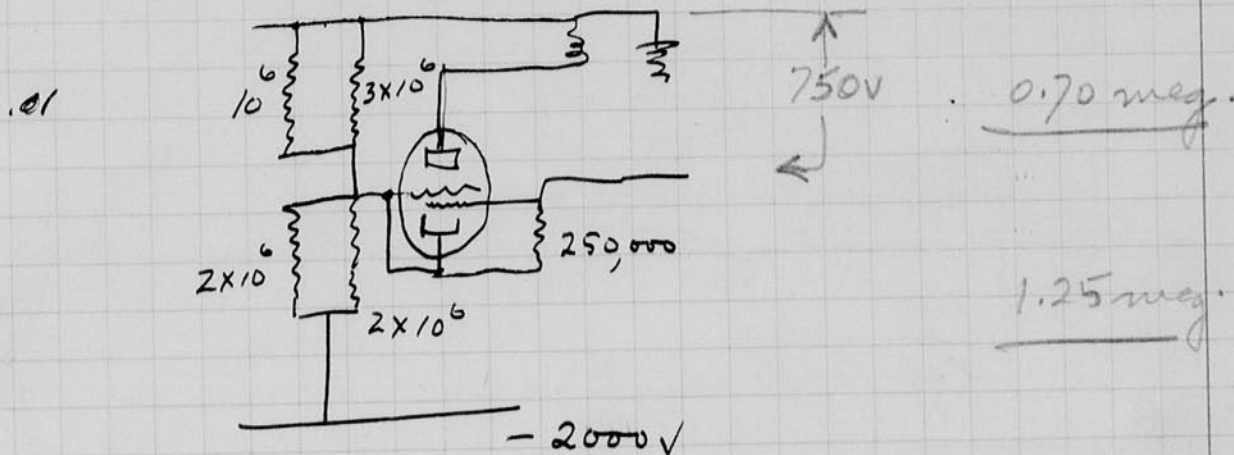
Transformer

Kodak type.

.00025
 2×10^6

contactor

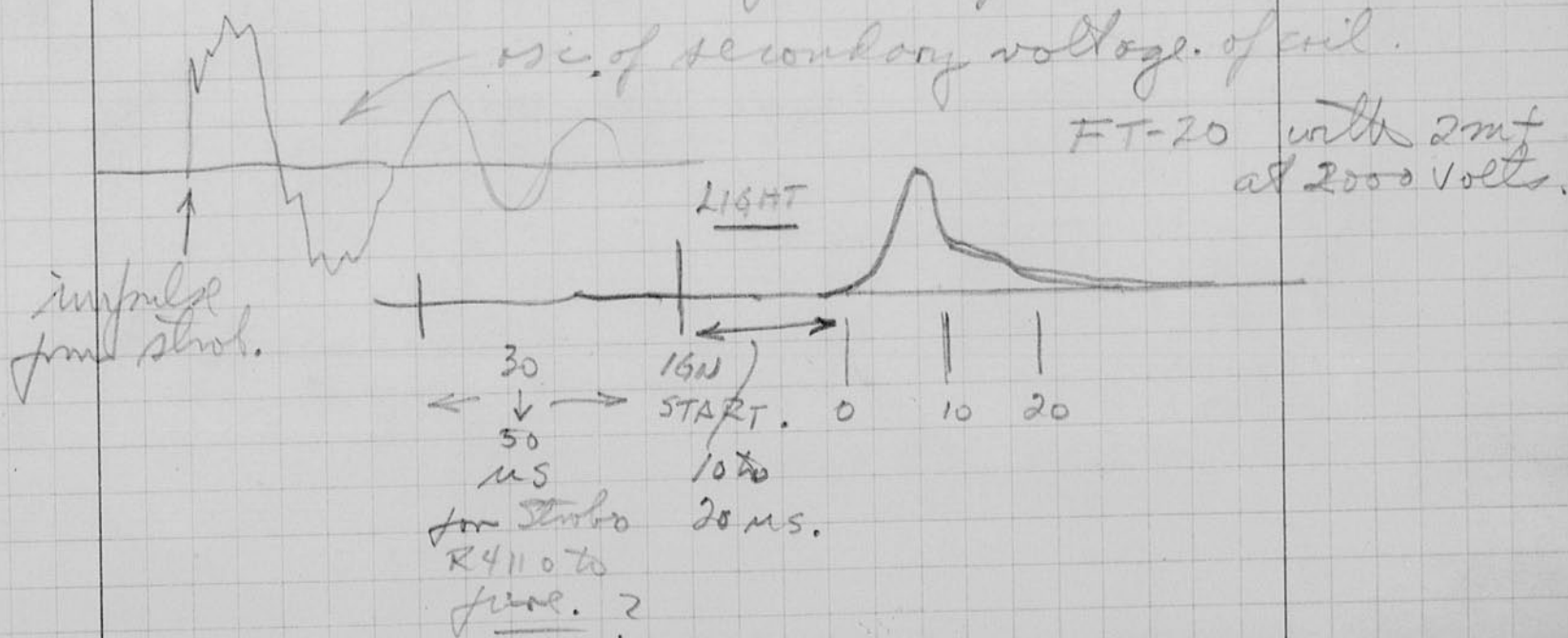
With 2 m μ f the tube gets too hot and skips once in a while. The transformer gets hot after a half hour or so with 1 m μ f at 10 flashes per second.



The 3 meg resistor was put in to stop the self firing of one of the two sample strobes that I had for testing.

June 2. cont. Connected above ckt to CR tube.

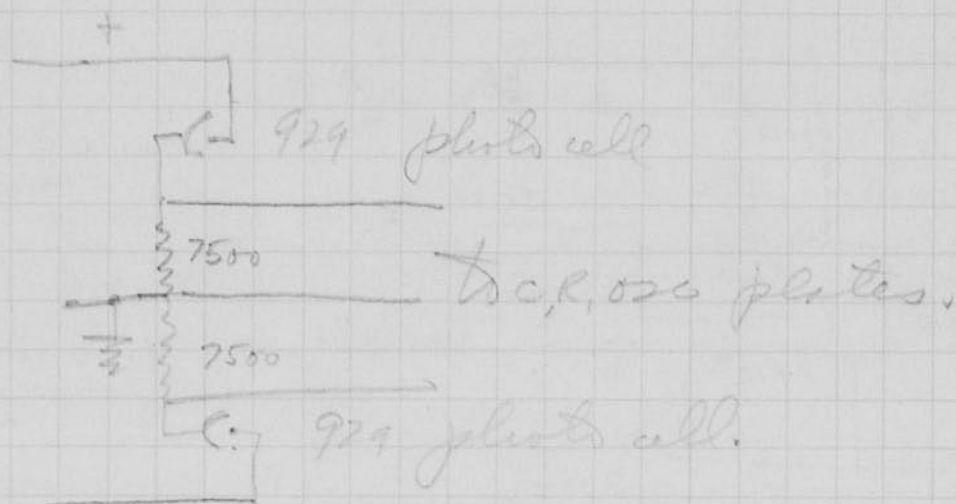
The CR shows the discharge of the 0.1 m μ f at 2500V into the 25 turn pri of the Delco coil to be very fast, that is about 2 microseconds or less. The secondary voltage is like this



June 4, 1945.
H.G. Egerton

I set up a camera for recording the C.R. tube that has three elements, yesterday.

Light measuring circuit,



Screens are put in front of the photo cells to attenuate the light. These screens have been calibrated in percent transmission.

0.3 ohm for current.

10^5 cycles timing,
5000 volts on C.R.

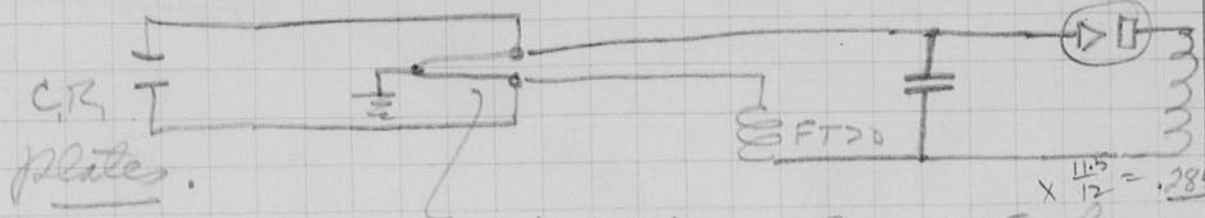
Exp. No.	Exp.	Volts.	Screen	
✓ 1-3	29	2000	9.2 x 48	
✓ 3-6	29	2000	9.2	
7-8	29	2000	9.2 x 48	Sweep speed increased x2
9-10	29	2000	"	" " " x6±
11-15?	29	2000	"	Focus adjusted.
Blank				
11-19	3	2000	9.2 x 48	fast sweeps.
20	3	"	9.2	
21	3	"	23	
22	3	"	49	
23-26	3	"	23	checked.
27-28	3	"	23	current mess <u>shorted</u> .
29-30	3	"	23	current measured <u>checked</u> .
31-33	1	"	"	"
34-37	1	"	49	

Developed 10 min in D-19. ok but thin.

1mf = 1.04
 2 = 2.05
 25 = 29.

GR Bridge
 in meas
 false.

Current meas.



$\frac{150}{3} = 50$

$\times \frac{11.5}{12} = .298 \text{ ohms}$

12 inch wire R = .298 ohms per inch

Calc for current 110 volts brings top two spools together.
 5000V on anode.

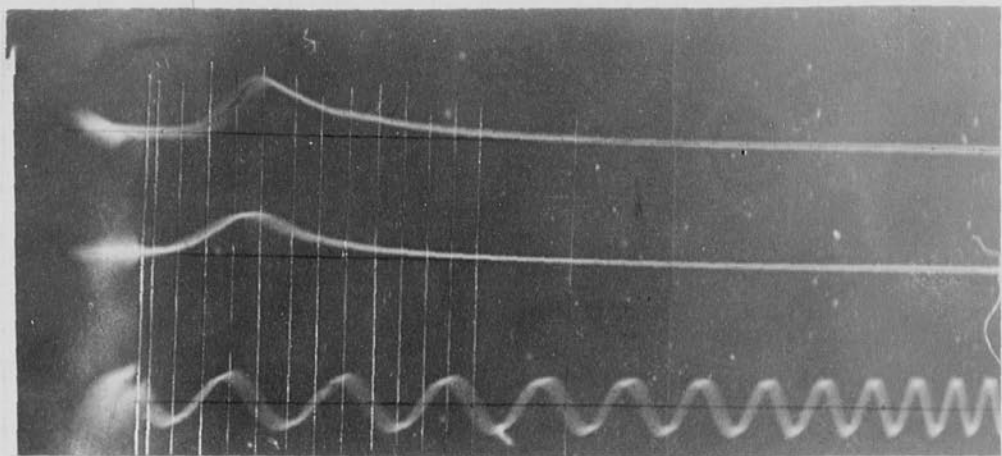
2	29mf	2000V	9.2 x 48%
6	29	2000	9.2
10	29	2000V	9.2 x 48
14	29	2000V	9.2 x 48
Blank.			
3	3	2000V	9.2 x 48
4	3	"	9.2
✓ 5	3	"	23
✓ 6	3	"	48.
?	1	2000V	23.

$\frac{1.6 \text{ cm on enlargement}}{1.6} = 110 \text{ volts}$
 $\frac{110}{.298} = 385 \text{ amperes}$
 $\frac{385}{1.6} = 240 \text{ amp/cm}$
 $= 24 \text{ amp/mm}$

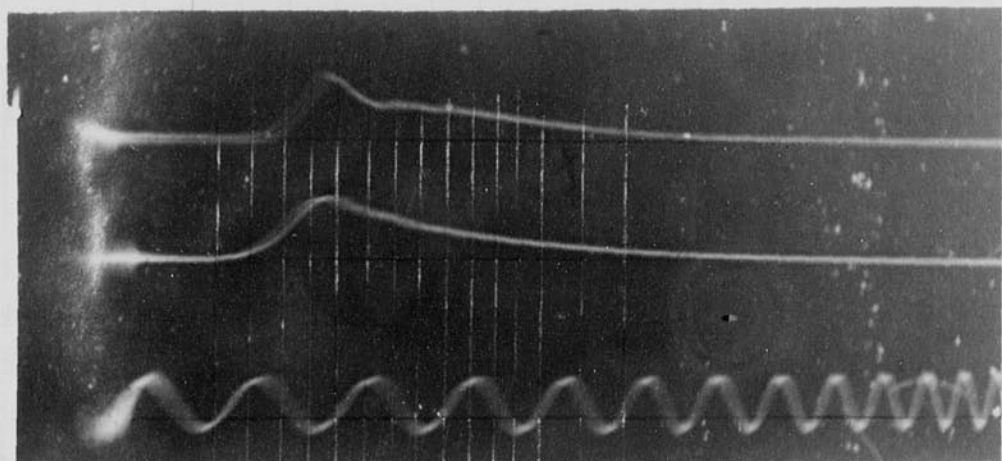
$\frac{17.5}{85} = 205$
 $\frac{23}{4.4} = 5.23$
 How come? referred light!

Readings from film

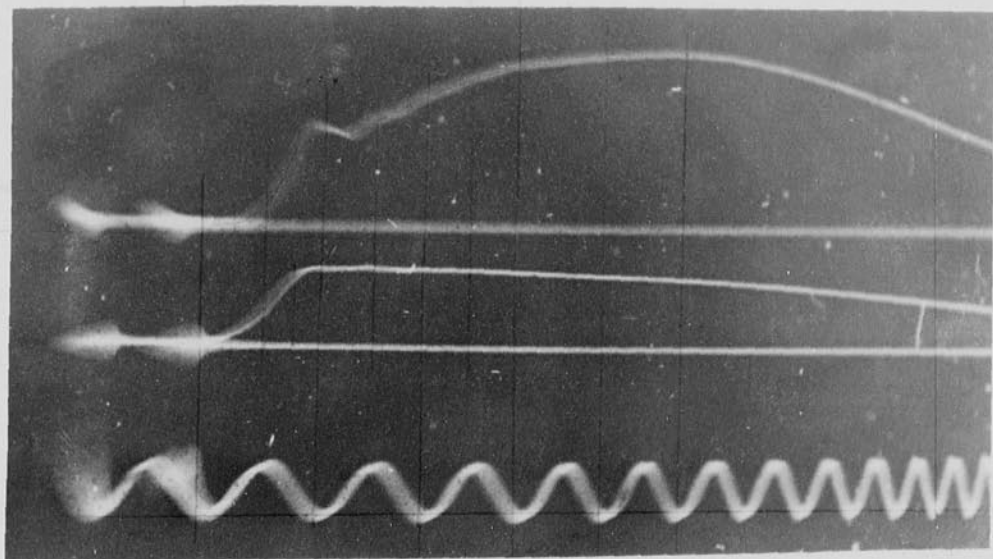
TIME. μ s	Current mm x 24.	Current amps.	Light.	3mf			1mf			
				I mm	I amp	Light	I mm	I amp	Light $\times \frac{1}{2}$	
29mf 2.5	1.5	36	0	1.5	36	0	1.0	24	0	0
5	4.0	96	2.5	4.0	96	2	2.5	60	1.0	.5
7.5	9.0	215	10.0	7.5	180	6	5.0	120	4.0	2.0
10	10.5	252.	18. 13.5 peak.	8	192	8	5.0	120	7.0	3.5
17.5				6	144	4.5	3	72	5.0	2.5
15	10.5	252	14.	5+	120	4.5	2.	48	3.5	1.75
20	10.5	252	17.5	3.5	84	4.0	1	24	2	1.0
25				2.5	60	3.0				
50	9.	215	23 peak.							
100	6+	144	14							
	4	96	9							
	3.5	84	6.5							



1 mt 2000 v



3 mt 2000 v



29 mt 2000 v.

Post D = 150x205x10 1/2 3500000000

Notebook # 16

Filming and Separation Record

___ unmounted photograph(s)

___ negative strip(s)

1 unmounted page(s)
(notes, drawings, letters, etc.)

was/were filmed where originally located between page 38 and 39.

Item(s) now housed in accompanying folder.

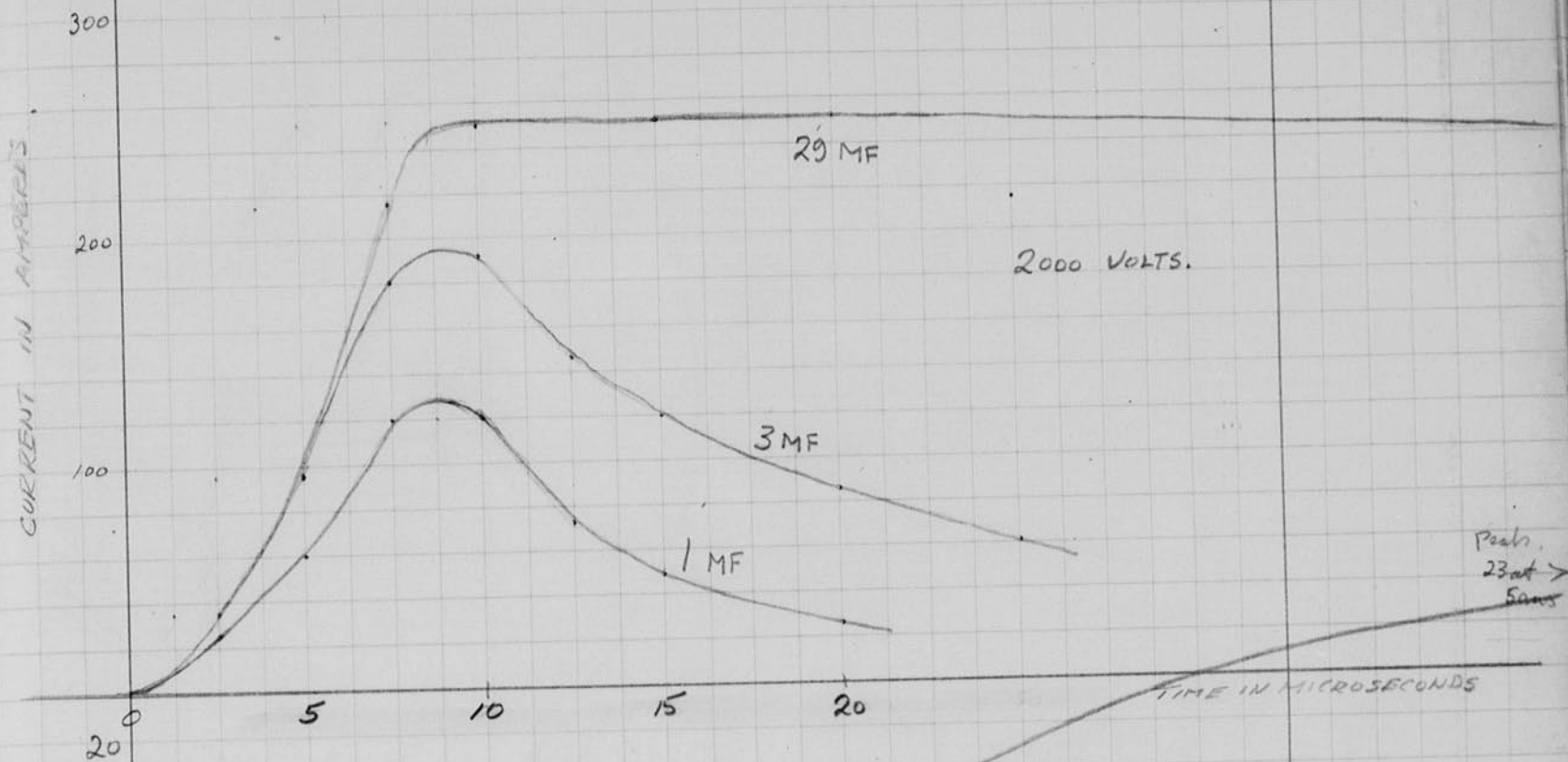
Push
23 out ->
50ms

05

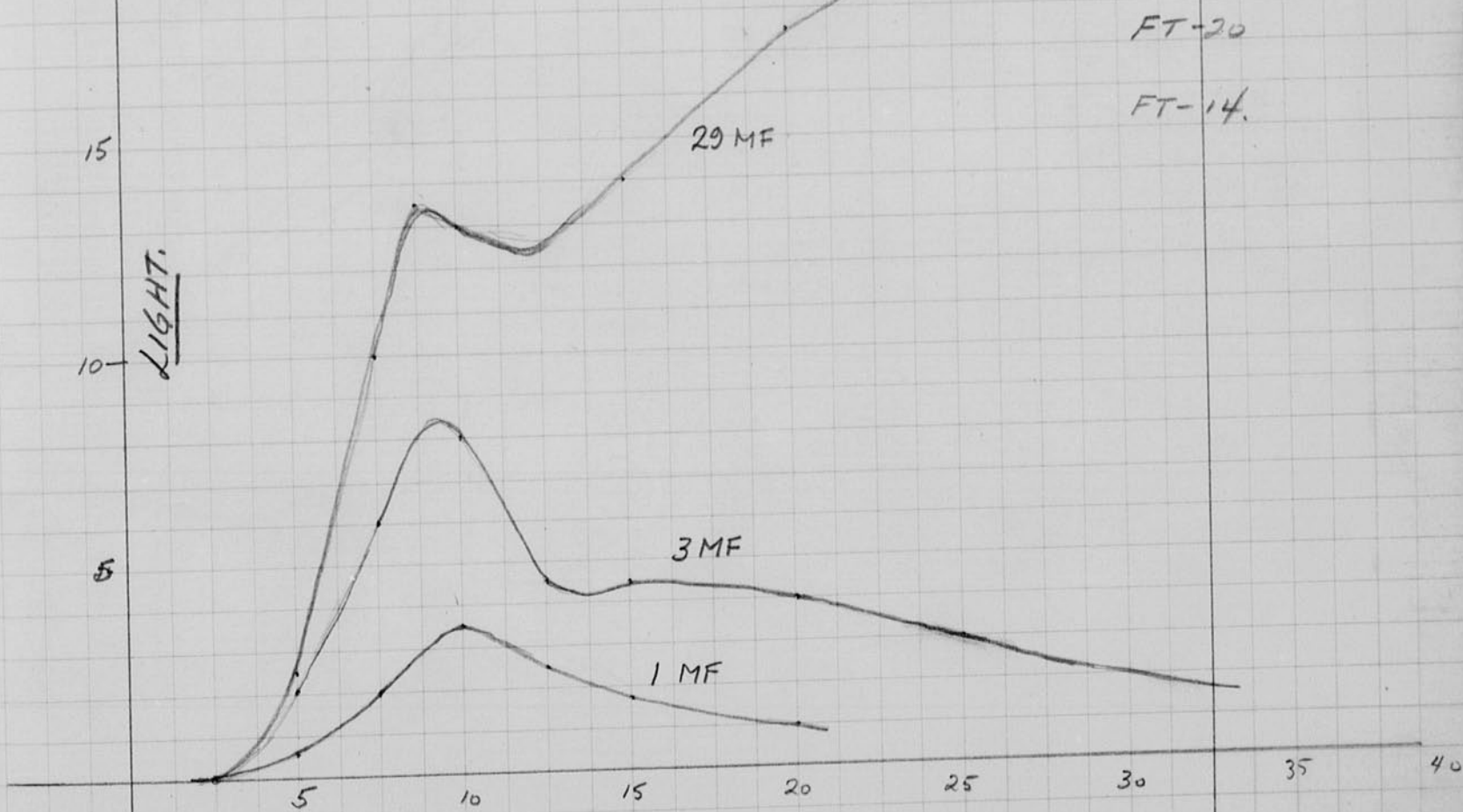


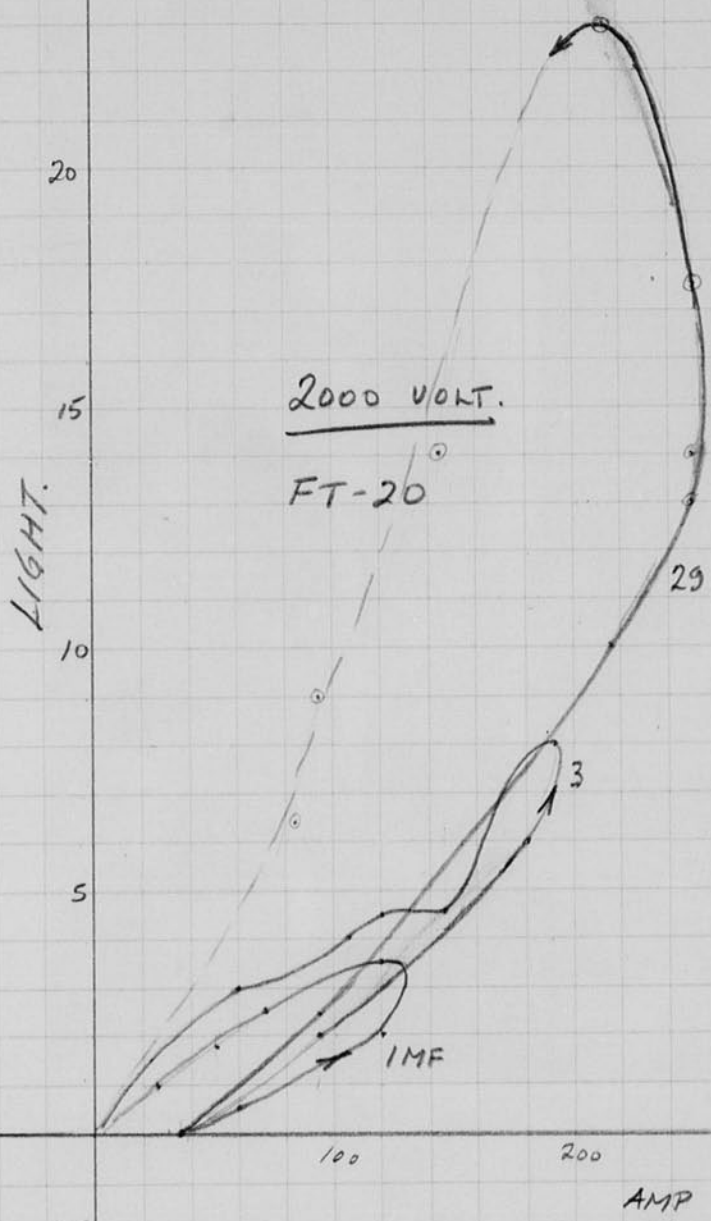
$$e = tp = 150 \times 2000 \times 10^5 = 300,000 \text{ joules}$$

$$\frac{29.4}{2} = 58 \text{ joules}$$

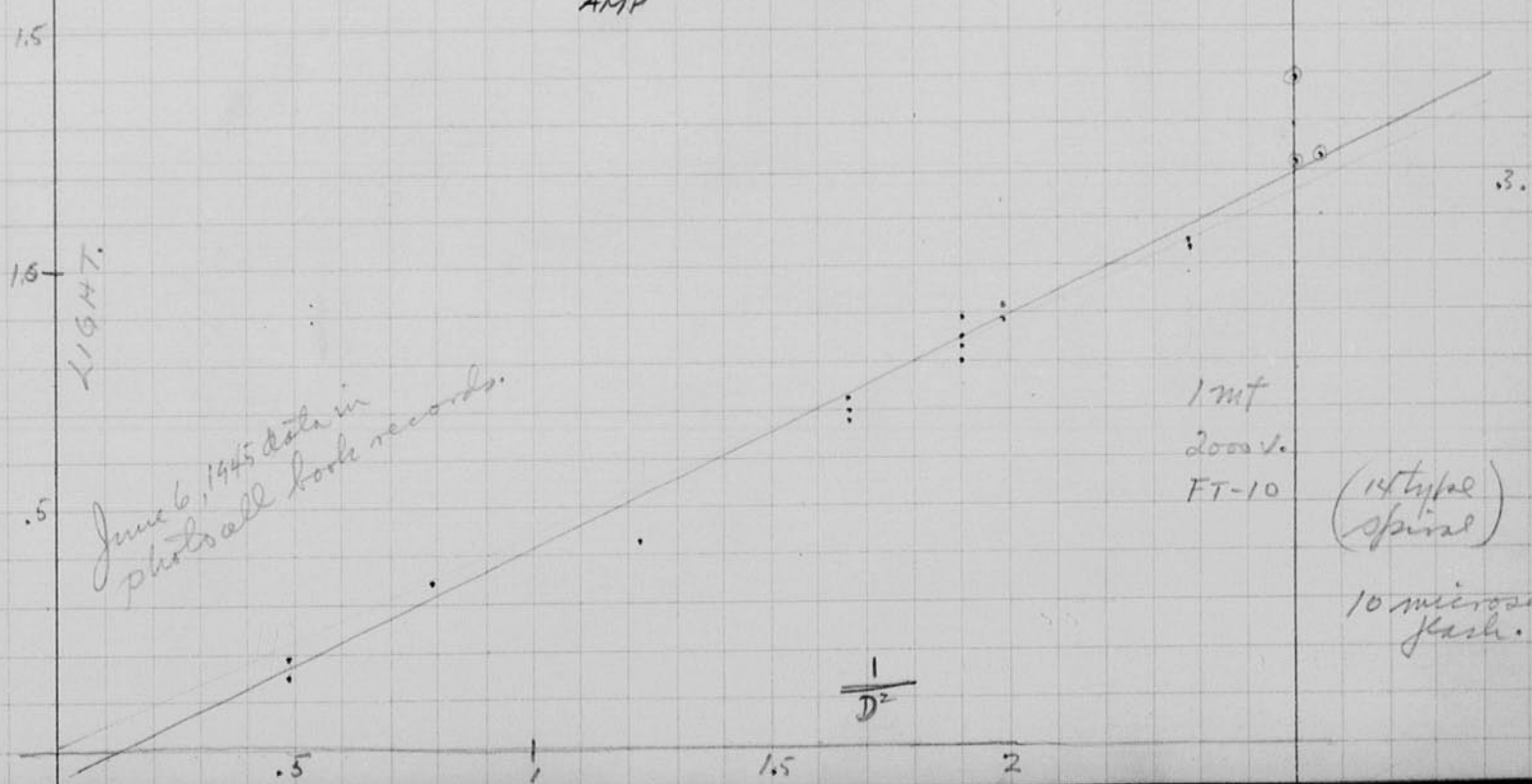


Peaks
23 at →
50ms





X not quite correct
due to phase shift
in linear



June 12, 1945
H.S. Edgerton

Wycliff and Campbell arrived yesterday morning from the Model Basin, Washington with our old movie equipment and with the new 20 lens (rotating) camera.

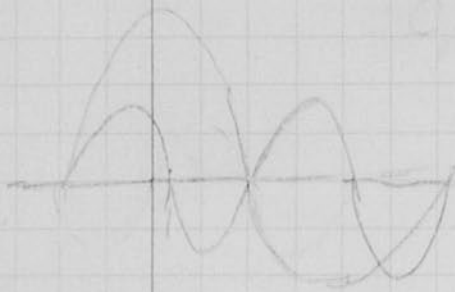
Meas. of coil spark from Model Basin

$$t_p = .003 \text{ h} \quad Q = 3.5$$

$$t_s = .56 \text{ h} \quad Q = 1.4$$

Assume $T = 2 \times 10^{-5}$ seconds secondary.

For Pri and secondary to have the same frequency.



$$2 \times 10^{-5} \text{ sec} = 2\pi \sqrt{LC}$$

$$\text{Solve for } C = \frac{(2 \times 10^{-5})^2}{(2\pi)^2 L} = \frac{1}{3} \times 10^{-6} \text{ farads.}$$

$$\text{for half period } C = \frac{1}{12} \times 10^{-6} \text{ farads.}$$



June 18 1945
M.I.T. Camb.

David S. Edgerton

Wychoff and Campbell were here on June 11 to experiment with flash tubes on the pump for the movie equipment. They left on the night of the 12th after pumping several tubes.

They concluded that a 1 mm H₂ 1 atm argon in the standard movie lamp would be a good pressure. Much data was taken of performance

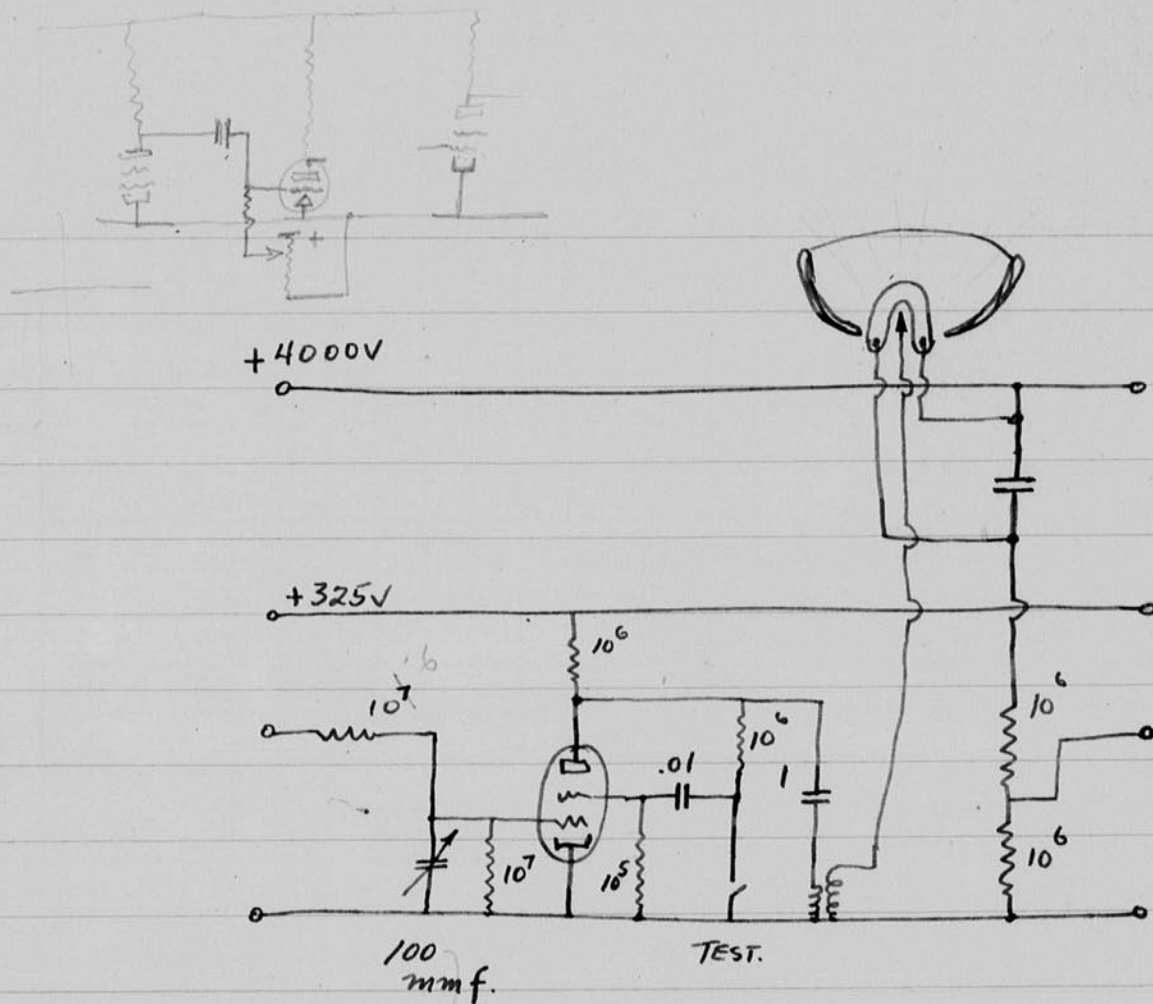
choke charging with 1 or 2 audio reactors 0.75h 0.5ma, 30 ohm chords on T-81 C15 chokes. The condenser was 0.1 mf. to 4 mf. Wound value 0.25 mf.

Kenyon came on June 12 for the D-3 for installation in plane 228. A flight was made June 14 over Boston at 5000 and 7000 ft. Negs were not processed here. Atkin and Harper were pilot and co pilot.

One condenser popped during the flight over Boston. The equipment worked ok after the pop.

June 22 1945 MIT
Harold Edgerton

Charles Coles called from U.F. Dayton for suggestions for a 5 flash unit for photography. He wants 40 micro second flashes at 1000 microseconds apart. I send him the navy circuit 1942 or 1943.



The above could be cascaded into as many units as desired, with adjustable time lag between them.

June 26 1945

N-2 tests.

Edgerton & Borstow
Dyna lab.

Large D.C. machine operated at 28 volts for current supply.

Series capacity with many inverters for finding max condition.

35 mtf 2100 volts.

23 2300

15 1700

32 2200

28 2500

18 2150

14 1800

24 2400.

Plan to use
25 mtf.

Heat run on a generator. Cold res of alternator = 0.66 ohms. after 1 1/2 min load = 0.87 ohms.

Meters are now connected to measure the D.C. input under load with two inverters. (800 ID).

A D-5 or D-3 control box is being used to operate the stroboscopy circuit the D-5 interometer sets the flashing rate.

The FT-17 with two inverters holdover into an arc. We used a coil in series with the condenser to prevent holdover. This coil was of the D-1 type. 0.5 millihenry. This is not quite enough. Possibly double this value would be ok.

no holder with 25 mfm inverter and 0.5 mh coil
 current from line 250 amps.
 frequency = $\frac{1}{2}$ ~~second~~
 Capacity 400 muf FT-17.

(the lamp held over with 15 mfm and 0.5 coil)

$1\frac{1}{2}$ seconds between flashes. 400 muf.
 Max voltage on the condenser 3500.

Condenser voltage rises to 5000 volts. \pm .

100,000 ohms load to stabilize output
 Reduces output by 200 volts.

50,000 ohms brings the peak voltage down to
 4300 volts.

Hits 3800 with 4. cond. 400 muf at $1\frac{1}{2}$ seconds
 between flashes.

50,000 ohms

Capacity increased to 600 muf.
 speed 2 seconds between flashes.
 400 volts 25 at generator.
 voltage adj. on inverter on max.
 Lamp holds over some.

Voltage adj. now moved back to half setting
 3700 volts at 2 sec. due to regulator.

at $1\frac{1}{2}$ sec. int 3500 volts.

no flash peak 4200 volts.

With bleeder off. 4750-4800 volts.

25 mf 580 amps avg input 26 avg input V
 600 mf 3 sec int. line. less c.c.d. relatively

15 mf 200 amps avg input 26 avg input V
 600 mf 2 sec int. " "

2 second intervals
 Regulators at $\frac{1}{2}$ on output between
 normal and max.

400 mf \pm
 27.5 volts.
 amps.
 3500 volts - momentarily.
 15 mf series condenser.
 0.5 mh inductance
 no holdover. 50,000 ohm bleeder.

At 1.5 second. all ditto 3500 V just reached.
 185 amps.

Next with 600 mf 1.5 sec. 3000 volts. 215 amps
 at 2 sec. 600 mf 3500 volts 210 amp. obs open

Ino. resist. adj. max 400 mf 2 sec.
 3800 Max I = 210 amps - down to 100%

600 mf 1.5 sec 3000-3100 volts. check. Max Reg

Ditto with 25 mf instead of 15. 3600 volts, Max Reg
 290 amps input.

15 mf series Reg at $\frac{1}{2}$ normal - max. 15 sec. int.
 600 mf with 50,000 bleeder.
 3850 volts 70 amps - hold.

Ditto 4200 with 100,000 bleeder. 190 max

Ditto 4600 with no bleeder.

all with 0.5 mh
 no holdover.

June 27 1945.
cont.

Ind. mh.	Ser. Cap.	Lamp.	Input volts.	to start holdover.		Remarks.
				C	T	
none	15.	5 turn.		600	2 sec	no holdover.
none	15	5 turn	32	600	2 sec	H.O.
0.5 yes.	15	5	31	"	"	"
no	15	6 turn ^{Dif}	32	"	"	"
no	39	5 turn.		"	"	no H.O. upto 38 volts
no	25	5 "		"	"	no H.O. upto 38 volts.
1.5	15	5 turn		"	"	ok no H.O. upto 38 volts.
3.0	15	5 "		"	"	ok no H.O.

changed capacity from 600 to 400 mf.

Regulator adjustment screws in M-6 base backed off 3/16 to 1/8. to give 140 instead of 120 volts. Potentiometer at max value. 1.5 mh not enough to insure no holdover.

With no bleeder 4700 max.
" 50,000 4100 max

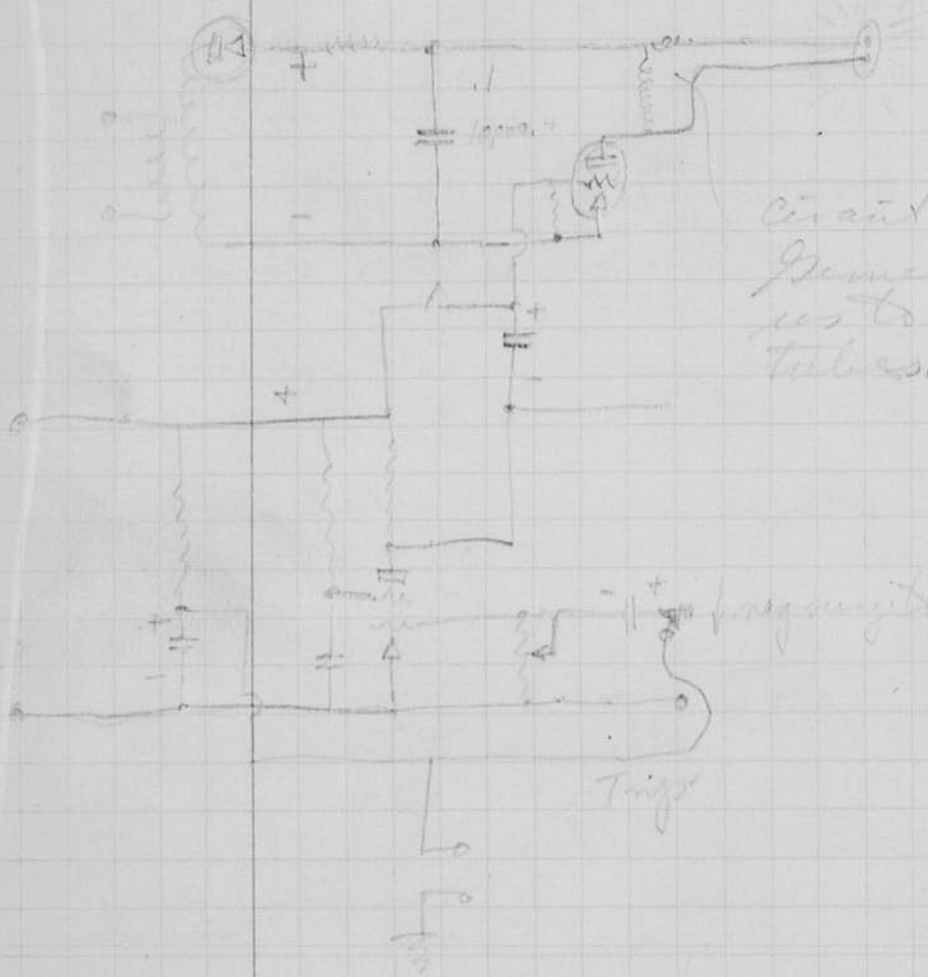
1.5	15	5	27.5	AC 145 on in	400	2	4100 max. 4400.
1.5	15	all ditto	27.5	except for	600	2	3700.
			27.5		500	2	4000
			24.		500	2	3700.
			27.5V		500	2	4000
			27.5 V.		600	2	3700-3800
			27.5		400	2	4100 → 4000
		50000 ohms bleeder	27.5		400	2	4600
		100000 " "	27.5		400	2	4700-4800.
Ready reg.		50,000 ohms.	27.5.		400	2	4000.
		50,000	27.5		400	∞	4400-4500.
		50,000.	27.5		400	5	4200-4250

Plants use 50 or 600 mf.
set regulators for 4000 v.
2 second external
relay protection for holdover.

June 28 1945.

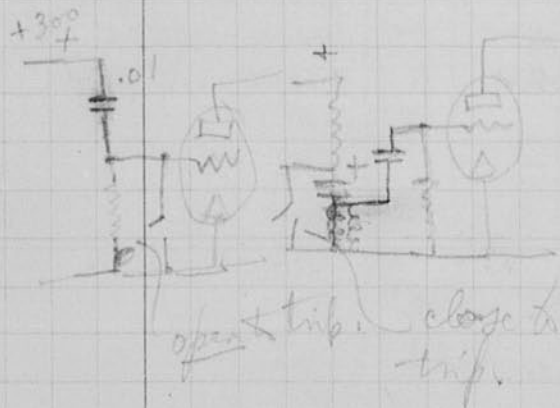
Chas. Wydruff arrived today to work on
 new circuit. - Connected selenium
 rectifier for experimentation on the
 new No. 2 flash unit.

Trips flash unit.



Circuit suggested by
 James Clemens to enable
 us to use high pressure
 tubes.

frequency trip. signal or contact.



open trip. close to
 trip.

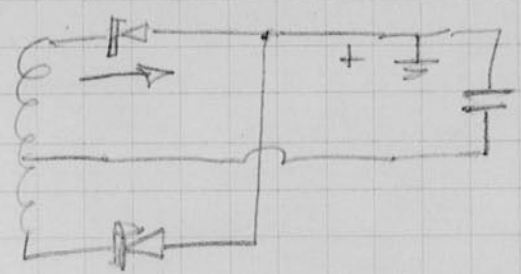
June 30 1945.

Ely & Barlow Selenium Rectifiers on $M=2$

10 stacks x 40 disks in each element

thin line

S.G. type 1" diam.



Ind	Sec Caps	Tamp	C	Time	V	V	Remarks
1.5	15	5	no Bleed 600	2	27.5	3400	voltage. 5000
1.5	15	6	" 600	2	27.5	3300	Sel
				∞		4300	"
1.5	15	6	" 600	2	27.5	3450	Tubes
1.5	15	6	" 600	∞	11.5	4650	Tubes
1.5	15	6	" 600	2	"	3800+	Tubes
	15	6	" 600	∞	"	4750	Tubes
	15	6	100000 600	∞	"	4350	Tubes
	15	6	50000 600	∞	"	4175	Tubes
	15	6	10000 600	2		3475	Sel
			600	∞		4650	Sel
			100000	∞		4300	Sel
			50000	∞		3800	Sel
			50000	∞		5300	Sel. ✓
			100,000	∞		4300	Sel. ✓
			25000 400	2		3700 3600	Sel Ho.
			600	2		3600	Sel.
			600	2		3750	Tubes

gm at max

3 1/2 in f in parallel with ~~trans~~ trans.

	15	6	100000	400	2	4000	Tubes
	15	6	"	400	∞	4250	"
	15	6	"	600	2	3650	"
No parallel cond.	15	6	"	600	∞	4250	"
	15	6	100,000	500	2	3800	" parse slip
	15	6	"	500	∞	4550	"
	"	"	"	600	2	3550	"
1.8 in f in ll →	"	"	"	600	∞	4550	"
	"	"	"	500	2	3750	"
	"	"	"	500	∞	4300	"
	"	"	"	600	2	3450	"
	"	"	"	600	∞	4300	"

June 30

F. Borst

N-2 Flash Unit.

The following are for optimum adjustments of regulator and 27-28.5 volts input while flashing.

Parallel Cap.	Series Cap	Ind.	Lamp	C	Time	Volt	Remarks
0	15	1.5	6 turn	500	2	3800	100,000 w. bleed
0	"	"	"	"	∞	4500	"
0	"	"	"	"	∞	4250	50,000 w. "
1 mfd	"	"	"	"	2	3800	100,000 w. "
1 mfd	"	"	"	"	∞	4250	" "
$\frac{1}{2}$ mfd	"	"	"	"	2	3800	" "
$\frac{1}{2}$ mfd	"	"	"	"	∞	4550	" "

Reg readjusted so that 500 mfd's would just reach 4000 volts in 2 sec.

0	"	"	"	"	2	4000	50,000 "
0	"	"	"	"	∞	4300-4400?	" "
0	"	"	"	"	∞	4700	100,000 "
$\frac{1}{2}$ mfd	"	"	"	"	2	4000	" "
$\frac{1}{2}$ mfd	"	"	"	"	∞	4300-4400?	" "

When using 600 mfd's, the cond does not reach full charge in 2 secs, so the reg. adjust. can be moved back 500-300 volts & still not affect the max volt reached for the 600 mfd's. At the same time the voltage for time = ∞ is decreased 500-300 volts. Thus it would be practical to use a 100,000 bleeder only (no // condensers). However, if the flashing rate is ever ~~increased~~ slowed down to 2 $\frac{1}{2}$ to 3 per sec., no appreciable gain in light will result in this case.

June 30 1945
 Harold Edgerton
 McRobert & Wydeoff

Cal. Tech. Movie Unit.

3500 volts = 15 division

3000 μ .14

871B, Hard tube.

choke = 0.45 h

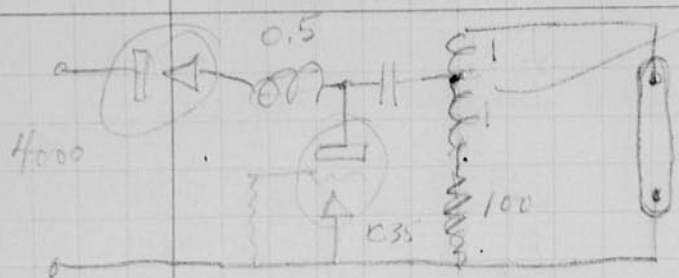
118V 60 μ I = 0.7 amperes

Sluggish Capacity = $.02 \times 10^{-6}$ farads.

freq.	Initial volts.	div up	div down	V.	operation	Remarks.
	Div.	Arm 0				
1000	3500 - 15	30	1.0	.2	3750	
2000	3500 "	28	1.0	.30	2950	
2500	3500 "	28	1.	.4	2900	
3000	3500 "	28.5	3	.450	2850	rough.
1000	4000 - 18	33	0.0	.200	3650	
2000		32	0.5 \rightarrow 0	.300	3450	
2500		31	.5	.400	3350	
3000		32	.5	.450 - 475	3250	
1000	4500 - 20	—	+x/.	.2	4100	
2000		—	+1 \rightarrow 0	.350	3850 - 3700	
2500		35 \pm	+1	.400	3800	
3000		35 \pm	+1	.5	3700	
2000	4500		+1 - 0	.370 - 390	45 ma. at zero	
2500			+1 \rightarrow 0	.46		
3000			+1.	.500+		
3000				.6	4300	Data from prior.

230
 220
 210
 205

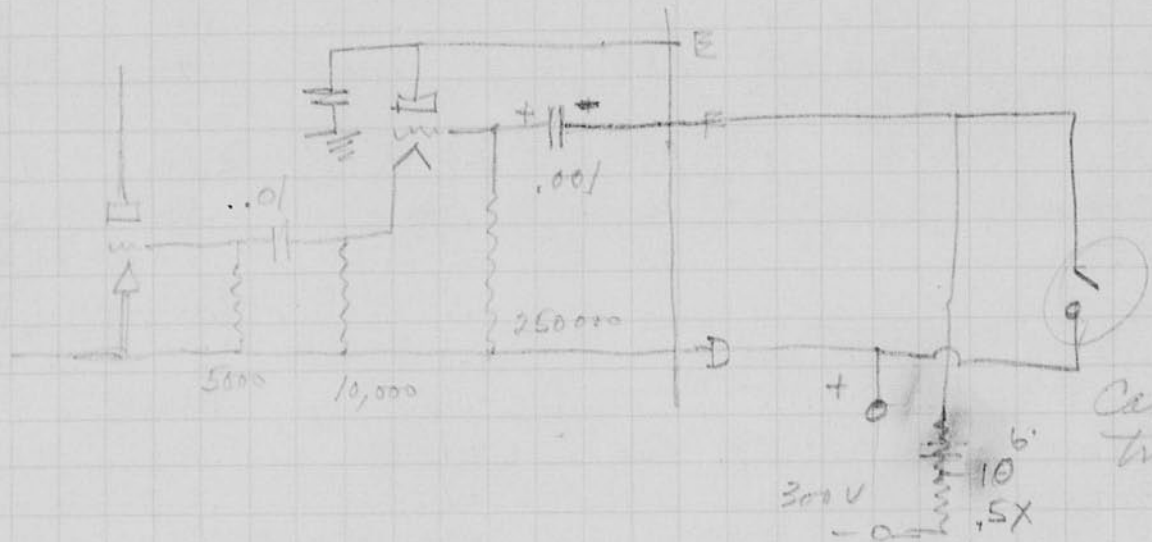
July 2, 1945
 Physics
 Electronics

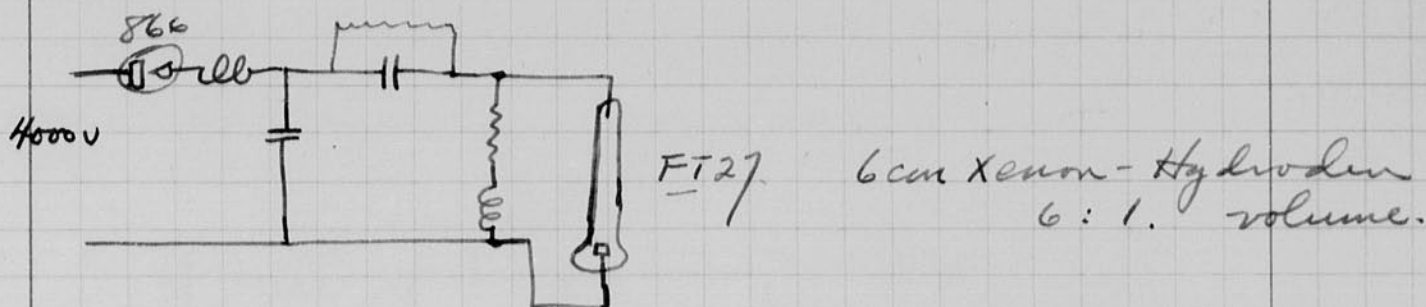


240 turns with C.T.
 1/2" square core Hypersil

Step-up transformer to
 increase voltage on lamp.

The core also will saturate.

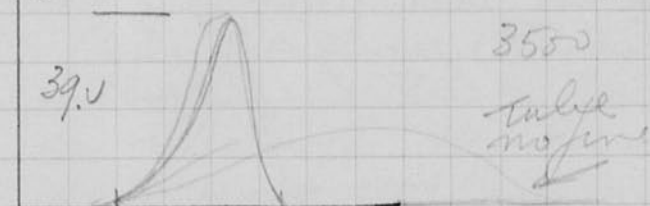




Irregular operation showed two kinds of operation. By some experimentation it was found that the arc sometimes occurred on the reverse cycle in the lamp. This explained the reason that the anode showed darkening.

Other tubes than the two FT27 that had large anodes, showed a breakdown arc after every cycle with ~~in~~ ≈ 0.2 . That is no jitter.

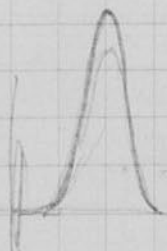
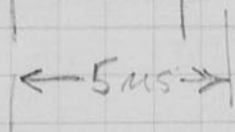
Impedance in the discharge path.



$$I = \frac{39V}{.39} = 100 \text{ amps.}$$

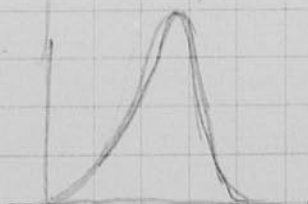
12 turns on 1/2" Hypersil core
Inductance in series with
flash lamp

$$1/5 = 5ms$$



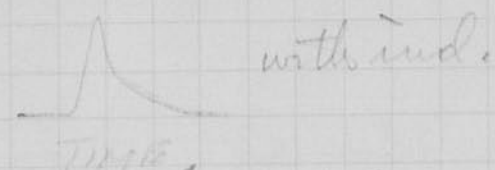
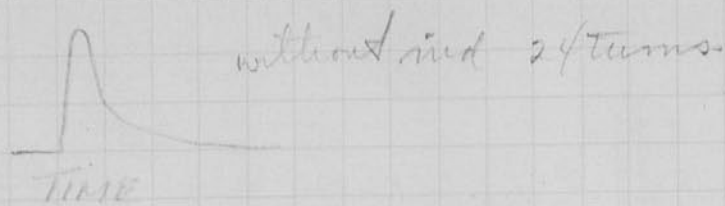
no choke

Build-up time is second
due to



24 turns on Hypersil core.

Light

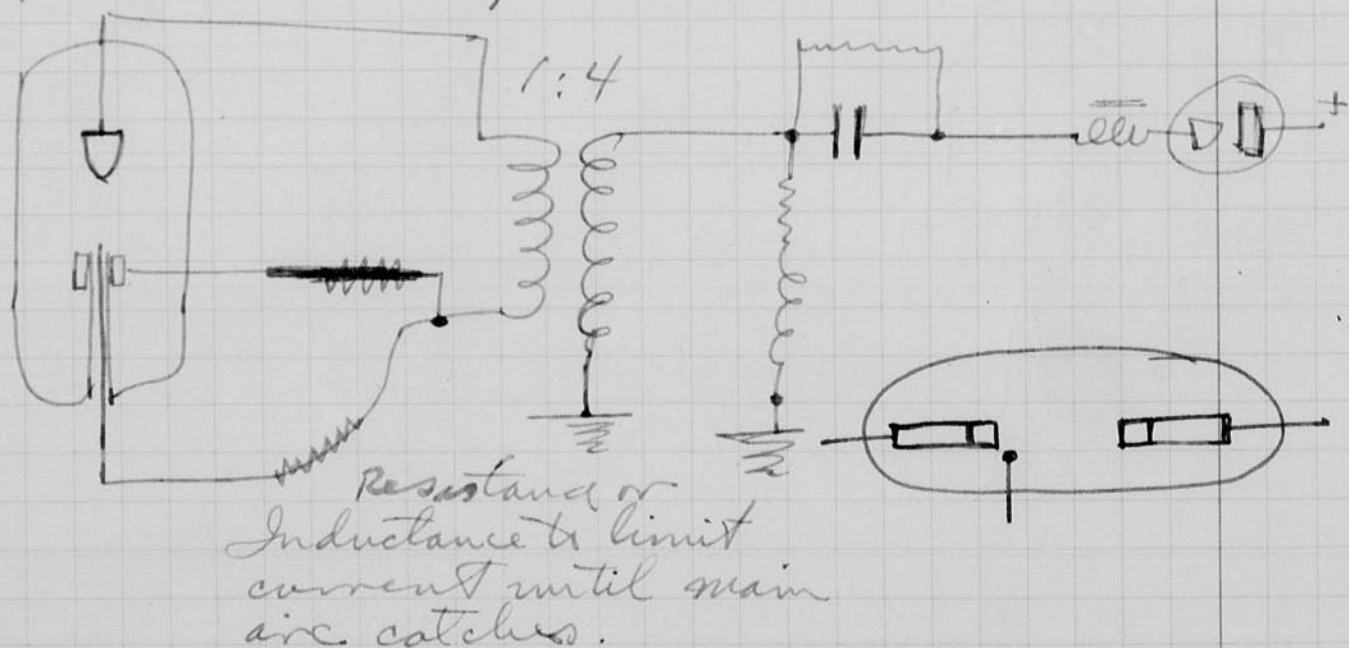


July 3, 1945 David Egan — Ken Gemmeshauser. Herb Pennington

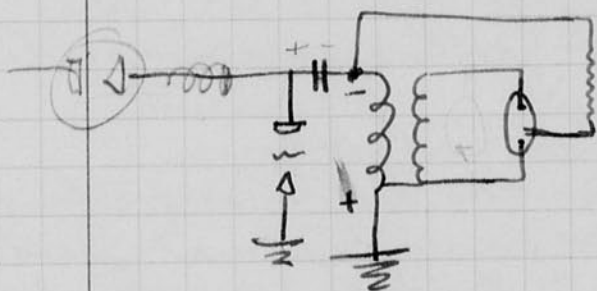
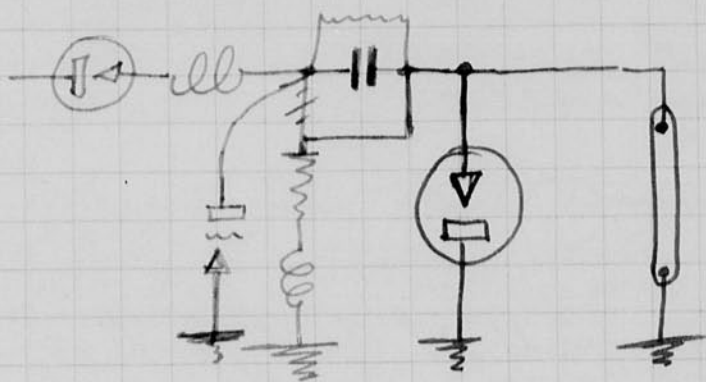
A few experiments were tried with a choke transformer 4:1 step down. Difficulty was experienced in obtaining a tube that would start at the low voltage. By the help of a sparkler it was possible to run a gap tube (argon). The first blew out several times due to holdovers.

The light from the high pressure argon gap was considerable. The oscillograph showed the same after glow as found in the Xenon lamps.

A starting electrode might be effective. One type is sketched below.



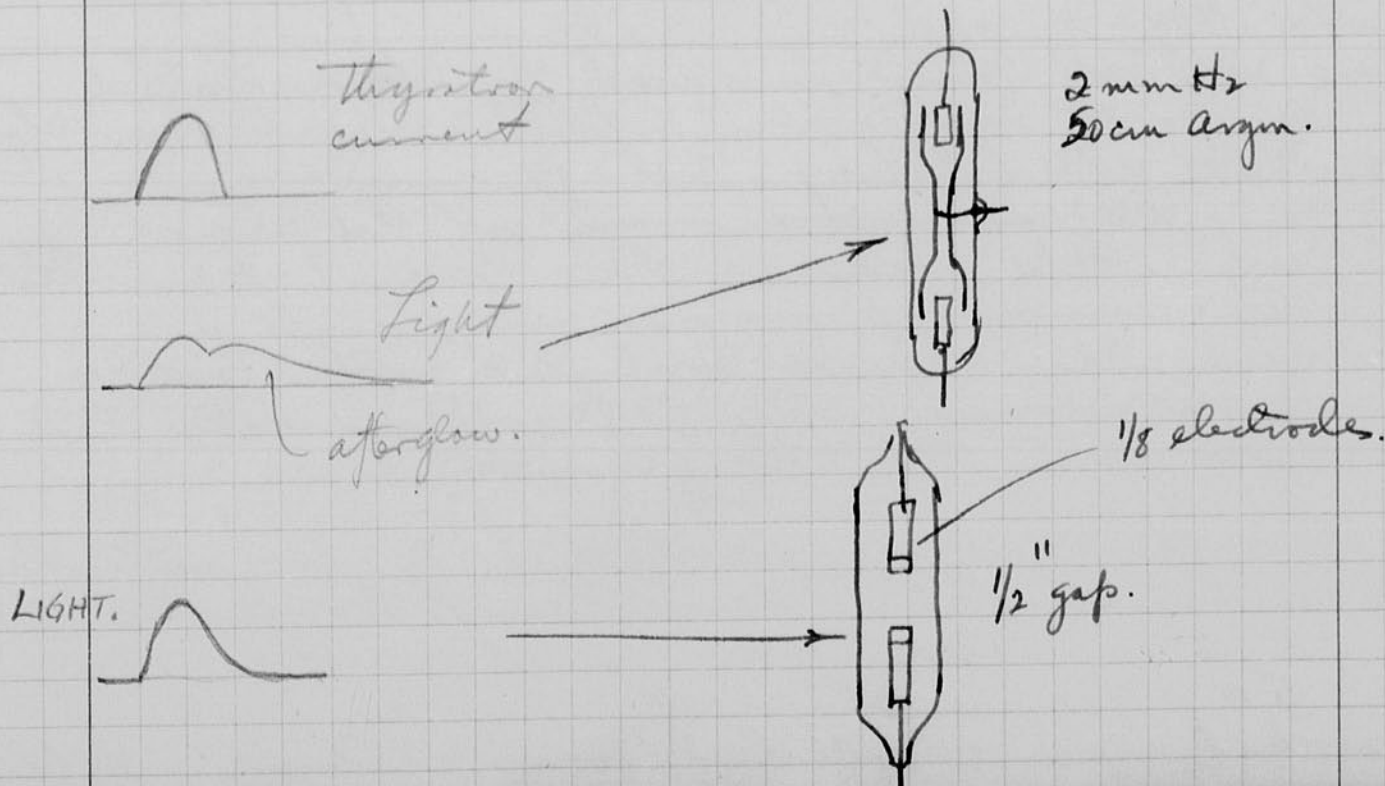
A reverse rectifier would be useful to overcome accumulation buildup of the d.c. voltage due to swinging.



Suggested by Genus for transformer test.

Chas Wyckoff helped with these tests.

Connected and tried. The tube was a FT-21 with an internal 3rd electrode as made by Wyckoff. Worked fine at 500, 1000, 2000, 3000 and 4000 cycles with 4000 volt input.



$\frac{1}{8}$ " gap tube pumped with argon at 1 atmosphere. Static test showed about 2000 volt break down when tube was degassed and gas was fresh.

Operated ok at 3500 volts with tendency to hold over at 4000 volts.

Duration ok but with some afterglow.

July 5, 1945. TBM arrived at Bedford on July 3 late. for navy N-2 project.

Family left for Nebraska yesterday.

Lt. Col. Querry called from Florida on July 1 & 2 to tell me that he would be up here on Fri. or Sat. Apparently the radar is out of commission.

July 8, 1945 The A26 576 came in on July 6 with Querry, Starnort and Mc Lendon, Davis. Conf with White, Bonner, Johnson on July 6. Querry went to Washington on July 7. The radar is being overhauled.

Took Munnis and Judkins to the airport yesterday aft to check over the TBM 744. It has a K-19 camera directly ~~over the radar~~ at the place where the rear radar man operates. The camera, magazine, and an inverter were brought in to tech for checking. The B-3 intervalometer was given to Raytheon.

Also we inspected the A26 yesterday and found the flash lamp broken due to vibration. A new FT-17A 50 was installed. This is the tube that has a welded connection at the

bottom end in place of the threaded connection. A comprehensive set of light curves were made on this tube yesterday.

July 26 1945.

I went to W.F. with Starmunt in the #26. We left July 18 stopping at Elmira overnight on the way. Had conferences in W.F. on the 8 flash units as per Kenney cable A 75697. July 11. Star had a copy of O.C.R. letter that he obtained in the pentagon bldg. on July 16 while we were both there. I also saw Bobles, Vanden Berg, Phillips, Schaur, Kennedy, Powers and others. Foster and Starmunt wrote up the O.C.R. letter, which they had to go to the MES before transmittal to W.F.

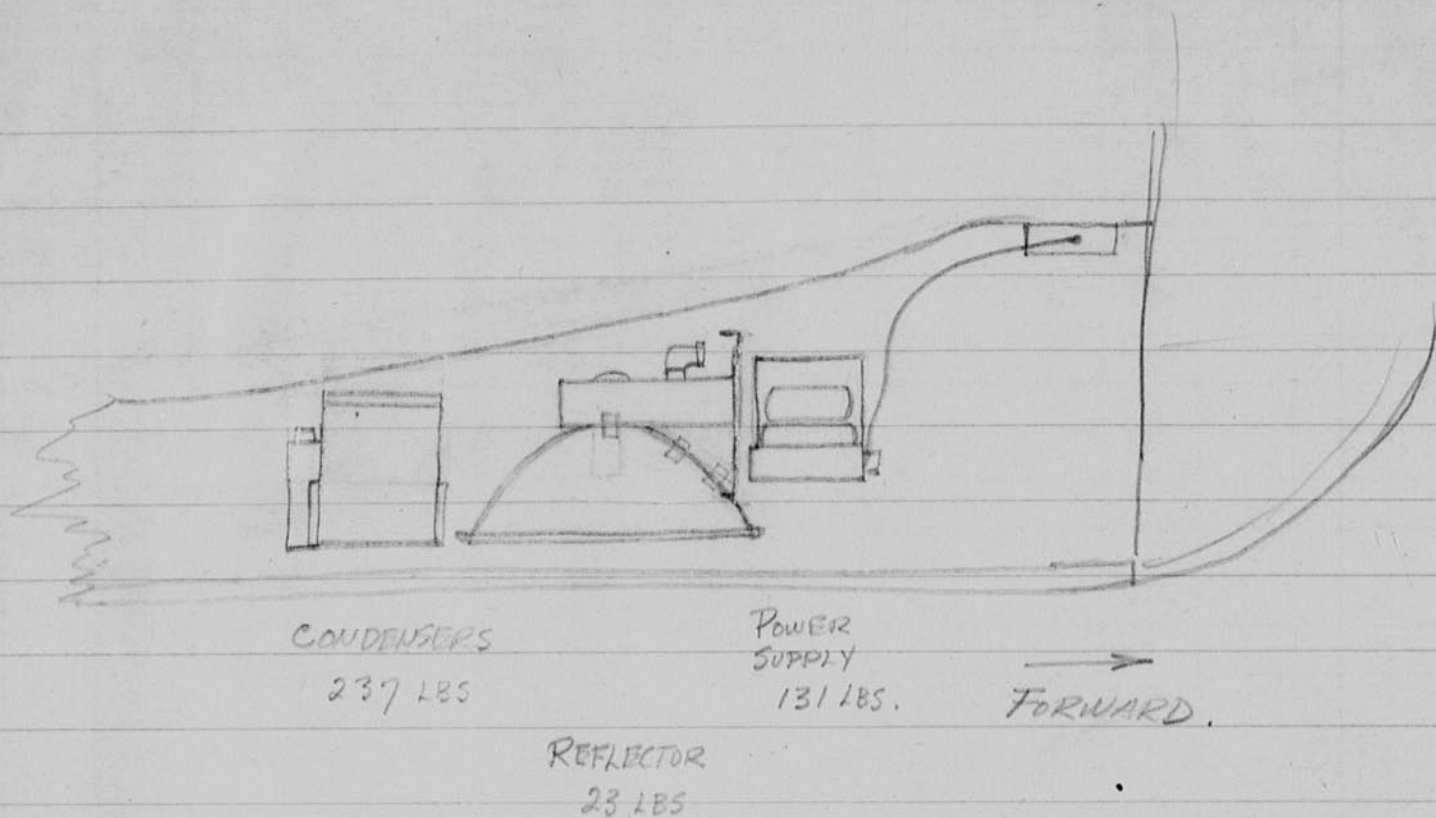
Vibration tests were made on the 426 tail reflector by McBrath and his helpers.

July 28. 1945. The Navy N-2 unit was operated in the Raytheon plane on ~~the~~ ^{Wed} July 25. Bruce Connor was there from the N.R.I. also Halpern. 1025 Commonwealth Ave
the N-2 unit was installed in the plane on July 26 and 27. The plane would have flown except for a bad scavenger line.

TBM-3E/

~~89744~~
?? 68744

July 30. Worked with Raytheon yesterday and today on the D-5 flash units. Kenyon is due here today in C47 to take these units to California.



CAMERA (60 LBS) AND
CONTROL BOX (11 LBS) IN
REAR COMPARTMENT.

12'-9" spacing
of lamp and
camera.

DIAGRAM TO SHOW
POSITION OF ELECTRIC
FLASH EQUIPMENT
TYPE N-2 IN
TBM No. 68744

JULY 26 1945
H. E. EDGERTON
M.I.T.

Notebook # 16

Filming and Separation Record

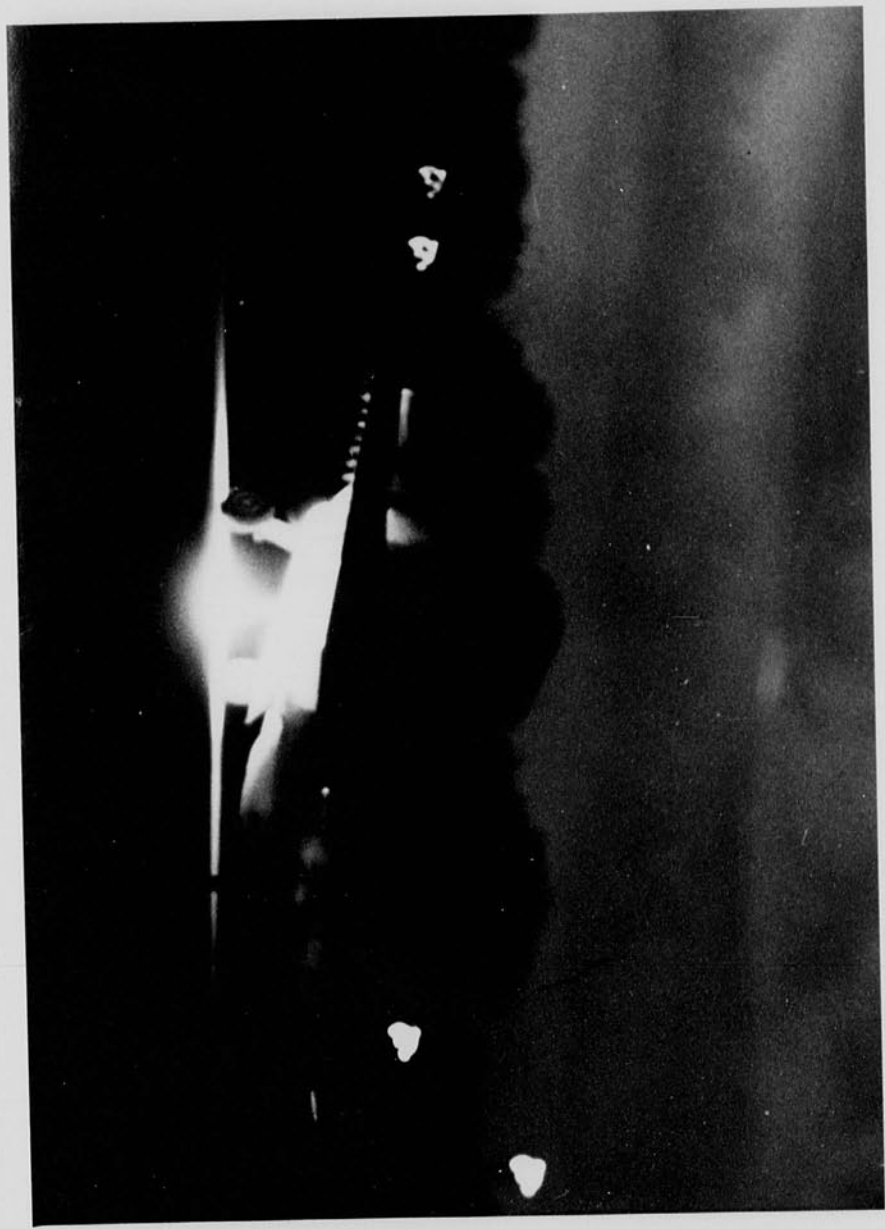
1 unmounted photograph(s)

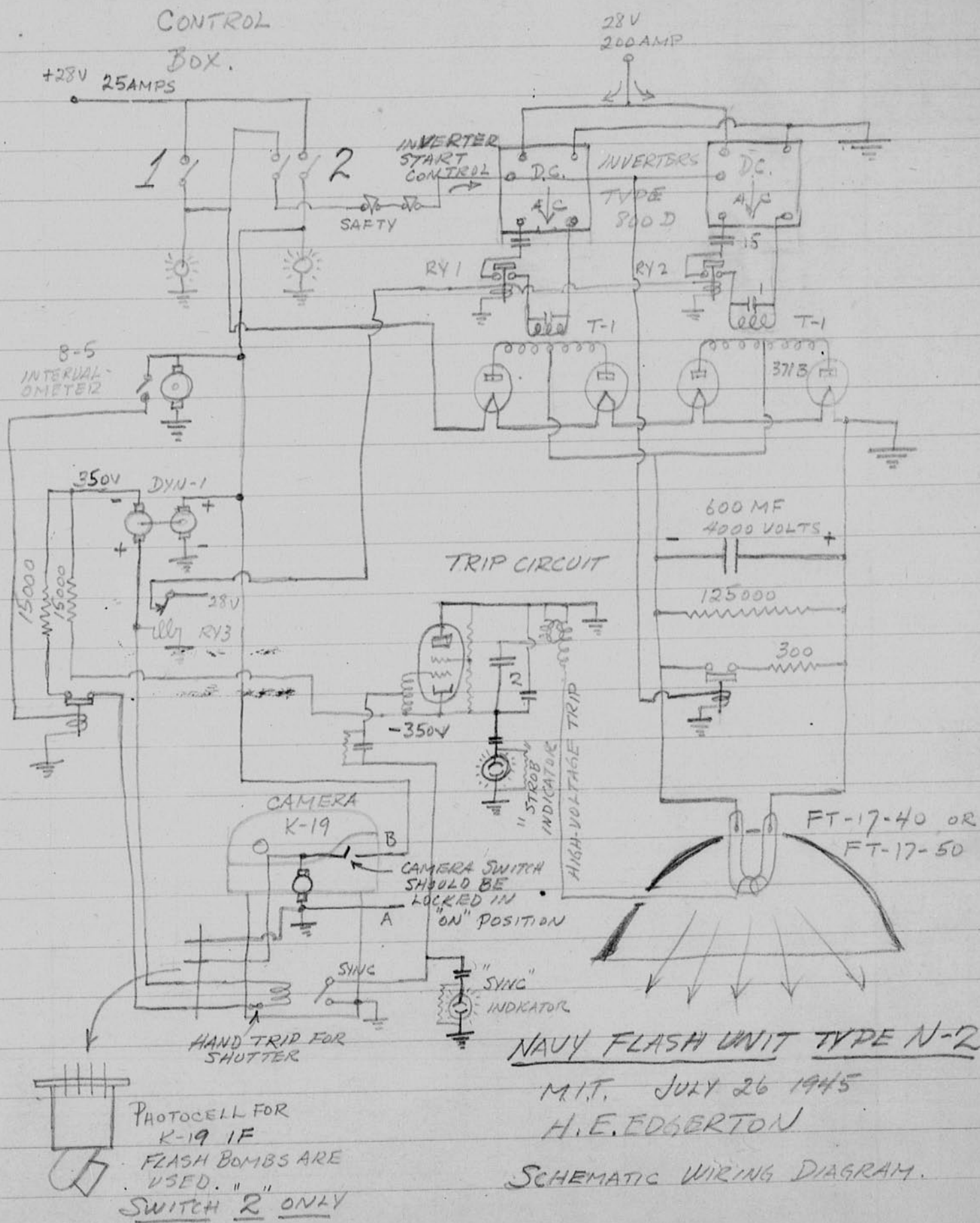
 negative strip(s)

 unmounted page(s)
(notes, drawings, letters, etc.)

was/were filmed where originally located between page 60 and 61.

Item(s) now housed in accompanying folder.





R.E. Egan M.I.T.

Aug 6 1945

The N-2 flash unit was tested on Aug. 3 out of Bedford at 500, 1000, 1500 and 2000 ft. The negs at 2 second intervals at 1000 feet were of excellent quality and had ample overlap. At $1\frac{1}{2}$ sec. intervals at 500 ft there was no overlap. The camera probably would have run at 1 second intervals but it was not tried.

The photos at 2000 ft were ok for finding autos, but were thin in the corners.

Id. A. Mattei was here on Aug 2 and 3 for the tests. Photo man Geo Heitpen has been here for a month to learn the details of the flash unit.

Kenny arrived July 31 in a C47 with Major Porter of A.F. to take the 3 flash units to Long Beach. The plane left Aug 2 in the afternoon.

The instruction book for the N-2 was finished in draft form yesterday. The same for the D-3 is being written by Barstow now.

I called Milt White (Rad. Lab.) about installing an APQ 34 in an A26 for our work. He said I could suggest this to O.C. T. The plane would then be a mock up for mine if they were desired.

Leaving tonight for Washington and then Nev., and Calif. Long Beach.

August 25, 1945.

Harold E. Edgerton

I returned from California yesterday afternoon via T.W.A., leaving ^{there} the day before. Below is a list of where I was during the trip.

Aug 7. Saw Bowler in Washington also Schauer and Mittle-Hooper, at the navy.

Aug 8 Dayton with Kenyon on D-5 in A-26 plane. Left that night for Chicago. Then on Aug 9 by Burlington to Omaha and Lincoln.

Aug 10, 11, 12 in Aurora.

Aug 13 left for Kansas city. Victory over Japs was announced about 6 o'clock. I called Schauer in Washington ~~on Aug~~ who advised proceeding to Douglas at Long Beach.

Aug 14 left K.C. with Laird, Peebles, in a C 54 for L.A. arriving on Aug 15.

Aug 16-17, 18 at Douglas were nothing was being done because of contract cancellation. Some 12000 people were fired on Aug 16 or 17.

Aug 18 Saw Knapp at C.I.T. to check over the flash unit. Shapiro postponed his next week vacation in order to work with me. I spent the 19, 20 and 21 tuning up the equipment. On the last day we took three pictures at 1000 f.p.s. of a model at 80 ft per sec.

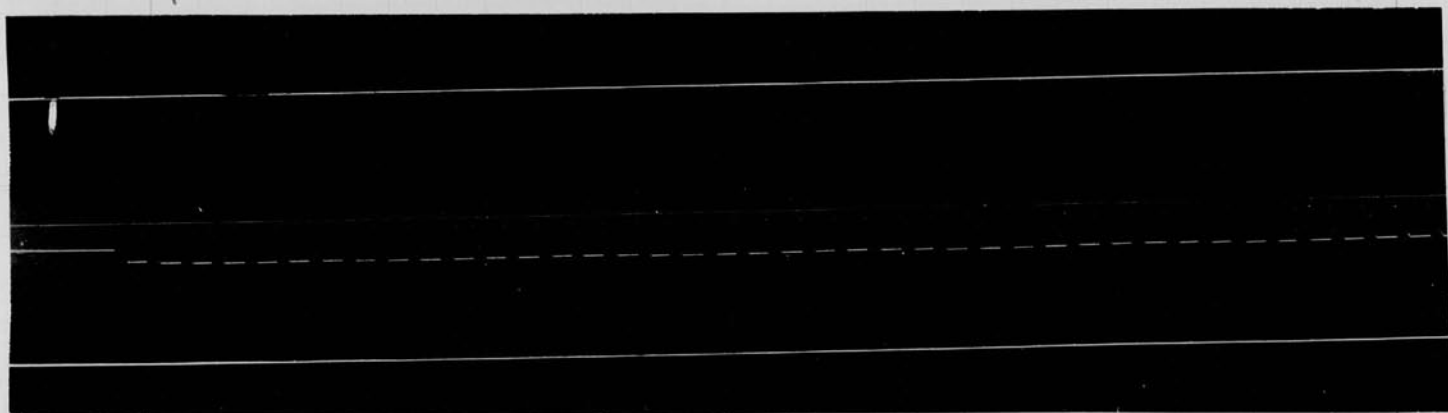
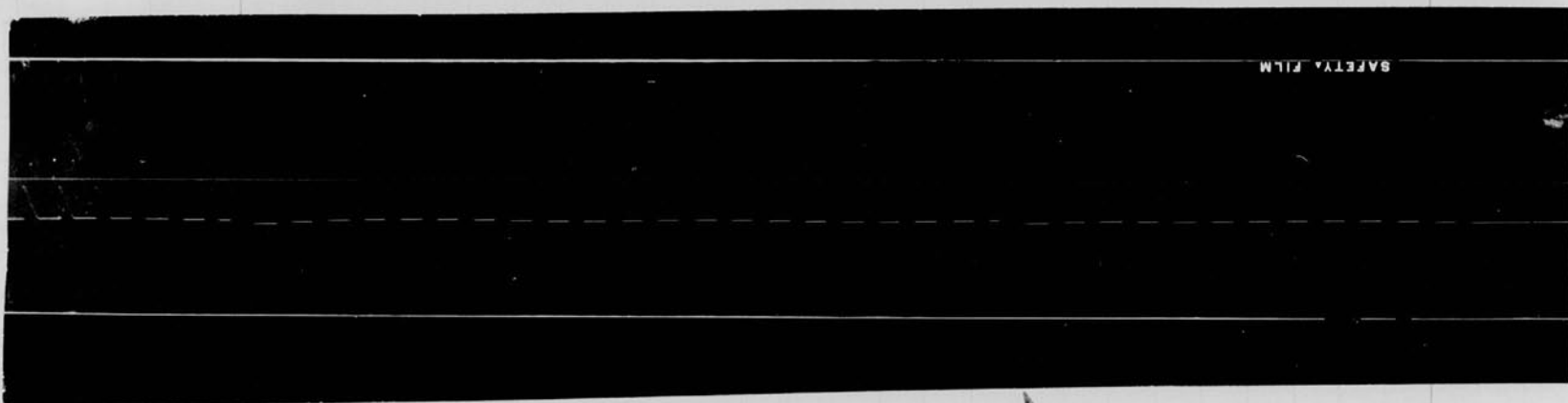
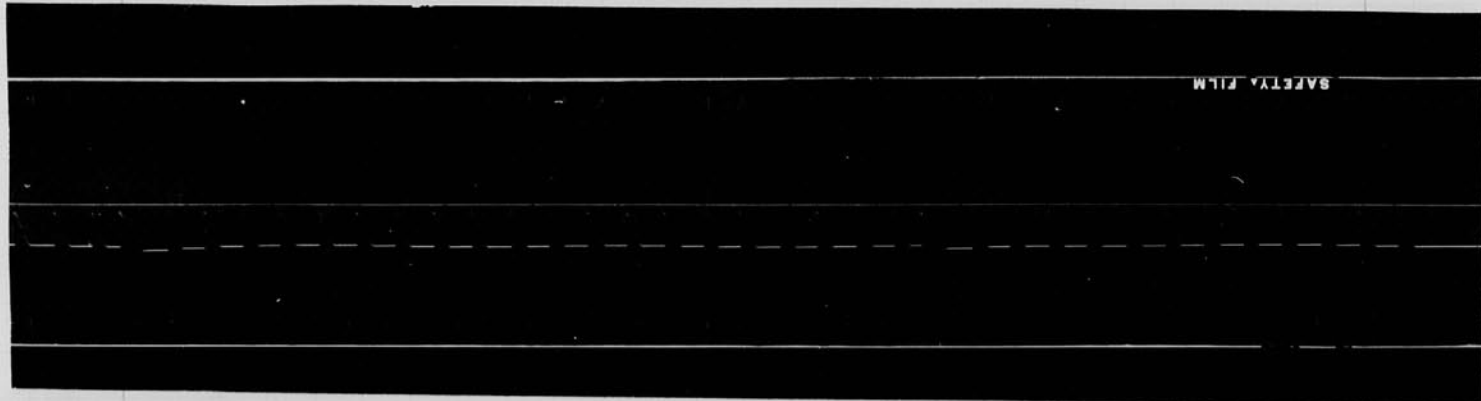
A .0005 mf condenser was put from the grid to cathode of all the movie panels. This helped prevent double flashing and fuse blowing.

There was also two shorted cables that sparked and two bleeder parallel bleeder resistors that were open.

Some of the 6J5 tubes show a glow when the thyristor starts. This is caused by energy feeding back from the grid of the thyristor. Cathode-ray oscillographs show the voltage to be greater than 500 volts.

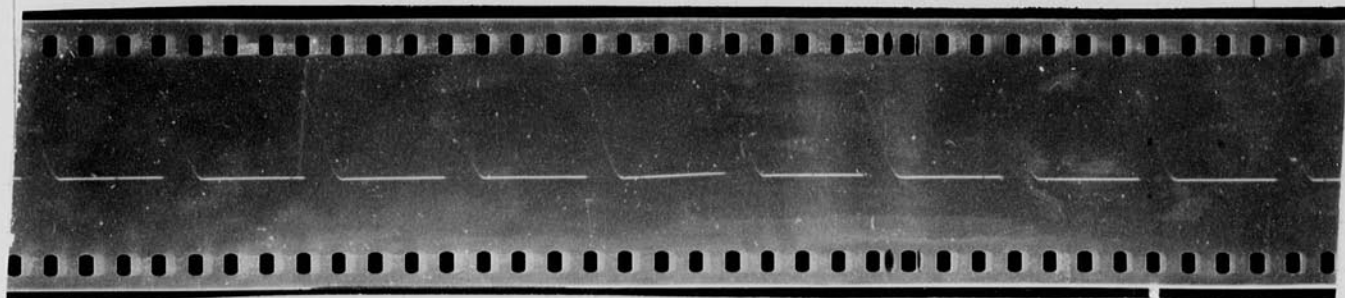
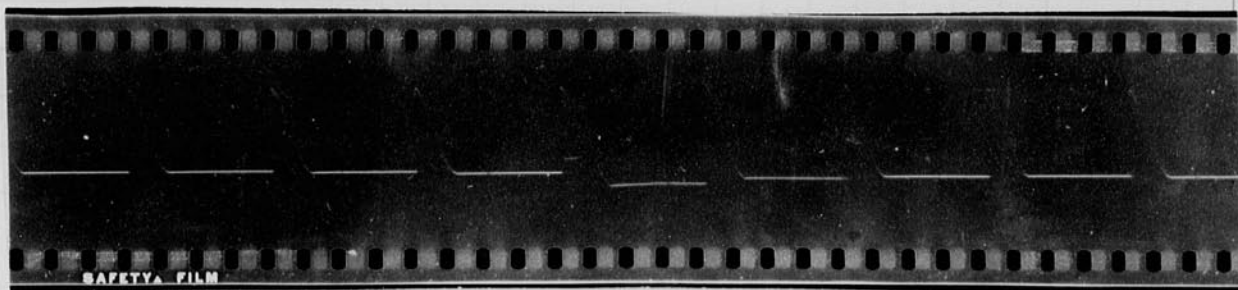
with a frequency of 10 megacycles \pm .
 Below are a few oscillograms of the
 plate voltage against σ time.

TIME \rightarrow

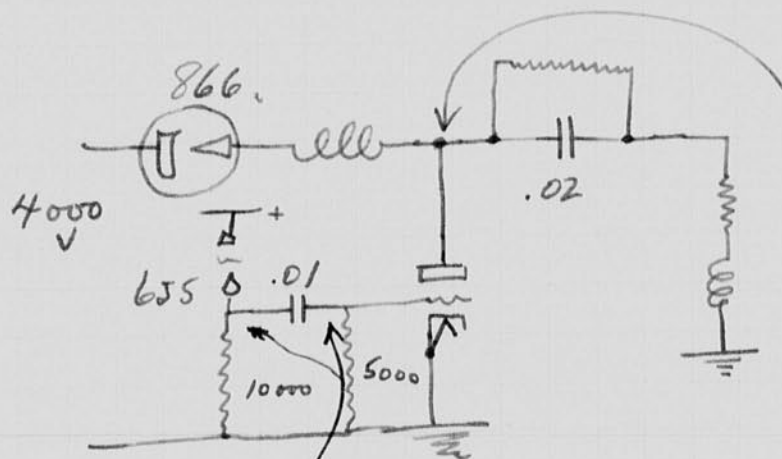


transient buildup

Double fine ↘



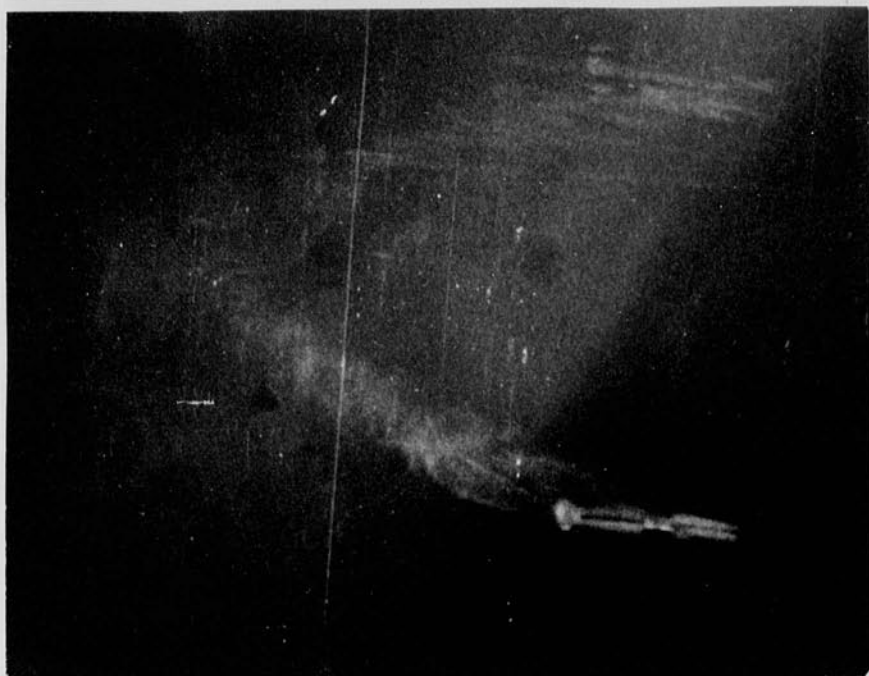
↑ note change in leakage
~~one~~ on one charge.



this voltage was
measured to
ground with a
cathode ray
oscillograph.

C.R. osc shows a violent surge
here which comes from the
thyatron. Energy is fed into the
6J5 and causes a glow to ground
from the cathode, burning out the
filament.

Aug 28.



water
surface

1000 frames per second
under water photo of
1 ft model.

30 lamps were operating
in synchronism.

24 lamps.

6.5 amps
3200V.

Troubles with movie equip

3600 - 0.4 amp.

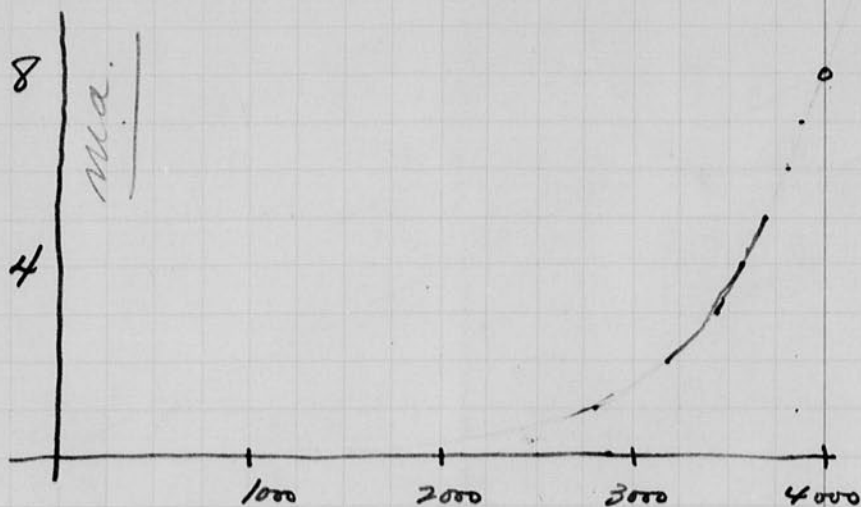
1. Amp. 655 tubes blow out cathode
Show visual glow
2. Wire on side of socket strikes
ground - lights up tungsten
filament in tube bottom,
causes slipping!!
cut wire shorter.
3. A 10005 condenser prevents
self firing on one set if connected
grid - cathode of thyatron. a
500 volt paper condenser shorted
after three bursts.
4. Condenser (main) broke down to
case? in one set.
5. Faulty 866 rectifier tube.
6. Shorted cable, causes fuses to blow.
7. 700 ohm resistors changed to 5000.
8. open 100 ohm resistor causes fuse to blow

A string of 40 60 watt lamps was put across
the 4000 volt supply as a bleeder.

Aug 28 1945
James Edgerton.

Test of Thyrite

V volts.	I ma
2800	1
3150	2
3400	3
3580	4
3720	5
3830	6
3920	7
4000	8



3 Thyrite discs cat 388038 in series.
3" diam 3/4" thick 1 3/8" hole.

10° rise of temp in 1 minute with
sawtooth voltage.

Rated: 5-17 ma 4000 V DC at 20-30 °C.

Aug 29, 1945.

Yesterday Grier and Barstow went to visit the Sprague co. at North Adams concerning condensers for the Kodatron and the portable. It seems that 4000 volts is the best level to operate the condensers.

A long discussion on Aug 27 was held on the portable, the Kodatron and other items with the above men, Gerneshansen and myself. Some conclusions were:

1 Portable - use conventional 3 element lamp at present instead of proposed new two element lamp. Cut down weight, eliminate charger

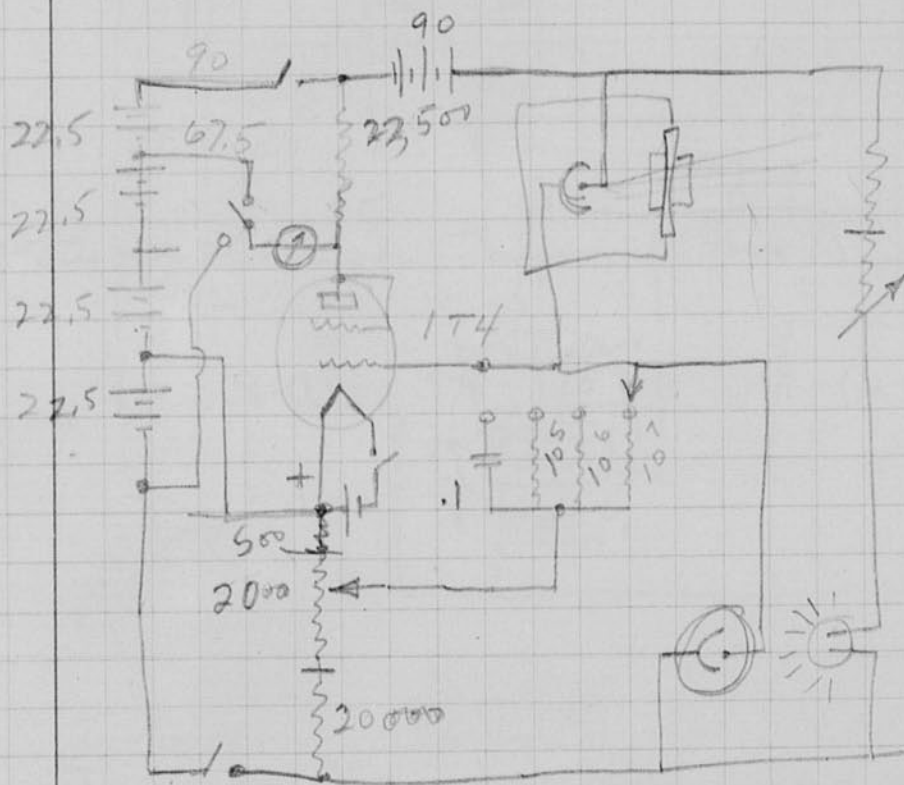
Aug 31 1945. Took Wm Bob and Mary Lou fishing in the Sebago river near Wayland yesterday. We caught enough for supper.

Sept 5 1945
 Harold Edgerton.

Tried G.R. model exposure meter on Sept 3 and 5. with Sinclair, it did not work so good today. 10-amp grid current + must flow to explain the drift. 1D-5 and 1D-8 tubes are used.

Another suggested circuit as of Aug 25, 1942 except with Nottingham's compensation scheme.

$$\frac{45}{15 \times 10^{-5}} = 30 \times 10^5 \quad \frac{1.0}{0.8 \text{ min}}$$



$$\frac{22.5}{R} = .0015$$

$$R = \frac{22.5}{.001} = 22,500 \text{ ohms}$$

- 1T4 $S_m = 750.$
- 3A3 $S_m = 1800.$
- 3A3 $S_m = 625$
- 155 $S_m = 1025$
- 1L4 $\mu = 14.$
- 1E46 $\mu = 8.$
- 1646

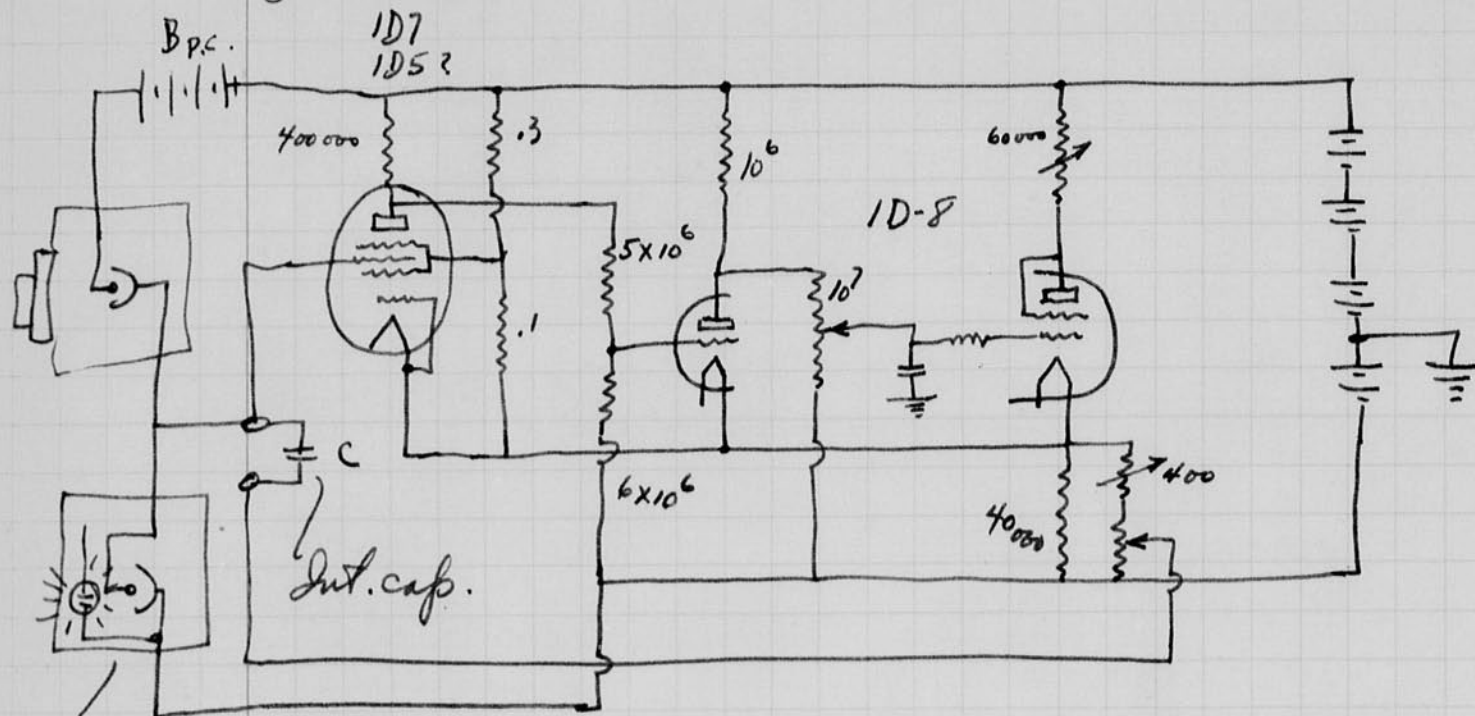
In the GR amp
 the overall $S_m = \frac{.0002 \text{ amp}}{0.1 \text{ volts}} = 2000 \mu \text{ mhos.}$

Don't
 trouble

Sept 8 1945 MIT
 J. E. Edgerton

Exp. meter circuit.

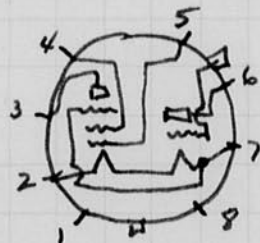
Circuit as wired by Powers of B.R. and
 Sinclair



Compensating lamp on 1.5 volt circuit. Incandescent.



1D7G.



1D-8.

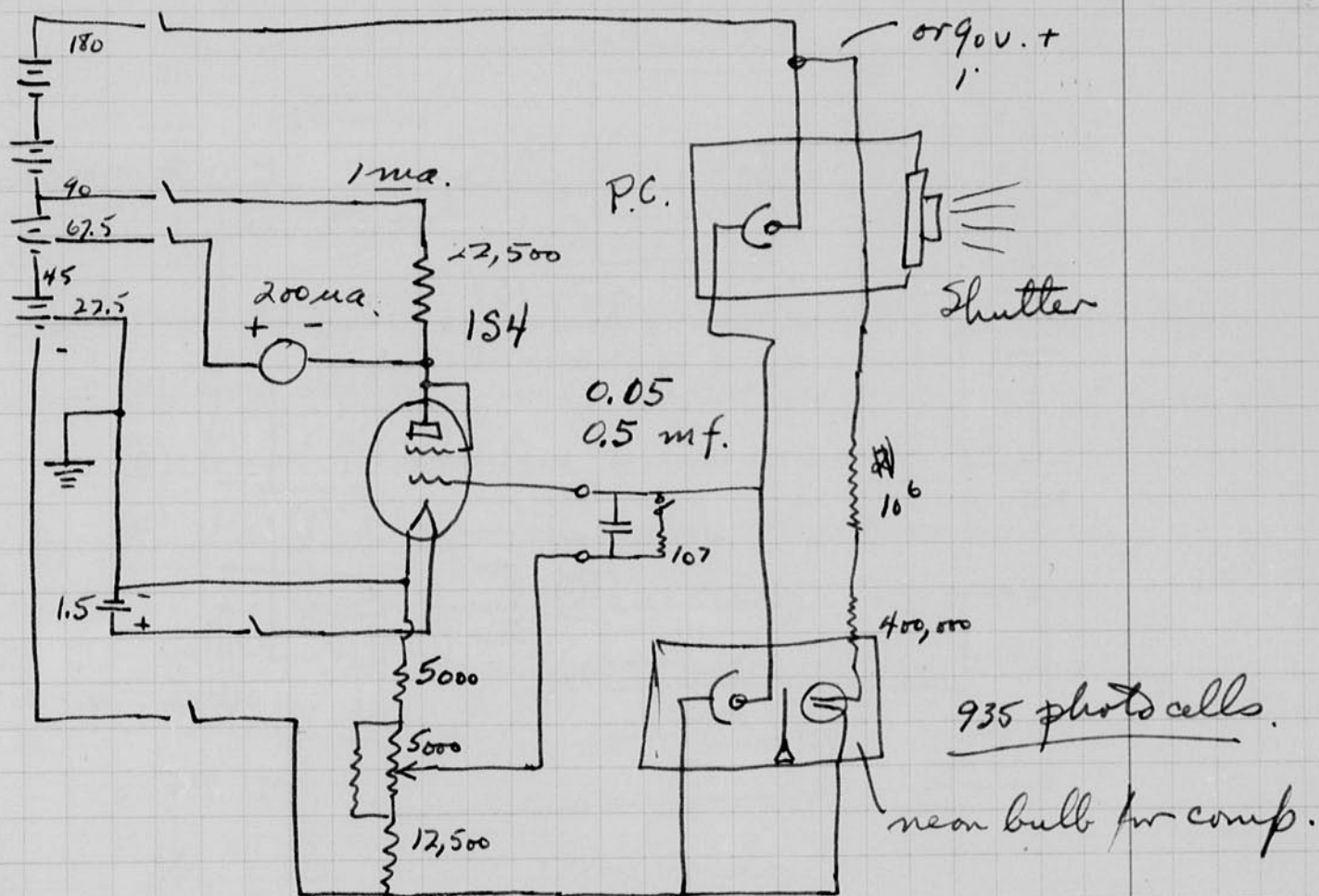
The B.P.C. battery was varied from 0 to 90 volts when tested with the microflash.

The equipment was not linear for these short flashes.

An integrating capacity of 10^{-5} amp was used for experimentation. One test showed leakage of 10^{-8} amperes. There was not sufficient compensation to correct it. The current evidently was in the grid circuit, since it persisted when all other wires and connections were eliminated. It could

also have been in the condenser.

On the 6th I wired up the following



Tube grid currents = +48 and +75 units

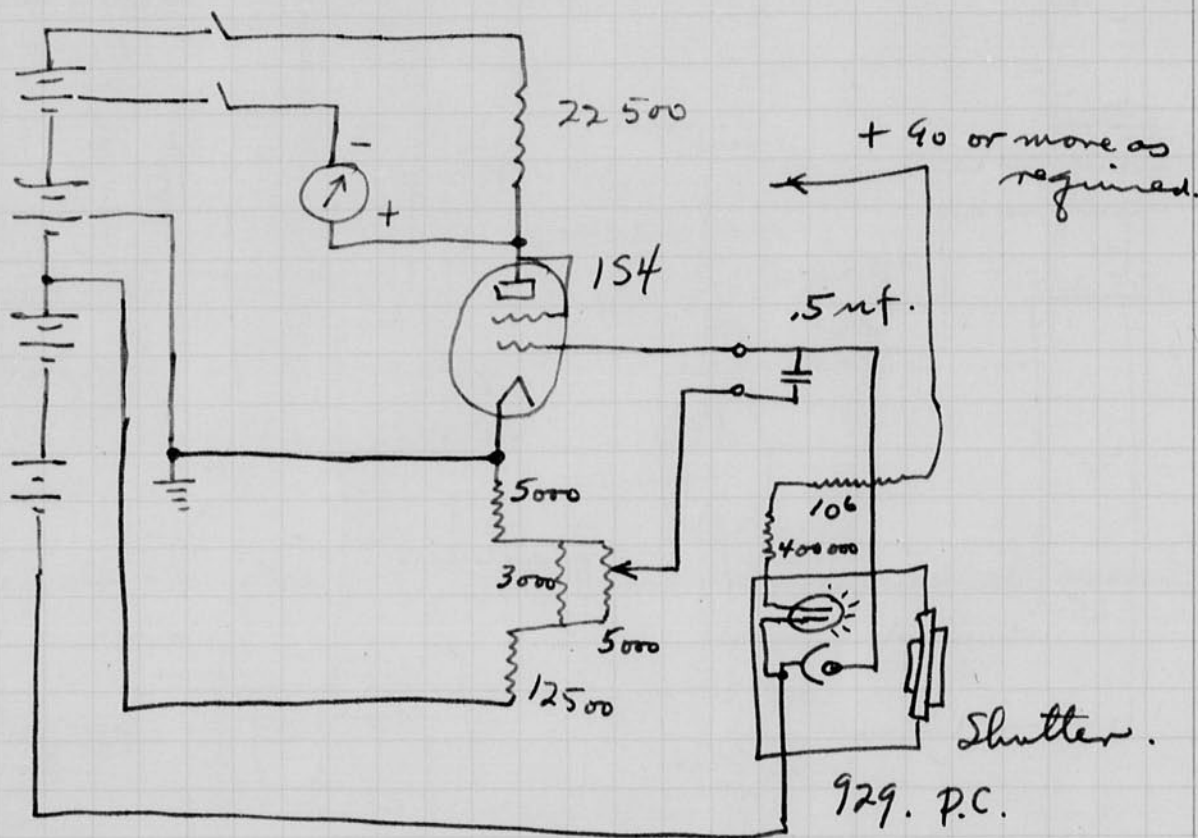
P.C. (upper) leakage = +35 units.

P.C. lower comp. ± 60 units.

One p.c. had a large leakage.

Note that the grid current and P.C. leakage add. Therefore the compensation must allow for the sum!

The circuit was changed to the following in order to let the grid current and the p.c. leakage current tend to cancel each other.



compensation only adds to the leakage of the photo electric cell current. therefore the triode must have ample grid current.

Conf with Boone.

Sept 8, 1945.

Studio 6 months.

two lights in port out.

Possible double outlet on old unit.

External -

Condensers better safety factor.
Less light. $5/8$ to $7/8$

Item 3 Variable capacity. not important

(a) Two buttons with different capacity.

(b) Double bottom with connectors

(c) Plug in variety with short circuiting relay and discharge resistor.

1. Photographer can change at will

2. Modify unit with addition.

3. Purchase different units..

Will do - 1. New condenser..

2. Double connection..

3. more caps. ✓

4. new Lamp. ✓

E.K. will do 4, 5, 6, of spec.

Portable - 1. covering angle (50°).

2. Rate of charging. 6-8 sec.

3. Reduce to minimum weight.

4. 50-75 flashes. 10^{-4} sec. flash.

5. Possible lack of plug. Case for camera and lamp.

✓ ans from
E.K.

Sept. 13, 1945.
David Ely

Transformer data from Raytheon.

Open cir.	I	0.1	.2	.25	.35	.4	.5
	V.	3.6	7.1	9	.98	.9	.96
							11.

Ratio with E.S. wattmeter

$$V_{\text{prim}} = 8 \text{ volts.}$$

$$V_{\text{sec.}} = 2700 \text{ volts.}$$

Short circuit test I 0.5 .2 $\gamma = \frac{2.8}{.2} = 140 \Omega$
E 4.8 2.8

Note large impedance of transformer.

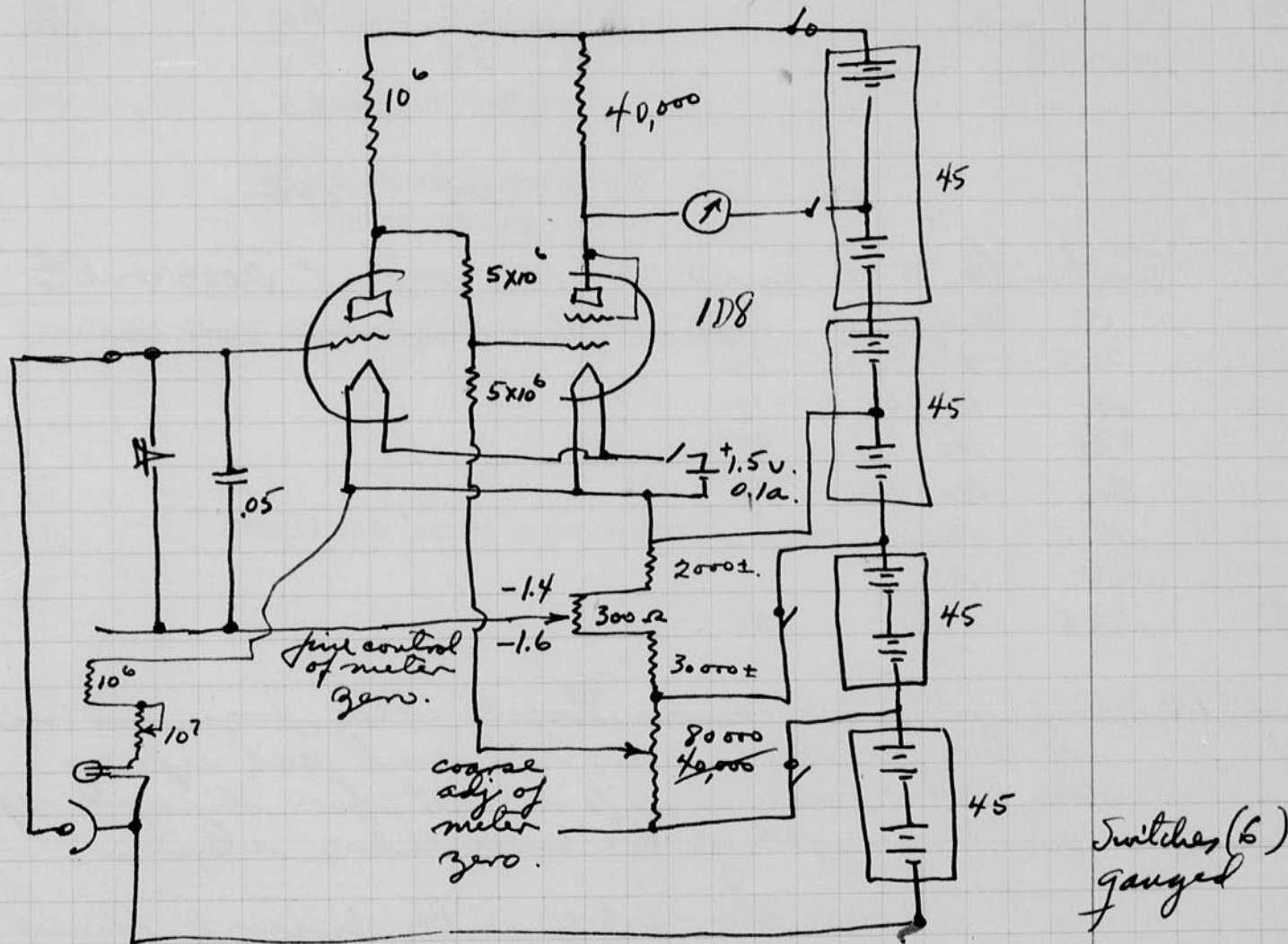
Conclusions from Barstow. study of lamps at different pressures, length and diam. at 28 mf, 2000 energy level. For same light. as present portable.

			Xe.	I.D.
12" glass	4000 V	4.6 mf.	20cm	
6" Quartz	4000 V	4.15	30+ cm	
4" Quartz	2000 V	16.5	30++	
5" Quartz	3000 V	7.35	30++.	
2" Quartz	1000 V	66	30+++	
	or less.			

Portable #15 12" Glass. 2000 28. 7 3.5

Sept 17 1945 MIT
 Harold S. Edgerton

much time was spent last week with
 D.R. co. on the photo cell exposure meter.
 I ended up with a two tube (1D8) circuit which
 is shown below. The input for a
 full scale 200 ma deflection is 0.1 volt.
 Grid current initially was 5×10^{-10} amps
 and it is now about 10^{-11} . Apparently the
 grid current decreases as the tube ages.
 Nottingham's circuit requires 0.4 volts for
 100 ma on the meter.



Dean Powers of D.R. is working on the circuit
 shown on page 70. This has degeneration and
 10^{-12} amps grid current.

cont.

Tests were made with circuit of page ⁷⁵
76 with the D.R. micro flash. Int. Cap = .05

Voltage on # Photo cell 935	45	90	135
Readings of exposure meter	43	55	63
	45	75	58
	43	73	58
0.1 mfas filter with	43	55	62
0.1 meg in series.	50	55	60
		55	73
			65.
	88	125	140.

Test with #14 lamp at 10.5 mf at 2000 volts.

V.	Reading	Cap = .05?
22.5	115	64
45	137-140	77
67.5	180	98
90	190-192	110
115.5	192	113.
135	192	
157.5	194	114

Sept 20, 1945. I was at Amer. Bosch with Ivan Eastman
of D.R. yesterday to install and set up a
1500 f.p.s. movie equipment for diesel spray
photography. We took three shots.

#1 Silhouette f 5.6 with paper diffuser
Sound recording film

#2 " f 4. " " " " " " " " " " " "

#3 backlighted - negative f 1.9.

P.G. Burman - engineer in charge.

Sept 20.

Light Combarator

77

Notebook # 16

Filming and Separation Record

___ unmounted photograph(s)

___ negative strip(s)

2 unmounted page(s)
(notes, drawings, letters, etc.)

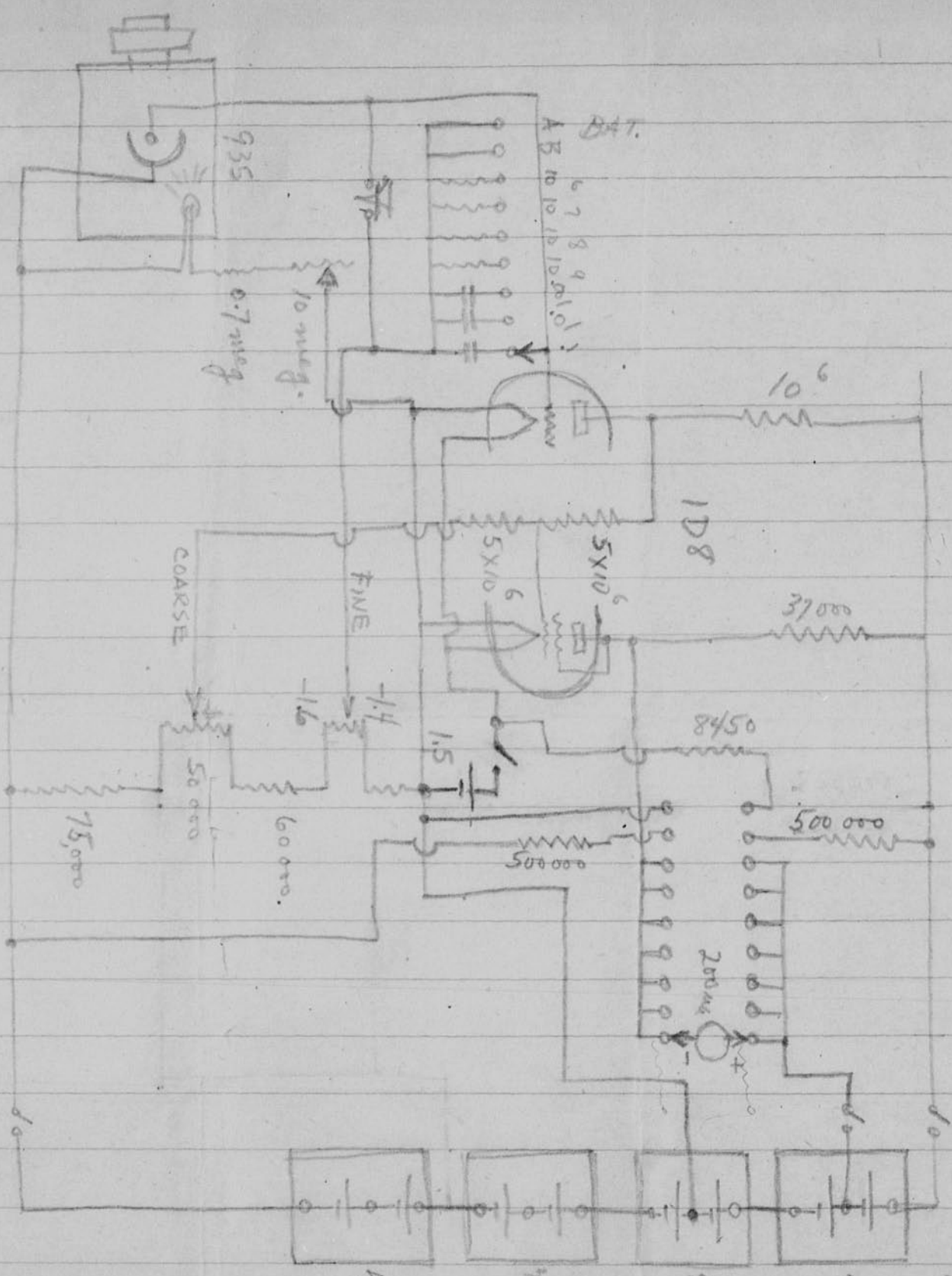
was/were filmed where originally located between page 76 and 77.

Item(s) now housed in accompanying folder.

18
76

e

ts



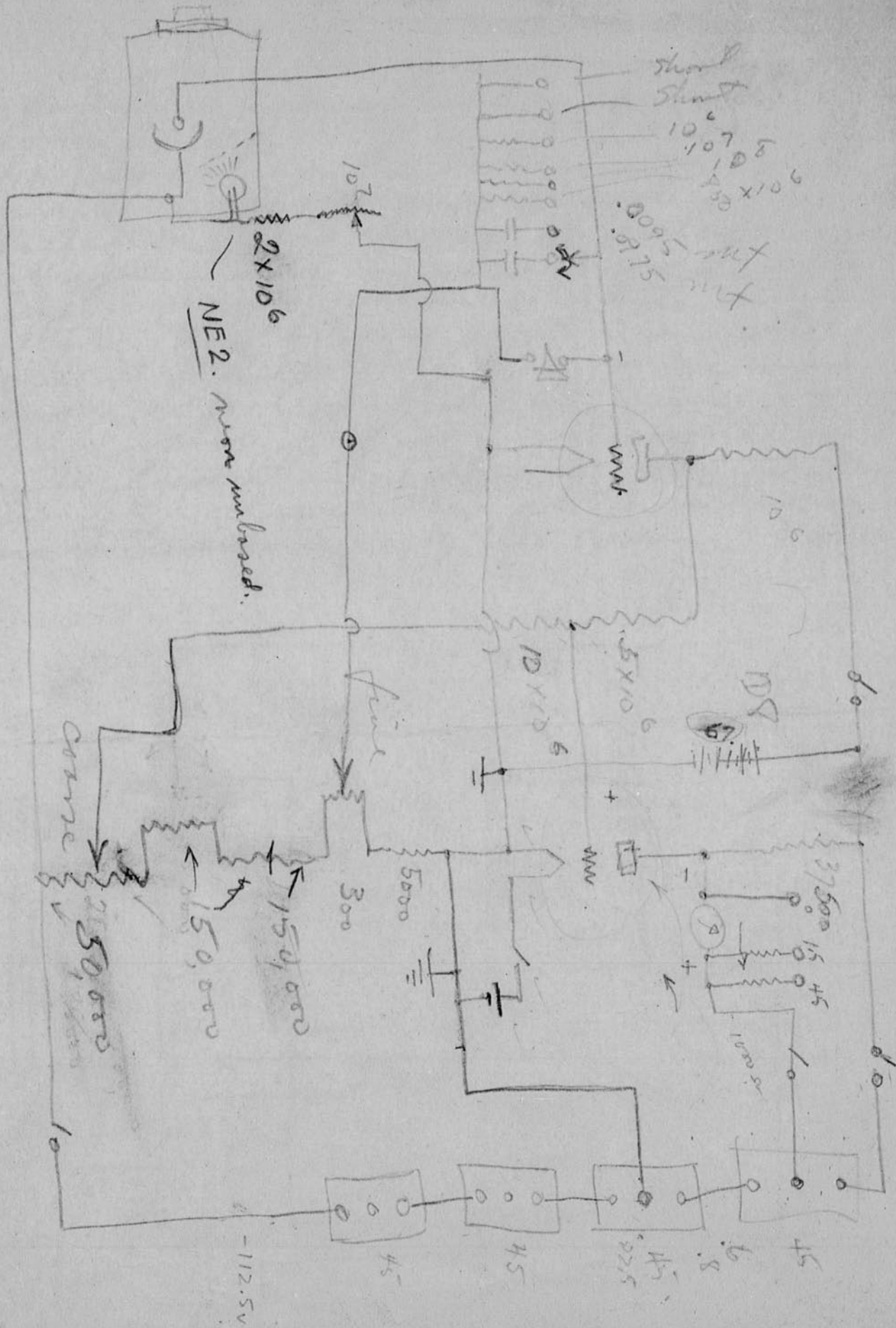
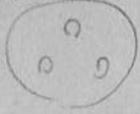
Sept 17 1945
 RAS Ely

150 ma at
 end point
 of battery

7

Sept 20.

Light Comparator



Handwritten notes on the right margin.

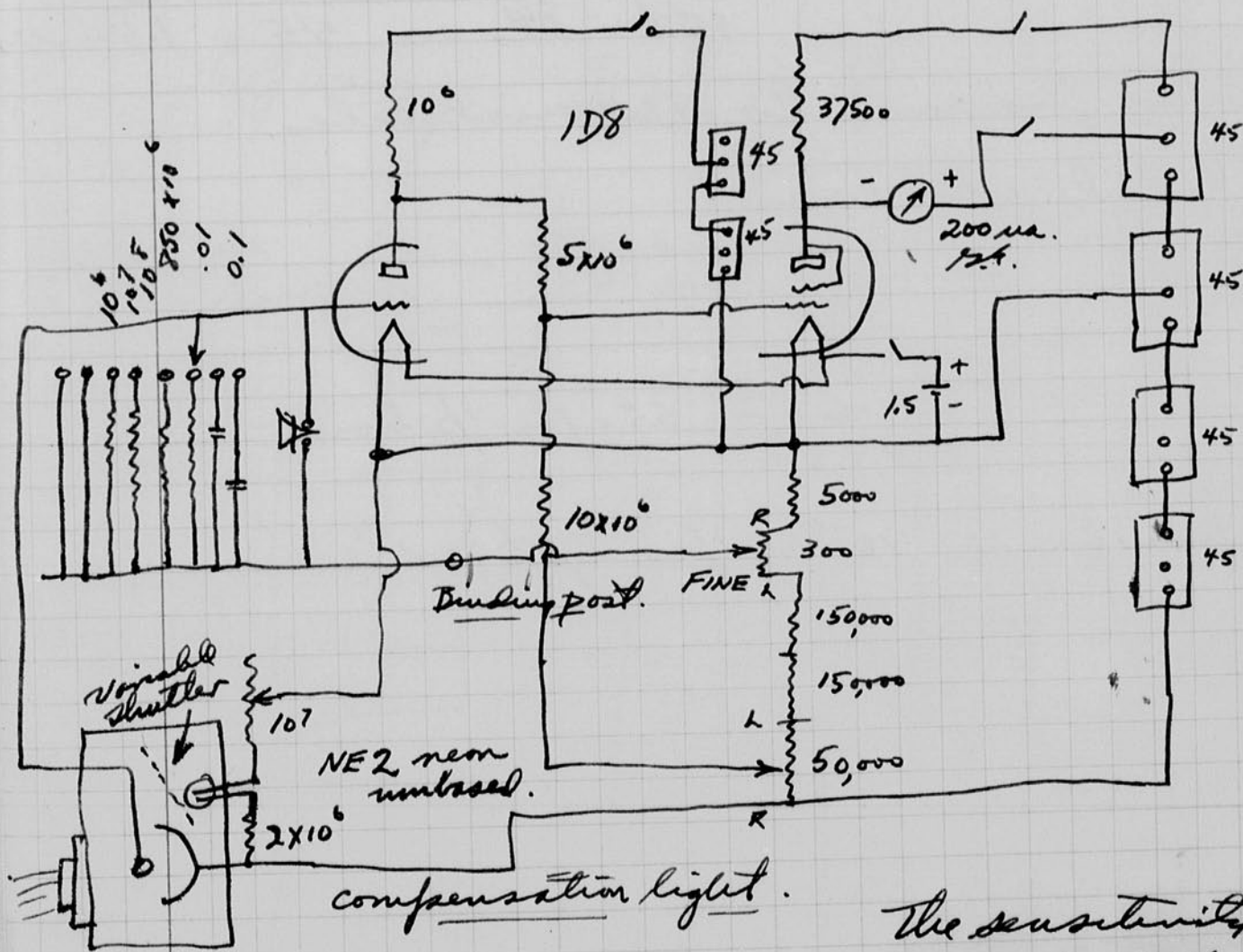
Handwritten notes on the right margin.

Handwritten notes at the bottom right.

Handwritten mark at the bottom right corner.

Light Comparator

The ~~drift~~ drift of the zero after resetting from a deflection was noticed in both the circuit of page 75 and in the circuit of Powers. Apparently the current in the battery or the plate of the output pentode changes when the meter deflects. This change of voltage is coupled into the input grid. After the instrument returns to its initial state the battery continues with the old stable voltage for 10 seconds or more before finding its new value. Powers put in a separate battery on the triode. This almost eliminated the trouble. I installed a 67.5 battery in my unit to accomplish the same result.



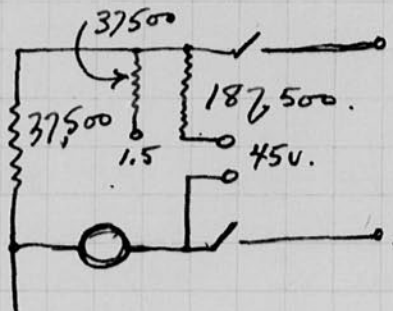
The sensitivity of the device is .06 to 0.97 volts for 200 microamp output.

935

Cont.

H. B. Dyer

There should be some method of checking the batteries of the comparator. One method would be to bring out the leads of the meter and a resistor so that it could be used to measure voltage. For example:



$$\frac{45V}{.200 \times 10^{-3} \text{ amp}} = 225,000 \text{ ohms.}$$

$$\frac{225,000}{37,500} = 6$$

$$\frac{1.5}{.2 \times 10^{-3}} = 75,000$$

This gives full scale with 45 volts or 45 or 1.5 volts.

These are grid currents of several tubes.

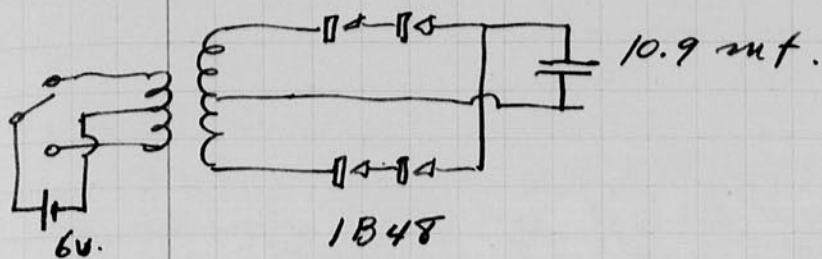
Initial after 1 min.

-5	-2	
-4	-1.5	
-3	-1.5	
-10	-6	- 5.5 after 1/2 hour.
-3	-1.5	

1 division = 10^{-10} amperes approx.

cont.

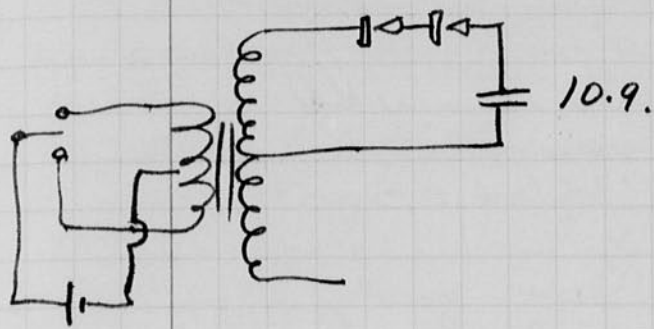
Portable power supply test of Sept 18 with McRobert



amps meter. \rightarrow 0.8 amp.
 $2\frac{1}{2}$ sec. to 2000 volts.
 final 2200 volts.

Half wave with half the transformer

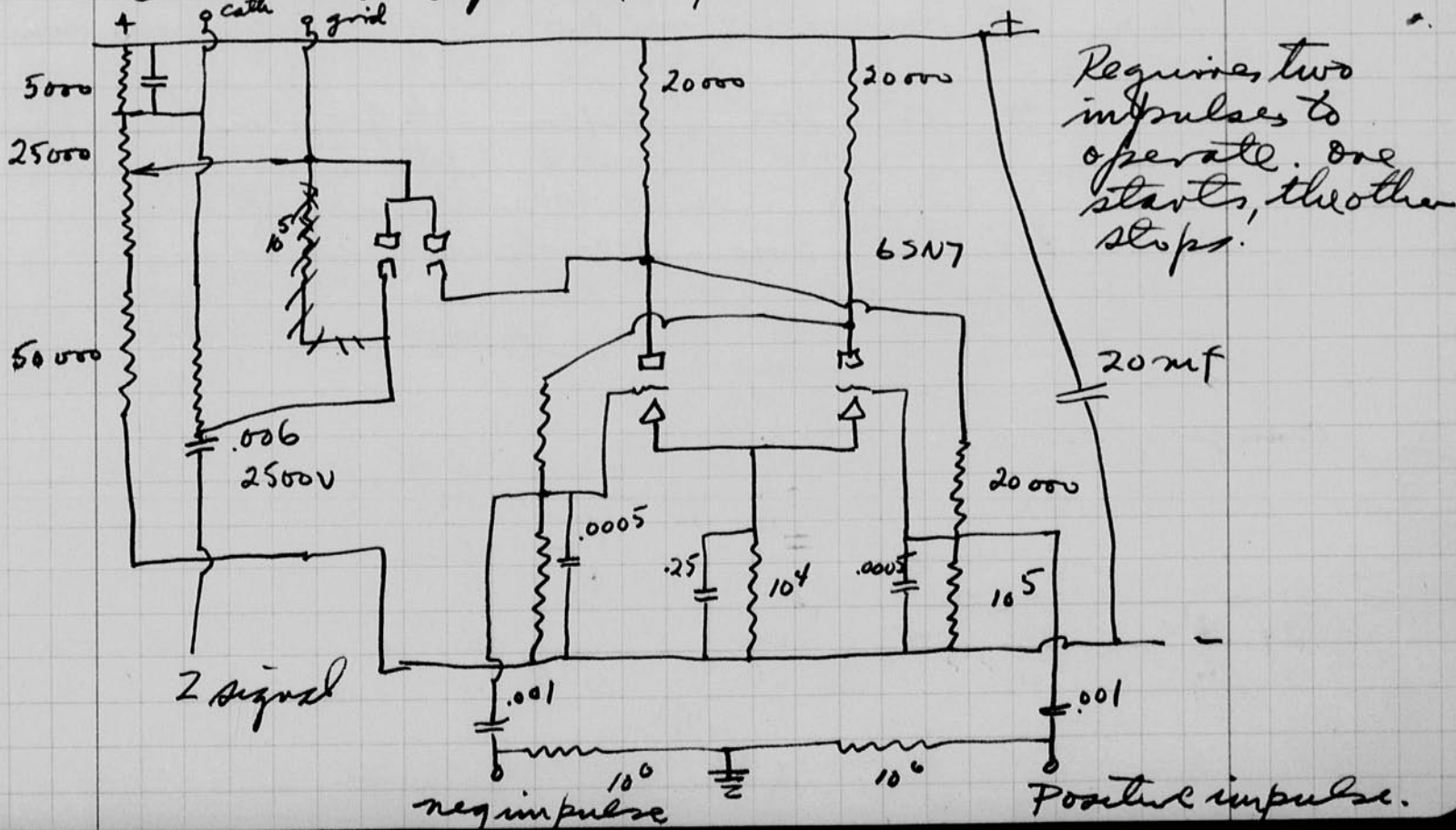
$3\frac{1}{2}$ seconds charging time.
 2 glow tubes used.



$7\frac{1}{2}$ amps \rightarrow 0.65 amp.
 final volts 2200 volts.

Half wave - entire transformer gives 4500 volts.
 4 glow tubes.

Sept 24 1945 Beam Blanking Circuit - Richter allis chalmers.
 Electronics. Sept. 1944. p130



Requires two impulses to operate. One starts, the other stops.

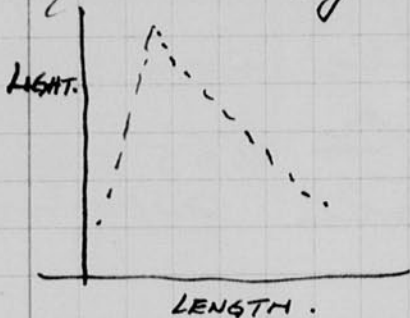
neg impulse

Positive impulse.

Sept. 24, 1945 MIT

David S. Edgerton.

Barstow and McRoberts have been experimenting with flash tubes the past few weeks. The last results were directed to low voltage, 500 or 1000. At 1000 volts a 2" tube of the 4 mm diam. of quartz showed a decided peak. The pressure of xenon in this series of tubes was about 50 cm.

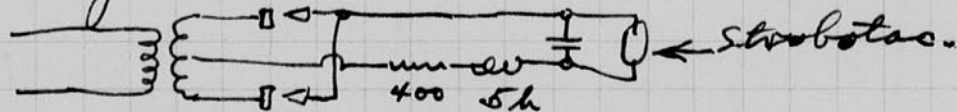


Each tube was tested for light output vs pressure. The curves showed a broad maxima of light at 30 to 60 cm of Xenon.

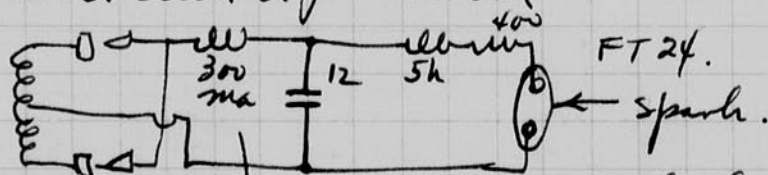
Tests were started today on 48 cycle lamps for use as a movie source.

Tube no.	R	C	V	Comments.
# 24	4 1/2 turn	400	2	2880 fpm = 48 cycles. holdover and misses
"	"	"	"	ok = with 5h in series. * Blower ^{50V}
"	2 1/2 "	"	"	H.O. " " 46. "
"	3 1/2 "	"	"	no. H.O. " " misses some."
# 24	4 1/2 "	400	12	2700 fpm ok for 12 sec then miss. arced cathode dull red heat.
"	"	"	"	" ok with air blast 50 V.
"	4 1/2	200	12	2880 ok with lots of air.

circuit for above.



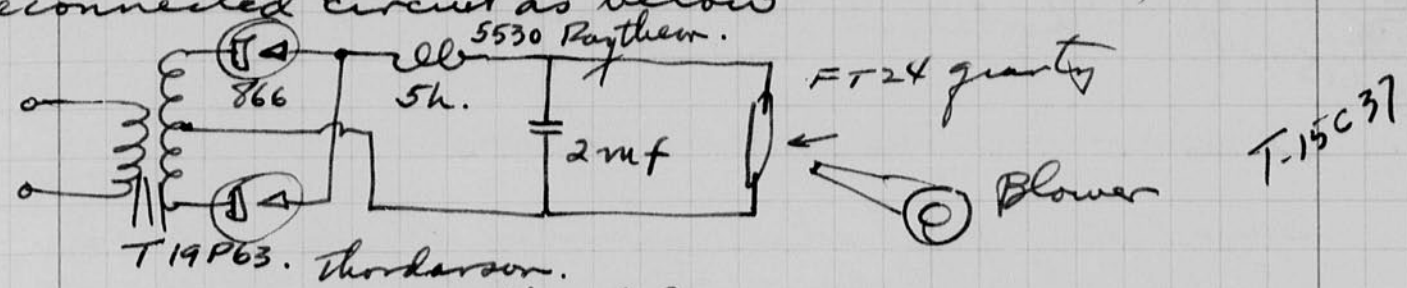
change of ~~the~~ circuit to follow



24	4 1/2	400	2	2000	5 henry choke irregular of
"	"	"	"	"	" " holdover continuous

T 15637.

Oscillograph connected to measure ~~continuous~~ transient voltage of condenser. Dumont blue tube 7 meg + .1 meg for voltage divider. Last exp on last page shows oscillation of condenser voltage due to charge cycle. Reconnected circuit as below



Also will run without blower for more than a minute.

With 4 mf. the variation of the peak charging voltage is more, about 10% total. More air is required for cooling. Anode and cathode both run red hot - with cathode slightly hotter.

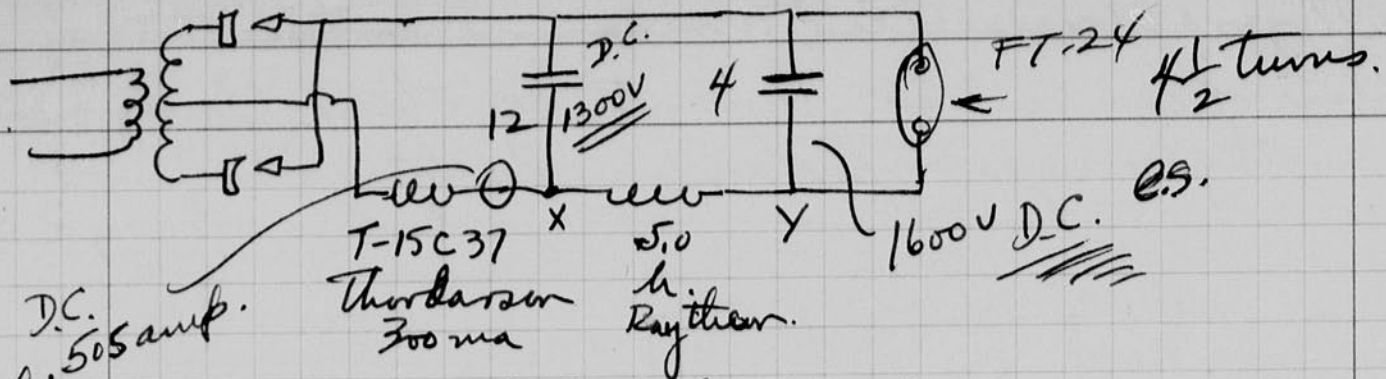
With 1mf the variation of the peak charging voltage was large - about 50%. No air cooling was required. The light variation was objectionable. 90 ohms.

Another choke, Thordarson 300ma, was put in series with the 5530 Raytheon 50 ohms. The performance was improved! Operation ok. up to 100 cycles before flicker came in. The inductance should be larger still, a 45h 100 ma R=200 was tried.

1mf 45h (200 ohms) ok upto 4500 c.p.s. Capacity decreased to 0.5mf. Works fine up to 120 cycles.

Capacity decreased to 0.1 mf. Holdover
tube ~~chm~~ changed to 1 1/2 turn - Holdover
cap " " ~~4~~ 4mf. " "
tube " " 2 1/2 turn " "
old 4 1/2 turn tube put in as before - operation ok but with variations probably due to overload of choke.

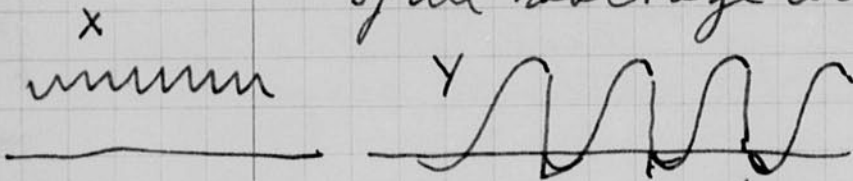
original #5,0^h choke put in, with initial results.



Blower needed at 50 cycles.

Blew 15 amp fuse when operated at slow speed. Light part flash occurred dim since voltage did not rise.

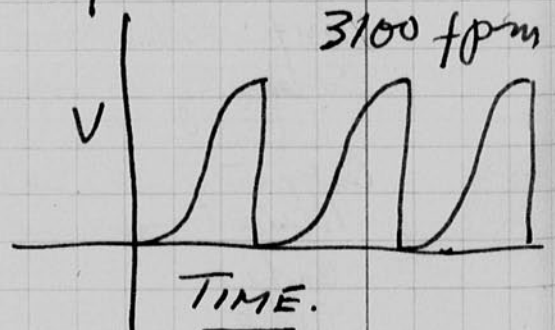
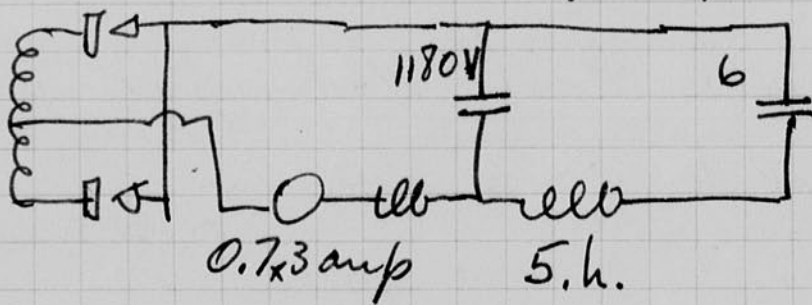
Fuse replaced. at 50 cycles with 4 mf. the oscillograph shows the following variation of the voltage with time.



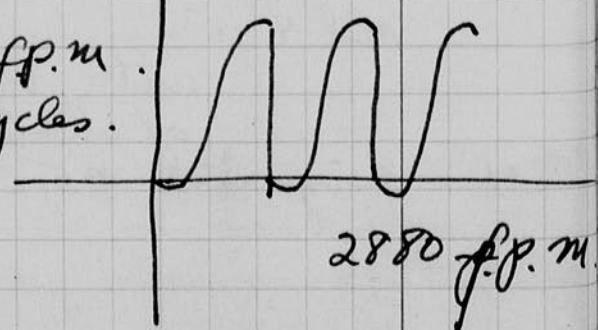
↑ Break where lamp flashes.

Note reverse charge due to initial current in the choke. The current in the choke was actually flowing ag from the condenser to the power supply at the instant of flash.

Increased discharge capacity to 6 mf.



1320V } at 2880 f.p.m.
.66 amp. } 48 cycles.



Capacity increased to 8 mf.

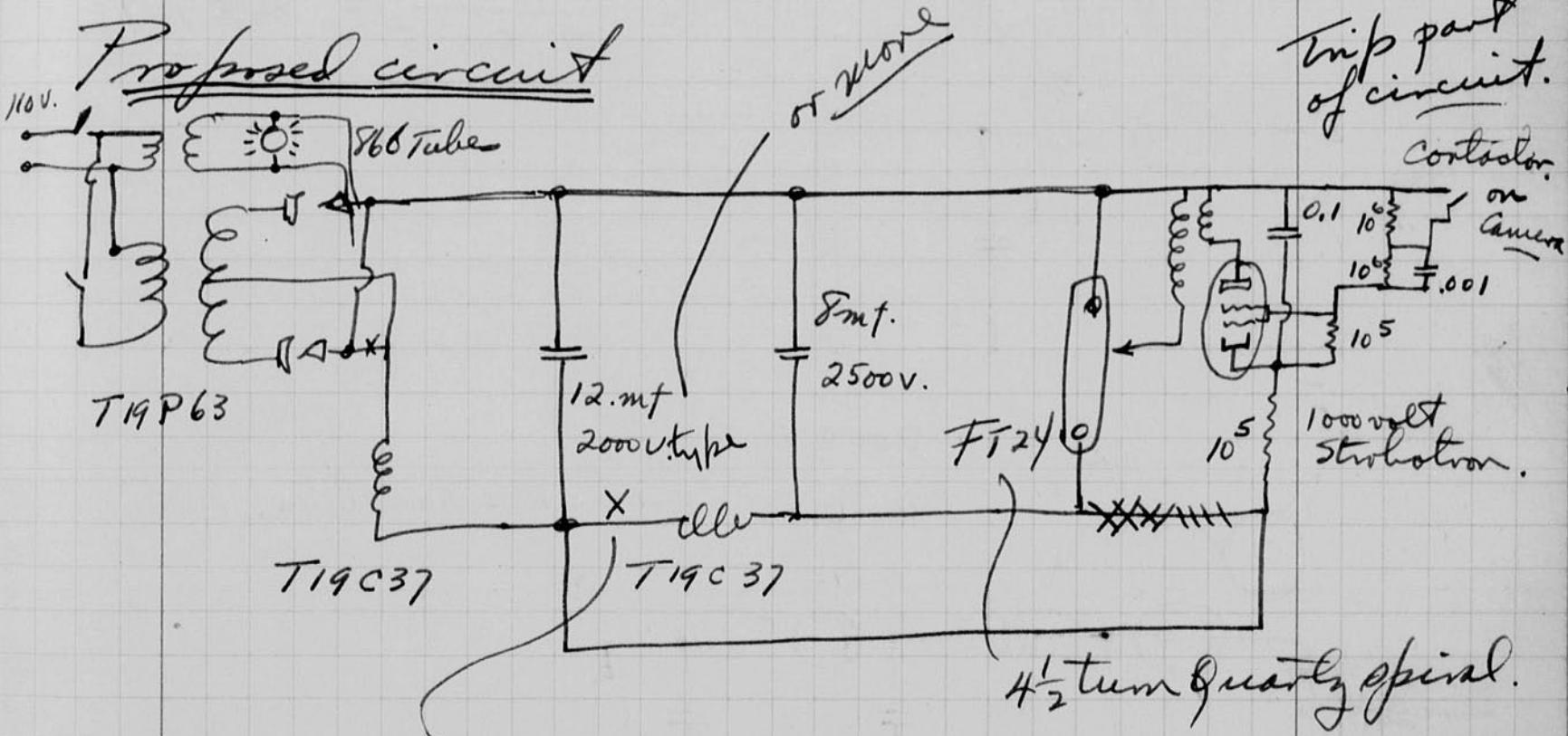
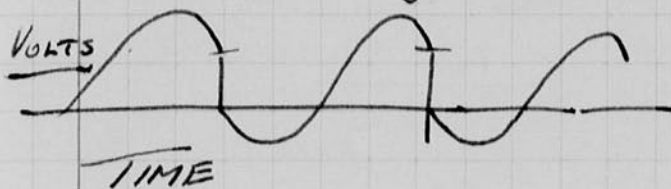
Current = .81 amps at 1200 volts on filter condenser.

Osc shows freq of secondary charge = 1/2 that of 480.

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{6.28\sqrt{15 \times 8 \times 10^{-6}}} = \frac{1}{6.28 \times 6 \times 10^{-3}} = \frac{1000}{40} = 25 \text{ cycles.}$$

$\frac{1700}{960.0}$ volts. or about the rating of the transformer.

A series tube in the charging circuit is not needed except for slow frequency, that is less than 25 cycles. ±

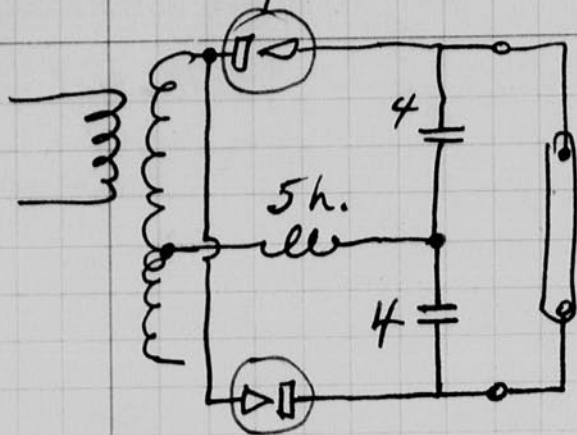


If a series charging tube is used filament transformer no T19F90 is reqd. 7500 volt test to primary. Insert tube at X

for 96 cycles use 4 mf instead of 8 or lamp.

Sept. 25, 1945 M.I.T.
Harold E. Edgerton

Voltage Doubler



operates ok. but with slight flicker due to inadequate filtering.

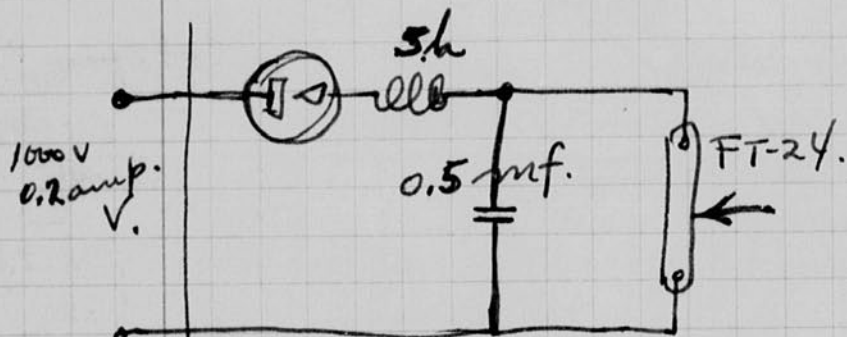
new J.R. Stroobler design.

2000 V 0.5 mf 120 cycles. = $\frac{CE^2}{2} f = 2 \times 120 = 240$ watts.

60 cycle = $\frac{1}{2\pi fRC}$

$L = \frac{1}{(2\pi)^2 60^2 C}$
 $.5 \times 10^{-6}$

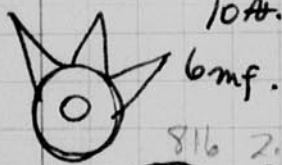
= $\frac{10^6}{39 \cdot 3600 \cdot 5}$ = ~~14.1~~ 14.1 h



120A 0.5

60A 1.

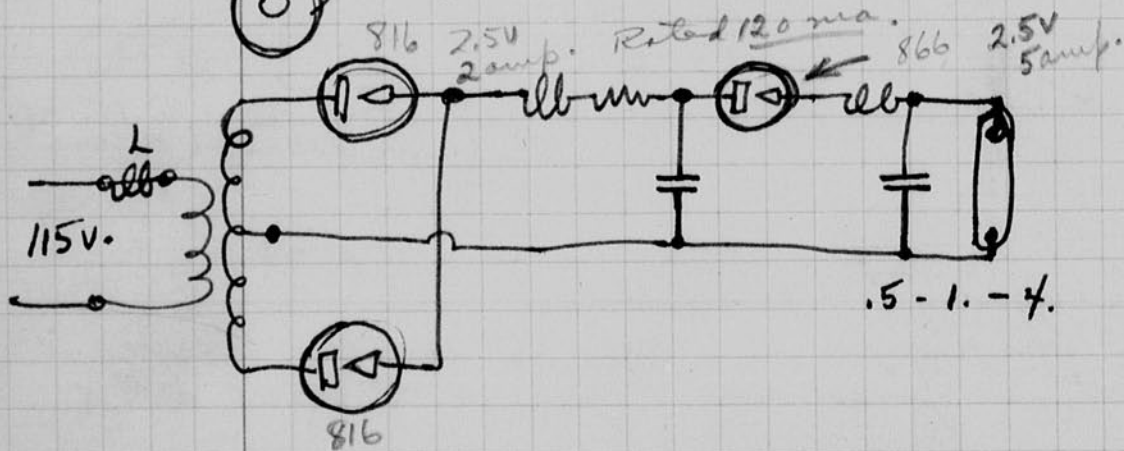
2000 V



10A.

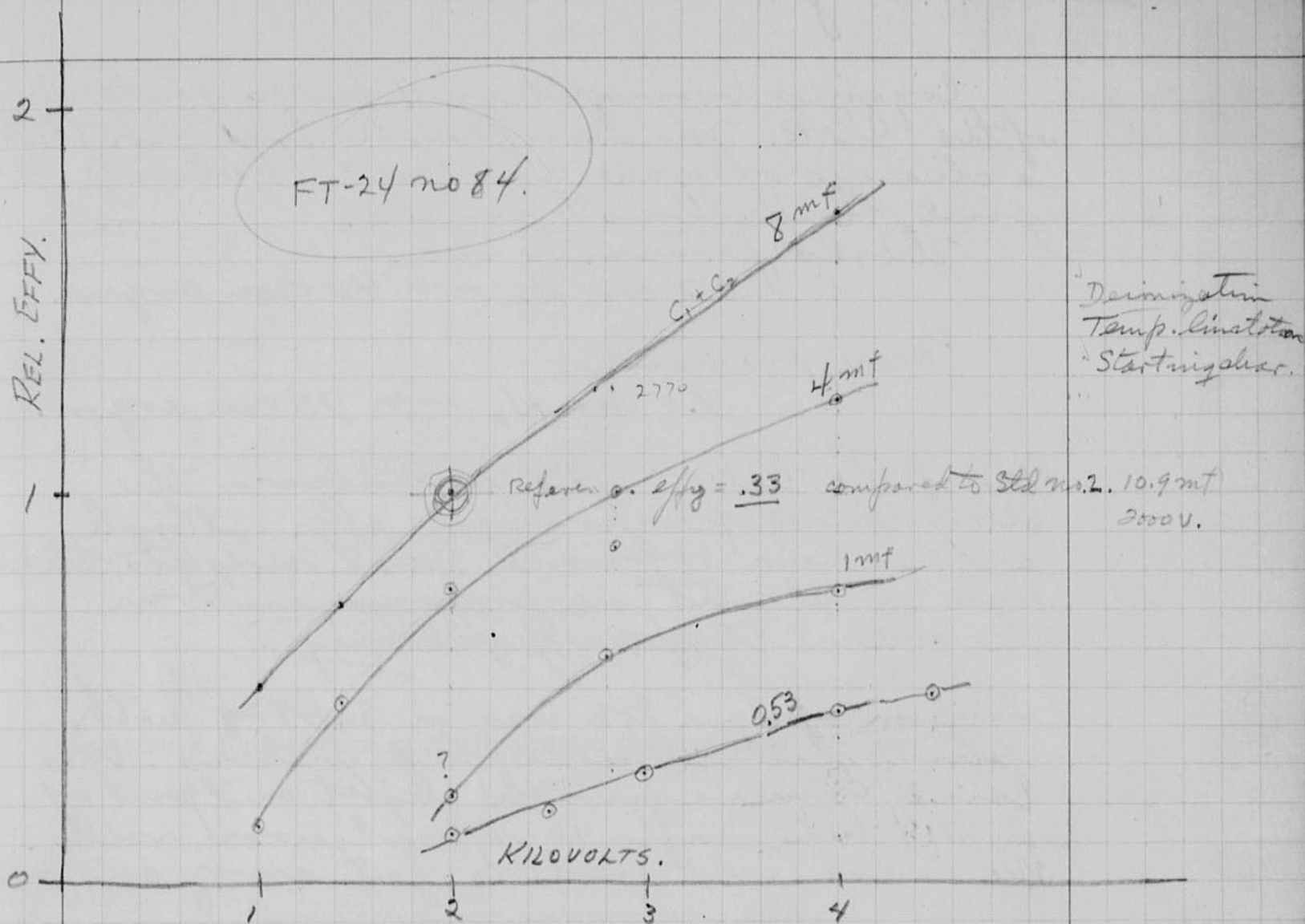
6mf.

$.2 \text{ amp} \times R = 1000 \text{ V}$ $R = 5000 \text{ ohms.}$



0 to 5000 volts

- .5
- 1.
- 2.
- 4.
- 8.



Lamp Research

- Current (or current density)
- Voltage gradient.
- Energy per unit volume.
- Pressure
- Length
- Diameter.

Hold constant - for similar output per unit length.

Initial gradient - volts per cm

Energy per unit length.

Sept 28 1945 MIT
 James E. Edgerton.

Microflash tubes.

Coygins brought in 4 tubes yesterday of the G.R. microflash type with a change of gas content, which I give him last week.

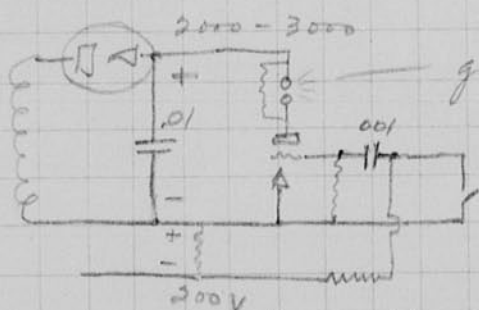
The old pressure was
 $0.2 \text{ cm H}_2 \rightarrow 40 \text{ cm argon}$

New pressure
 $1.0 \text{ cm H}_2 \rightarrow 75 \text{ cm argon}$.

One of the tubes was a leaker - the other three performed ok. I took a duration record last night. There was a slight improvement in the new type of filling.

Simpson of Lynn G.S. was in Sept 28 with photoelectric cells and meters. We tried to measure the light output of a #14 tube with 10 mf at 2000 volts. We were not able to get any output.

Suggested stroboscope for Lewis tunnel propeller under water. Garmeshausen suggests 3C45



600 hrs. 40 amp peak
 200 hrs 50 " "

Oct. 2, 1945. Conf. with Sinclair and Wilkins yesterday on Photocell meter. S.R. will build up model with 3 tube circuit for experimental use.

Obtained 5 additional 935 photocells from Nottingham. Of these and two other tubes the leakage currents were as follows. All $\times 10^{-11}$ with 100 volts.

4	60	30	8	73	21	6
✓			✓	✓		

Only 3 which are ✓
 could be used with

Notebook # 16

ups.

Filming and Separation Record

___ unmounted photograph(s)

2 negative strip(s)

___ unmounted page(s)
(notes, drawings, letters, etc.)

7

h.

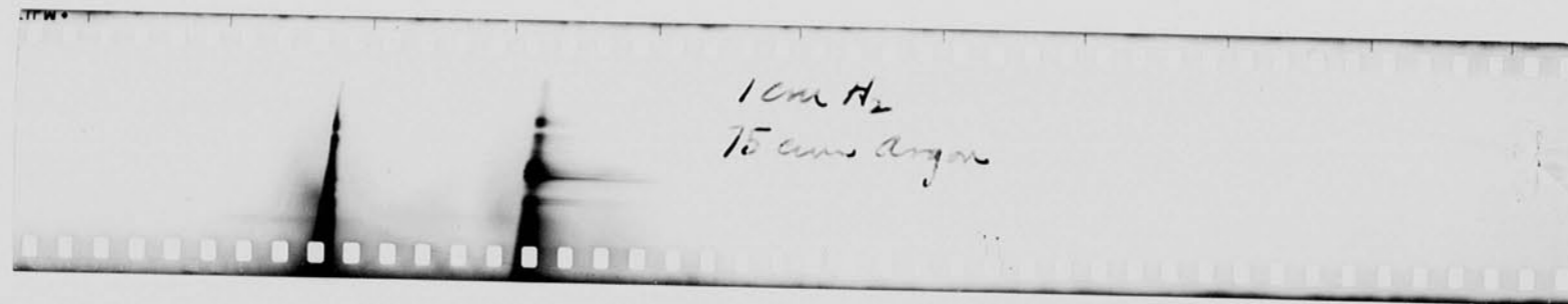
was/were filmed where originally located between page 86 and 87.

Item(s) now housed in accompanying folder.

12

000 V.

th



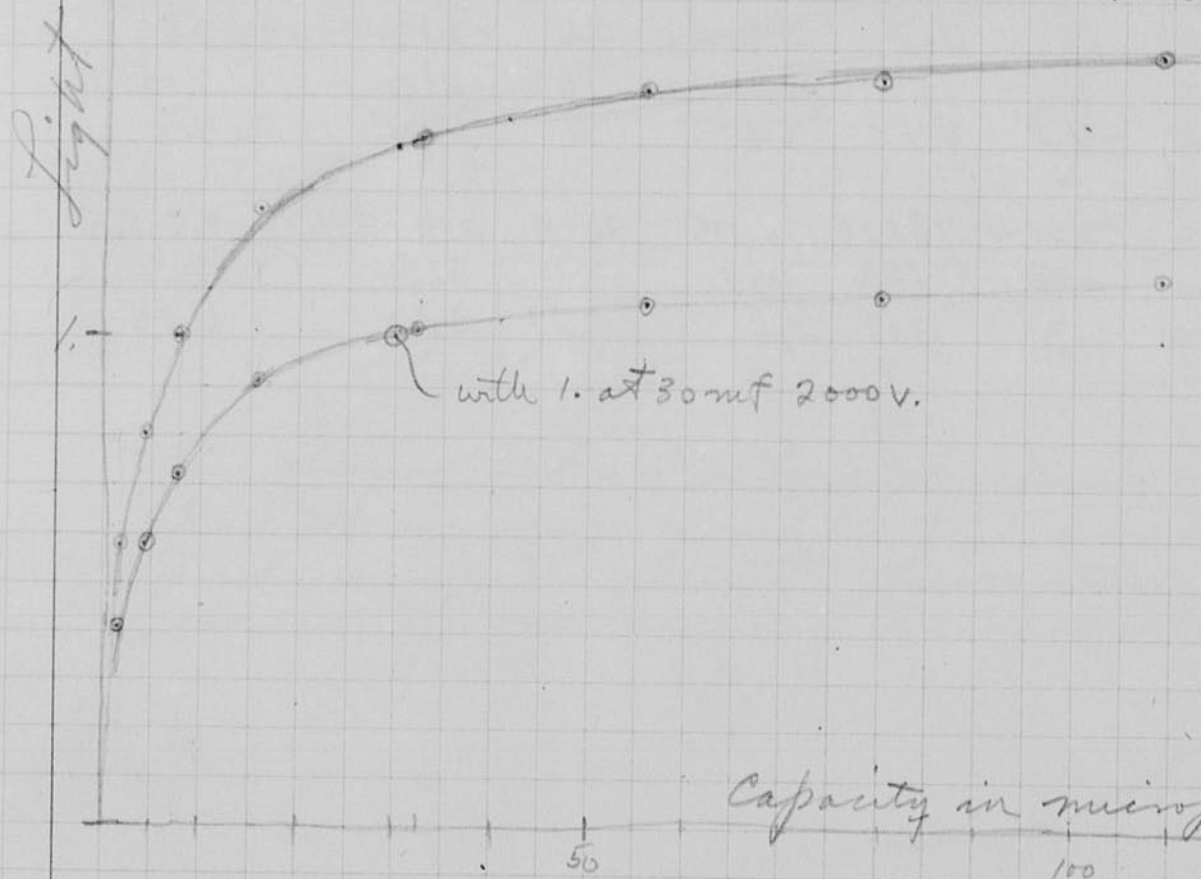
a 1D8 which had a grid current of -4.5×10^{-6} amps.
Two other 1D8 tubes had

$$I_g = 9 \times 10^{-6} \text{ in dark.}$$

$$20 \times 10^{-6} \text{ in light}$$

$$I_g = 90 \times 10^{-6} \text{ in dark or light.}$$

Nothing wrote Ulrey RCA Lancaster Pa today
concerning 3 photocells with 51 33 and
54 surface.

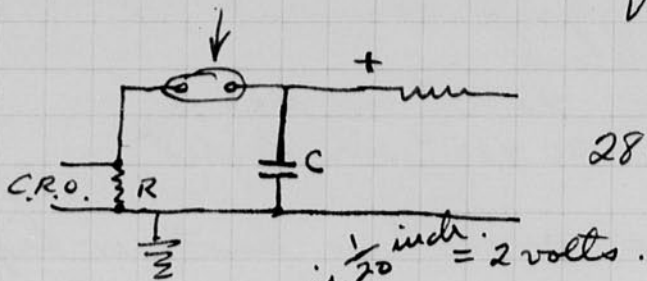


Oct. 4, 1945 M.I.T.

Harold S. Edgerly Peak-current measurement.

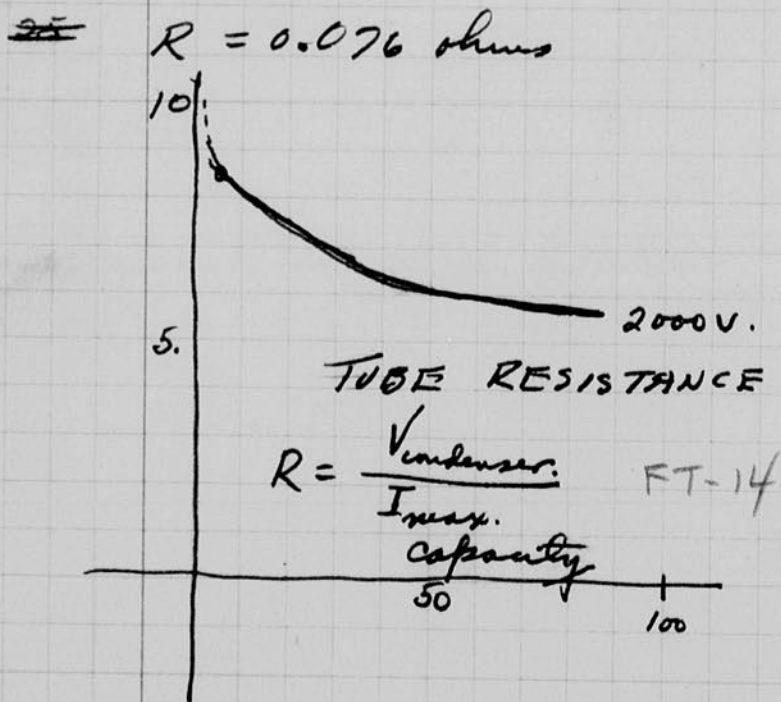
FT-14.

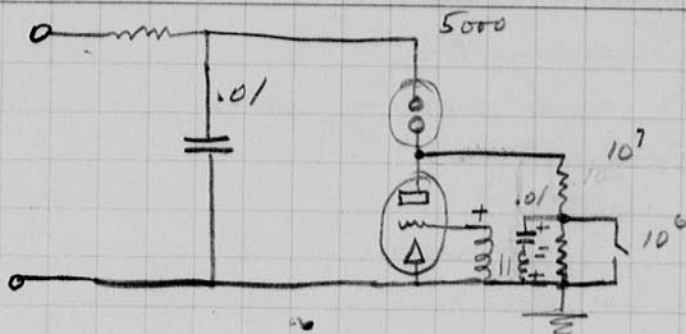
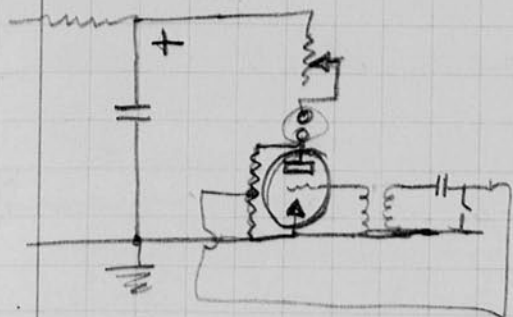
V = 2000. rated tube N-1 FT-14.



C	V _C	V _{CR} mm.	V _{CR}	I	V _{CR}	$\frac{V_{CR} = I_{max}}{.076}$	Tube ohms $\frac{V_{max}}{I_{max}}$	
N-1	28.5	2000	13.	20.8	276	26	342	5.85
	28.5	1500	8	13.	170	16	224	6.70
	28.5	2400	17	27.2	347	34	447	5.35
	28.5	1000	would not flash.					
Ref 2	28.5	2000	13	20.8	276	26	342	5.85
	28.5	1500	8	13.	170	16	210	7.15
	28.5	1000	4.	6.4	84	8	105	9.5
N-1	4.0	2000	8 or 9	13.2 14	170 185	16-18	210-236	9.5-8.5
	4.5	2000	12	19.2	253	24	315	6.3
	8.0	2000	13	20.8	276	26.	340	5.85

40 volts per inch. calibration.





Oct. 6, 1945 Hydrogen thyristor 3C45 rated 40 amp peak.
 600 hours.
 Cathode 3 sq cm.
 15 amp/sq cm.

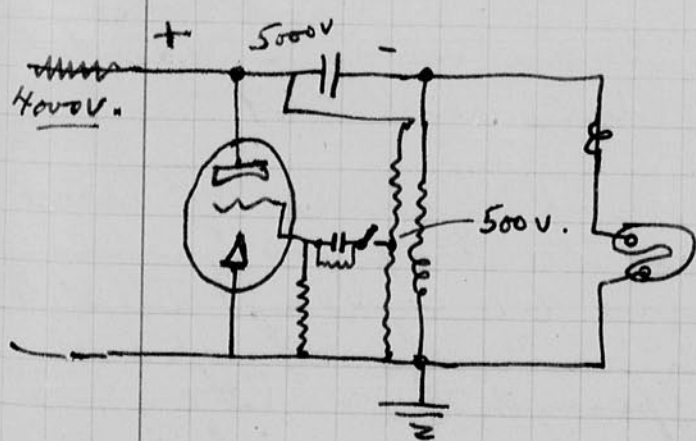
Inductance to limit current to 40 amps.
 4000 volts .01 mf.

$$I = E \sqrt{\frac{C}{L}} \quad \text{solve for } L = \frac{E^2 C}{I^2} = \frac{16 \times 10^6 \cdot 10^{-8}}{16 \times 10^2} = 1 \times 10^{-4} \text{ henries}$$

$$\frac{1}{f} = T = 2\pi \sqrt{LC} = 6.28 \sqrt{10^{-4} \cdot 10^{-8}} = 6.28 \times 10^{-6} \text{ sec.}$$

a half cycle = 3.2×10^{-6} seconds.

This shows that 0.10 mh inductance can be put ~~in~~ in series with the condenser and lamp to limit the current without unduly increasing the duration.



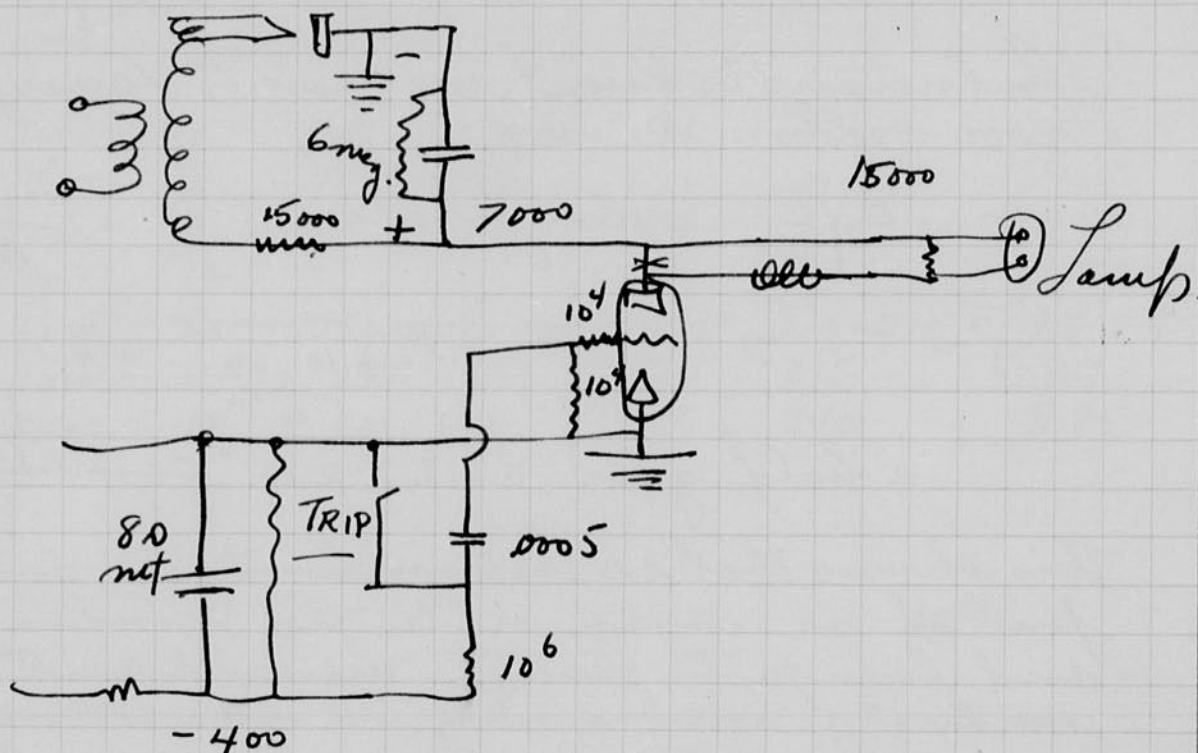
If both blades of the contactor are insulated the tripping is easier for the cathode grounded thyristor.
 See diagram.

Oct 9 1945 M.I.T.
David E. Edgerton

Leaving for Cleveland at 5 pm today.

Consulted fast trip equipment for Lewis yesterday.

4C 45 tube will ~~not~~ self start at 5000 with zero bias. Changed to 3C 35 tube (100 amp. peak)



I tried #15 lamp and an argon ^{spark} lamp as well as others in this circuit

There was some modulation of time, say about 20 ns, as the trip frequency went through 30 and 60 cycles. This is due to small changes of start time caused by different voltages on the anode or ~~anode~~ base grid.

Cloud Chamber

I went to the 4th floor with m.
to see the cloud chamber illumination
device that has been in operation for
about 8 years \pm . It wanted the circuit
to send to Prof. Deutch at Tenn.

A new type of lamp would be
better for their work with a cover on
a # 15 base.



6" or 8"

Oct 15 1945 Monday

I had a conference in Cleveland on
Oct. 10 with Noel, Carlson, Hammer and others.
Discussed television and color movie lamp with
Carlson and Noel.

Tungsten lamp 5KW \rightarrow 165,000 lumens
33 lumens/watt.

filter for color $\frac{2}{3}$ loss for daylight film.

55,000 lumens

$\frac{1}{50}$ sec

1000 lumen sec per frame.

The noise from the
lamps is
important!

with a flash lamp effy of 50 lumens/sec.

20 watt seconds per frame are required

Suggest 72 cycle light with two on frame.

power = $72 \times 10 = 720$ watts

5 mF at 2000 volts.

$\frac{CE^2}{2} = 10$ watt sec.

Carlson suggest at least 3 times this for start. I proposed
a small spiral with FT-17 electrodes at 15 cm Xenon.
Noel is going to make a lamp like this for test.

I took the ~~night~~^{aft.} train to Rochester where I met Herb and Fred at the R Hotel in the morning. We met Mentch and had a morning conference with Boon and Leavitt and Ford.

We spent practically all the time on the Studio unit. Decided to stay at ~~2000~~ 2000 volts for the time being with new, more efficient tube and new modeling lamp.

Each power unit will have an extra outlet for a second lamp. There will be no way to plug in extra capacity.

Leavitt reports irregular operation of lamps with double lamps on the Kodatron. We suggested new tubes which were ok. when an extra capacity of 1 mfd was connected to the spark trip circuit. Double light from 2 tubes is less than light from one since the efficiency drops with capacity.

Decided to use polarized jacks plug on the studio unit.

B.S. reports that 100 watt focus lamp causes one lamp to miss on new design when the other focus lamp is left off. The lamp by itself will fire if the cold ~~also~~ lamp is disconnected.

Spare parts will be available to rebuild the old Kodatron units that are out now. This will include a socket of the new type and a new plug arrangement.

New improved condensers will be available for the Kodatron unit. This and the double lamp arrangements are the only changes.

After lunch we had a meeting in the Kodak Tower with Farrow, Green, Vaughan, Boon, Mentch, Bairstow, Brier and myself.

It seems that Kodak want a

non exclusive licence ~~license~~ and wish to use us for design and consulting services.

E.K. wish to make the flash equipment in their own plant starting about six months from now after a move is made. We were asked to make a proposal to E.K. for a licence and for a consulting arrangement.

I left that night for Dayton after a dinner at the country club with Farrow, menck, Vaughan, Lt. Col Dick Tighorn. There was a fair at W.I.F. where developments were shown in fine style. Of particular interest to me were the displays of the Tech data Lab. where Major Perry Thomas, Capt Charles Coles, and Lt Steinmetz were in charge. Also the Photo. Lab. had a very fine exhibit with Col. Goddard in the front row. Welch Pogue was in from Washington and we had lunch together.

After several attempts to get a plane, I gave up and returned to Boston on the train. Major Thomas invited Capt Coles and myself to dinner at his home where I saw his family - ~~two~~ two boys Weg and Kirby.

I took a rather complete photo record of the stroboscopes at the W.I.F. affair. These negs were taken to E.K. today and given to Clayton and Worthen.

Noel in Cleveland says the new studio unit should have the following changes.

- 2 lamp outlets (3 preferable)
- 200 watt seconds total energy
- 4 to 5 KV for most economical condenser design.
- 2000 V 100%
- 5000 V 45% cost 60% weight.
- AN plugs.

Oct. 19, 1945 M.I.T.

Harold S. Edgerton

I visited Dr. A.N. Goldsmith in N.Y. on Oct 17 where a conference was held on motion-picture lights. Present was Menfee, Carlson, Farnham, Johnson and Marvin. A list of desired characteristics for the lamps was presented by Dr. Goldsmith. Lunch at Cornell club.

Met T.T. Goldsmith at Dumont at 5 and went to N.J. with him. Helped at the mens club Presby chur for Goldsmiths lecture on television. Then stayed with Westenberg over night at Dumont Oct 18, installed strobolux lamp in movie projector and ran film through with sound.

A test was made with a 1000 watt projection bulb. Light was picked up with a 929 photo cell into a 10,000 ohm resistor (200 volts).

Another test was used with the strobolux lamp excited with 2 mf (or 1) at 2000 V ±.

The peak of the light with the strobolux lamp was 12.4 times that of the 1000 watt lamp after the light of each went through the optical system of the movie (16mm) projector.

65 ft candles was measured with a Weston meter as the peak output of the 1000 watt bulb.

Integrated output on screen

$$I.T. = 65 \times 800 \times 10^{-6} = 52000 \times 10^{-6} \text{ f.c. sec.}$$

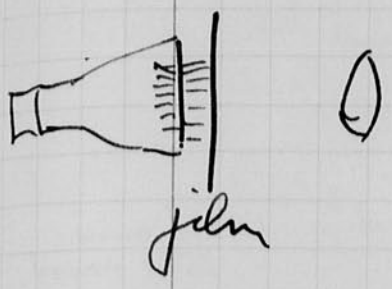
with flash lamp

$$I.T. = 12.4 \times 65 \times 10^{-6} \times 10 = 8100 \times 10^{-6} \text{ f.c. sec.}$$

$$\text{Ratio } \frac{81}{5200} = \underline{.15}$$

Dr. T. Goldsmith suggested the use of a

special cathode ray oscillograph tube as a plane light source to be located back of the film in the projector. The beam would be designed to be broad so that it covered the entire end of the tube. Light would be modulated by grid or anode voltage to flash at the desired time.

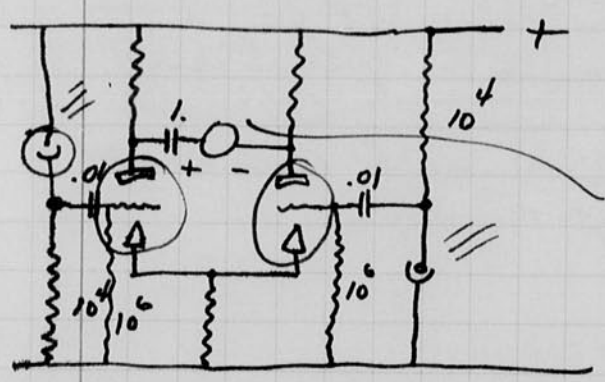


Peak current density = 100 ma per square mm.

Details of the scheme are in Goldsmith's note book as of yesterday.

Ballistic exposure meter.

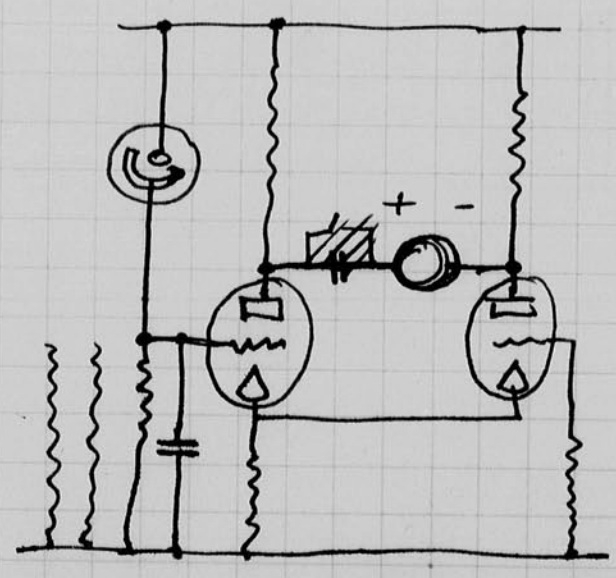
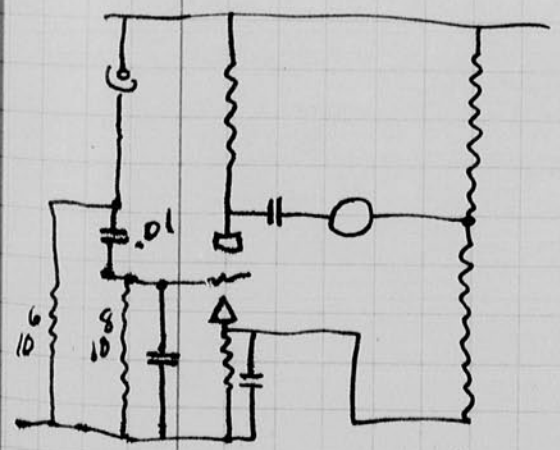
no shutter needed.



Ballistic meter

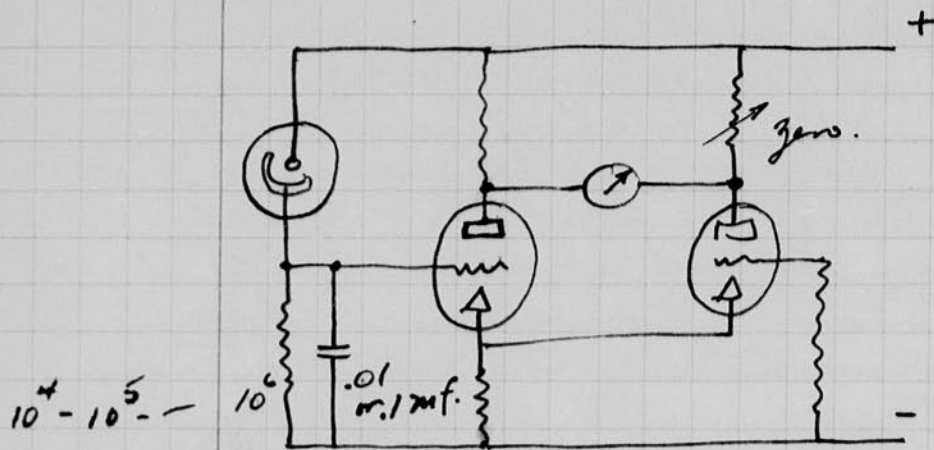
$RC \text{ in grid} = 10^{-3} \text{ sec or } 10^{-2}$

$10^{-2} = RC \quad C = \frac{10^{-2}}{10^6} = 10^{-8} \text{ farads.}$



50 mc coulombs.
50 ma for 1 sec.
 10^4 sec.
 $50 \times 10^4 \text{ amp.}$

cont.



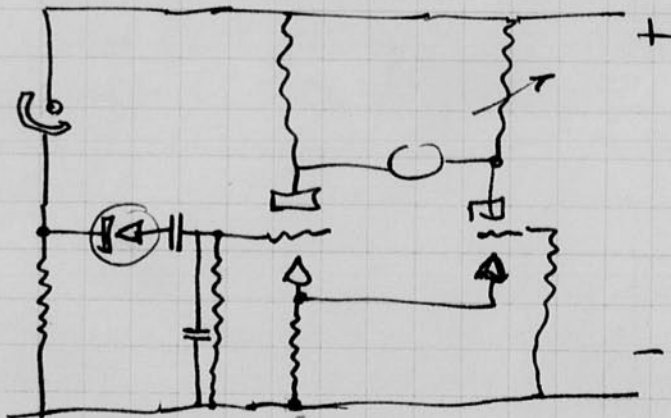
Ballistic meter to
measure flashing
light.

$$10^4 \times 0.1 \times 10^{-6} = 1.0 \times 10^{-3} \text{ min time const.}$$

$$RC = 10^{-2} \text{ sec. } R = 10^6 \text{ } C = .01 \text{ mf.}$$

In a lighted room this will be off scale due to the drop in the 10^6 ohms.

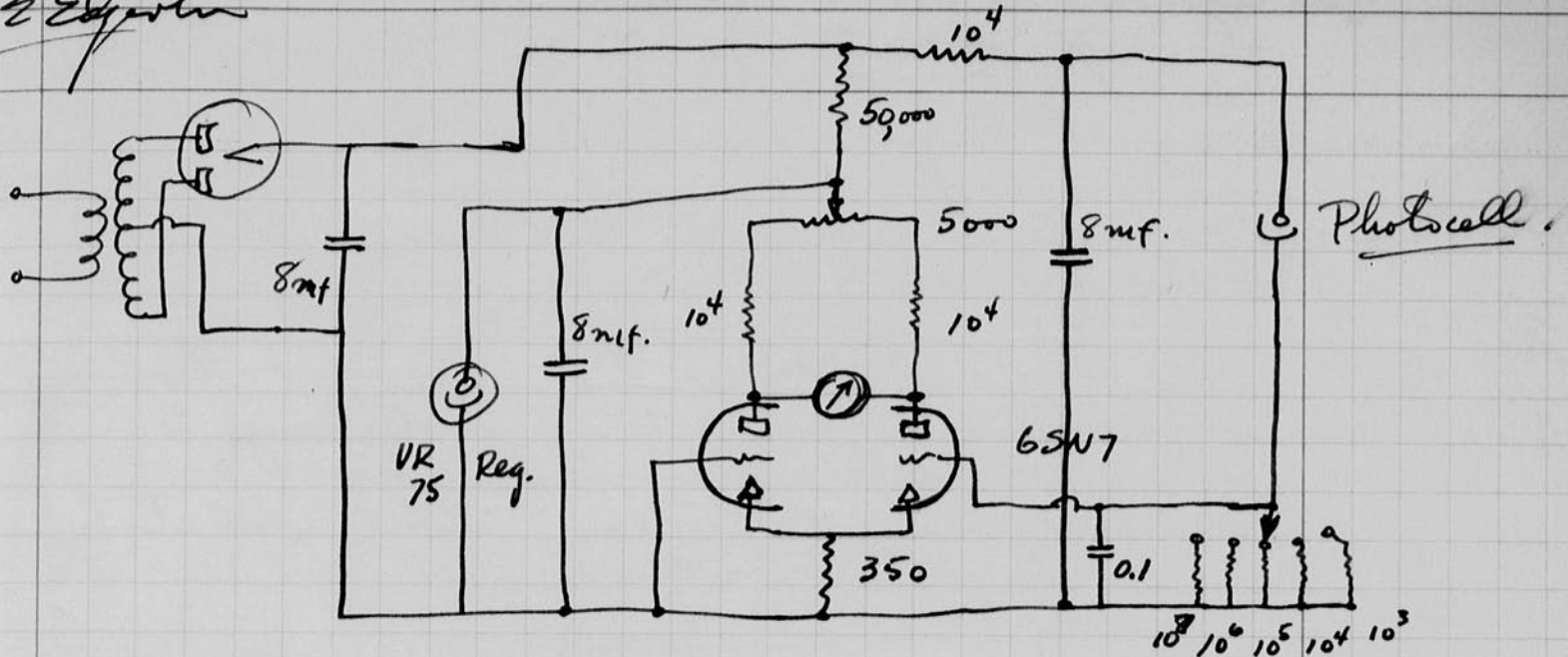
Oct. 20, 1945. meter design continued. It would be desirable to put in a circuit to take out the continuous deflection caused by continuous light. One such circuit would consist of a rectifier and capacity.



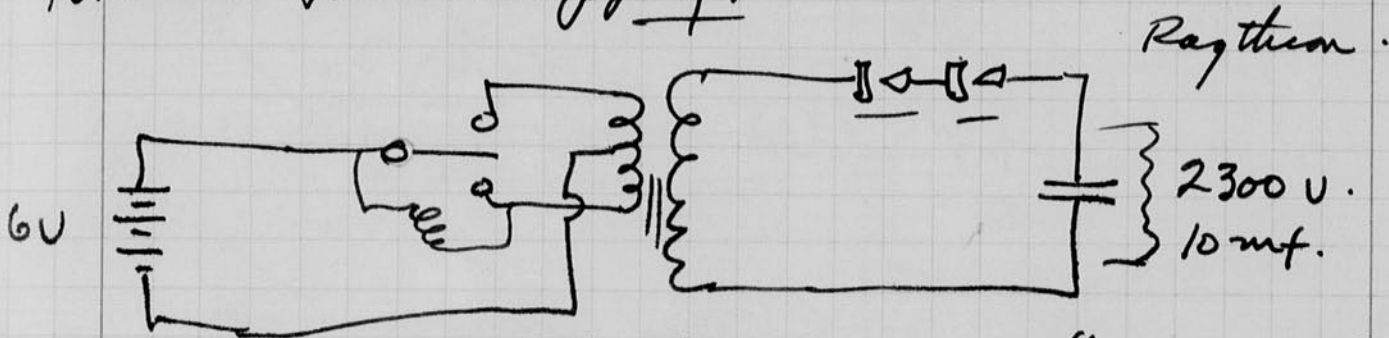
Oct 20 1945.

H. E. Edgerton

Ballistic Exp. Meter.



Portable Powersupply.



120 v. trans.
Vibrator.

with 3 meg load
the voltage drops to
1950 volts.

$$6 \times 300 = 1800 \text{ v.}$$

$$I = \frac{1950}{3 \times 10^6} = 650 \times 10^{-6} \text{ amps.}$$

$$= .65 \times 10^{-3} \text{ amps.}$$

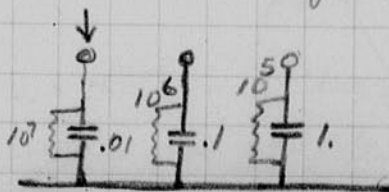
I connected 2 electrolytic condensers in series across the above circuit after a minute the voltage was 900 volts. excessive leakage currents must flow due to shelf life. The caps have not been used for some time. 3.9 volts from bat.

Bal. meter

$$\text{Let } C = 0.1 \quad R = 10^6 \quad RC = 10^{-1} = 0.1 \text{ sec.}$$

assume voltage on grid = 0.2 volt for 0.1 sec.

$$\Delta T \dot{q} = S_m \frac{q}{\Delta t} = \frac{0.2}{10^6} \times 2200 \times 0.1 = 440 \text{ micro amp. sec.}$$

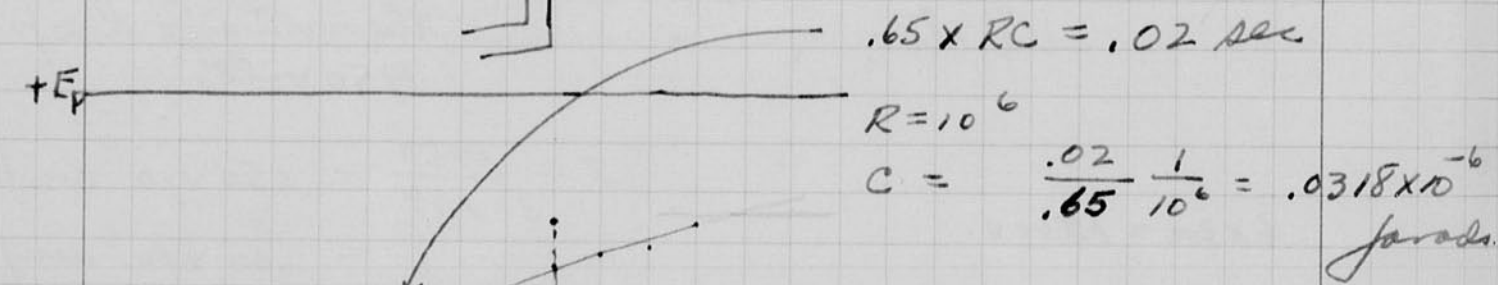
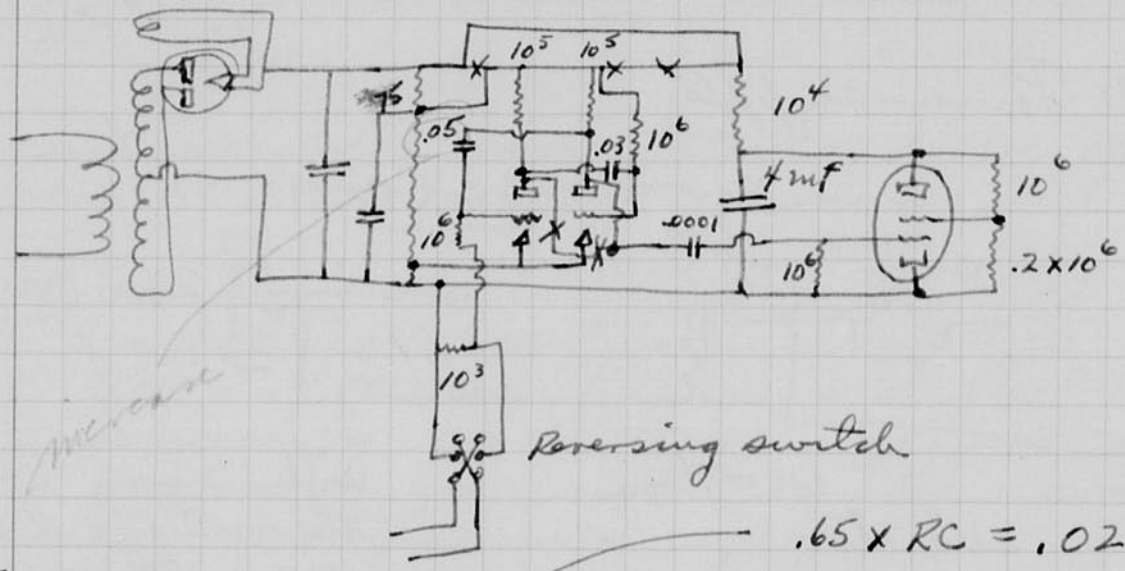


Harold E. Edgerton
 Oct 25, 1948 M.I.T.

I started a book on flash photography several days ago. This book had been outlined for several years. The subject I am working on is the basic electrical theory.

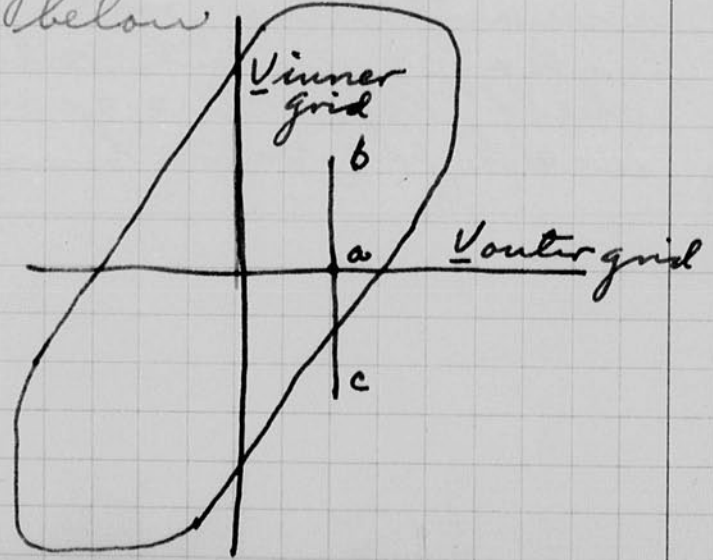
Flash bulb adjustment for shutter.

A circuit was given to Bill McRoberts to wire up for testing synchrotrons. A time delay circuit 0.02 seconds is introduced between the switch and a strobotron.

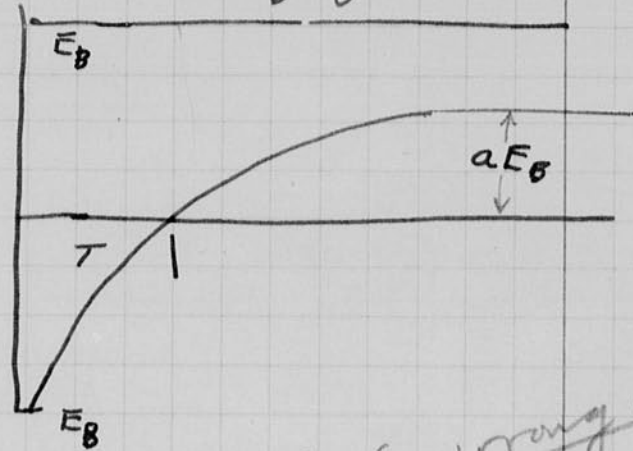
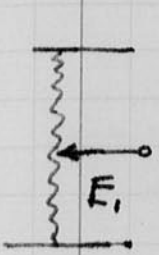


The starting characteristics of the strobotron are the below

-E_g
 .5 1.
 tube drop before firing.



The normal potential on the two grids is shown at point a where the voltage on the outer grid is about 75 volts. at the instant of trip the inner grid voltage goes to point b which is not enough to fire the tube. after 20 milliseconds the inner grid voltage swings to point c and the stroboscopy flashes the energy in the condenser (4mf).



$$e_g = (aE_B + E_B) - E_B(1 - e^{-\alpha t})$$

When $e_g = 0$ the tube fires.

$$0 = E_B(1+a) - E_B(1 - e^{-\alpha t})$$

$$\frac{E_B(1+a)}{E_B} = (1 - e^{-\alpha t})$$

$$a = -\epsilon$$

$$\log \ln a = \alpha t \quad t = \frac{\ln a}{\alpha} = RC \ln a$$

and since $\ln x = (x-1) - \frac{1}{2}(x-1)^2 + \frac{1}{3}(x-1)^3 - \dots$
 x between 0 and 2.

$$e_g = -E_B(1+a)(1 - e^{-\alpha t}) + aE_B$$

when $e_g = 0$ $aE_B = E_B(1+a)(1 - e^{-\alpha t})$

$$\frac{a}{1+a} = (1 - e^{-\alpha t})$$

$$\frac{a}{1+a} - 1 = -\epsilon$$

$$\frac{a - 1 - a}{1+a} = -\epsilon e^{-\alpha t}$$

$$\frac{1}{1+a} = +\epsilon e^{-\alpha t}$$

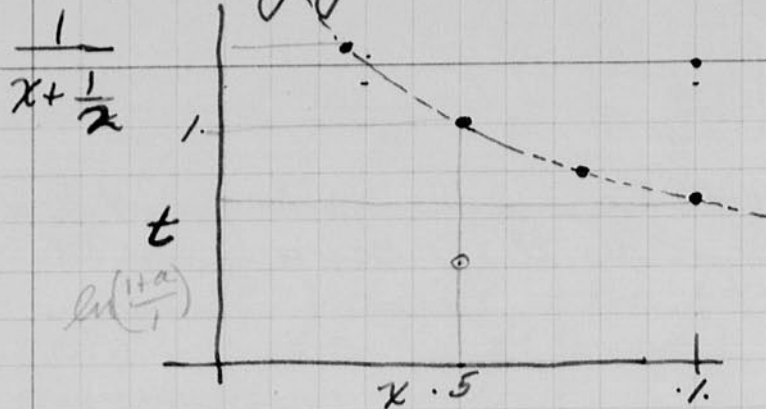
$$\ln\left(\frac{1}{1+a}\right) = -\alpha t = -\frac{t}{RC}$$

$$t = -RC \ln\left(\frac{1}{1+a}\right) = RC \ln\left(\frac{1+a}{1}\right) \cong RC \frac{1}{x + \frac{1}{2}}$$

wrong expansion
 $\ln\left(\frac{1+x}{1}\right) = 2 \left[\frac{1}{2x+1} + \frac{1}{3(2x+1)^3} + \dots \right]$
 $\cong \frac{2}{2x+1}$
 $f = \frac{1}{t} = \frac{(2x+1)^{RC}}{2} = (x + \frac{1}{2})^{RC}$

Con 7

Let x vary from $1/4$ to 1 .



$\frac{3}{4} + \frac{3}{4}$
 $\frac{5}{4} \quad \frac{1}{4} \quad \frac{2}{4}$

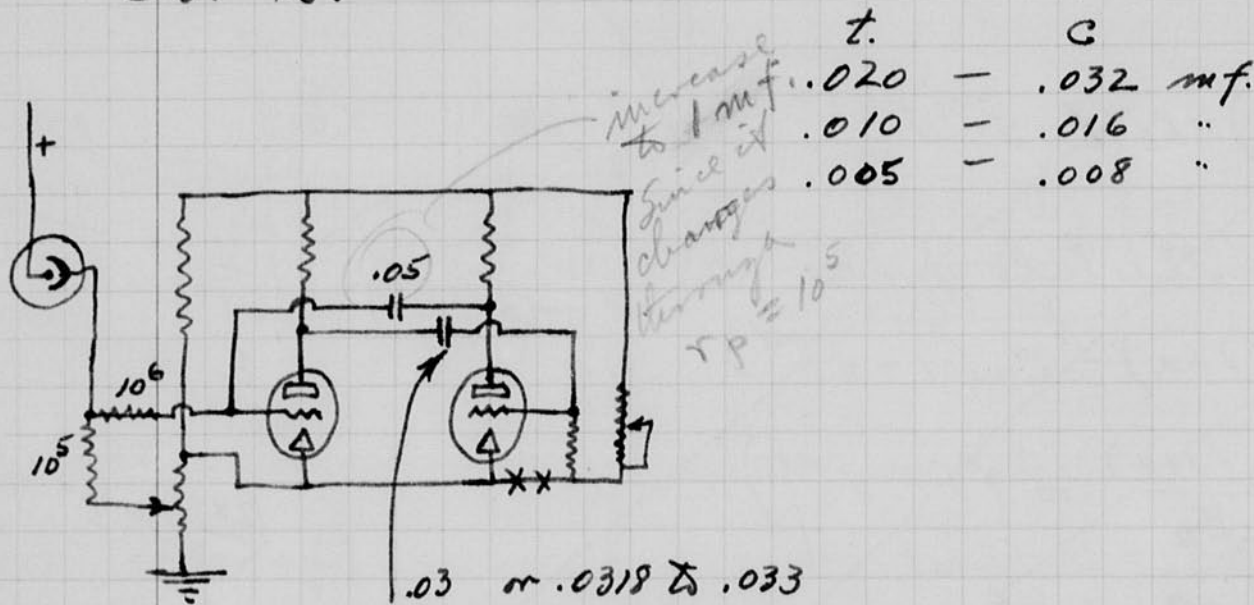
$\ln(1+a) = \ln 1.5$
 $\ln a \times B = \ln a + \ln B$

$\ln 1.5 \times 100 = \ln 100 + \ln$

$\ln \frac{1500}{1000} = \ln 1500 - \ln 1000$

$\frac{27081}{2306}$
 $\ln 1.5 = .402$
 $\ln 1.2 = .18$
 $\frac{2.485}{2.306} = 1.078$

To obtain a linear scale of time, vary C or R.



increase to 1 mf
 since it changes through
 TP = 10⁵

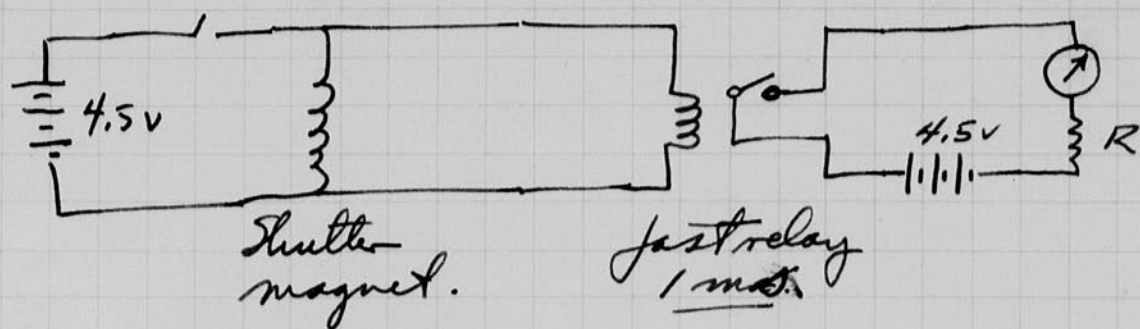
t.	C
.020	.032 mf.
.010	.016 "
.005	.008 "

Oct. 31, 1945 H. J. Egerton, M.I.T.

The shutter delay tester page 98 was wired up by Mc Roberts, while I was in Rochester on the 29th. Wiggin tested it yesterday with two shutters. The sensitivity adjustment seems to vary the time delay.

Yesterday discussed with Gurus and Herb the general problem. Suggested a scheme to give the actual time without a hunt and try method. Gurus suggested a series of neon lamps with different delay on each.

A meter needle could be used as a moving device for the test. A sketch of the scheme is given on the next page.



Arrange R so that meter swings to about double full scale. Let full scale equal .03 seconds.

Observe the needle through the lens at a close distance. Read the position of the needle when the shutter snaps. A Black scale should be used with a white needle. Large numbers should be used on the scale with 5, 10, 20, and 30 milliseonds marked.

10-31-45
Herbert E. Grier

Chicago Tribune
Sept 9 1945 issue v.

Sonya Heine.

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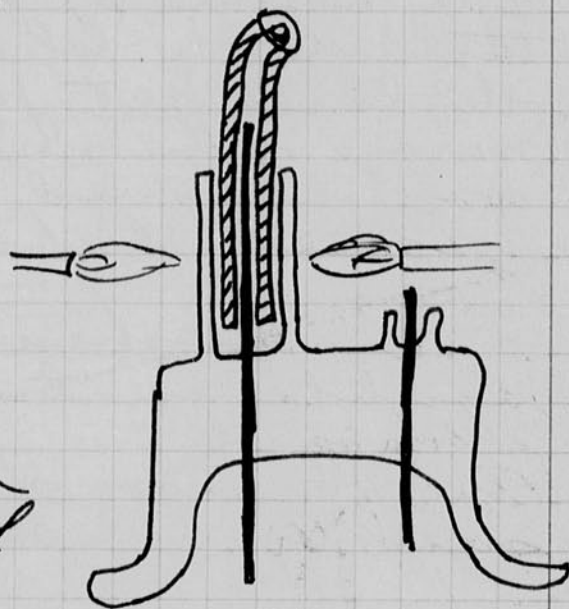
MIT
Nov 3 1945
J.E. Roughton.

103

Dameshauser and Burston made two tubes of the type shown in the sketch. The spiral was of quartz tubing about 5 inches in length, wound into a spiral. One end, the anode, was cemented with Insulate. Both tubes failed through the cement joint.



A suggested method. - Put glass on the outside of the quartz. Heat and press in against the quartz to give a close fit. Pyrex glass probably would not break when it cooled.

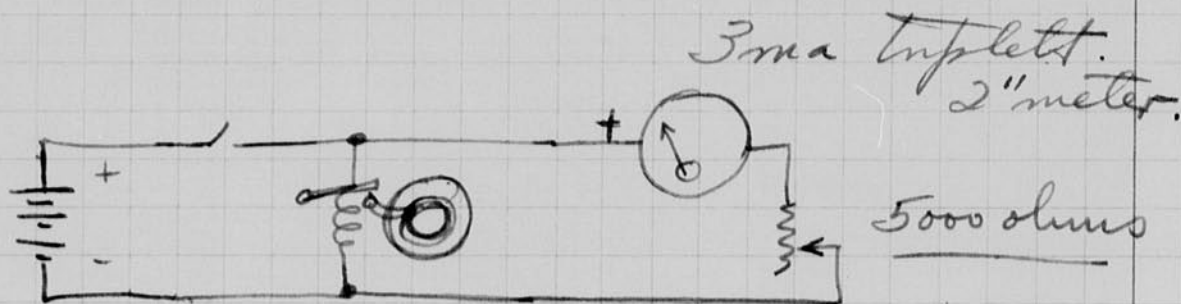


Yesterday I obtained from Roughton a collection of flash equipment to demonstrate in the court on the 10, 11, and 12 of nov. at the open house affair.

Nov 5 1945 M.I.T.
 Jared Edgerton

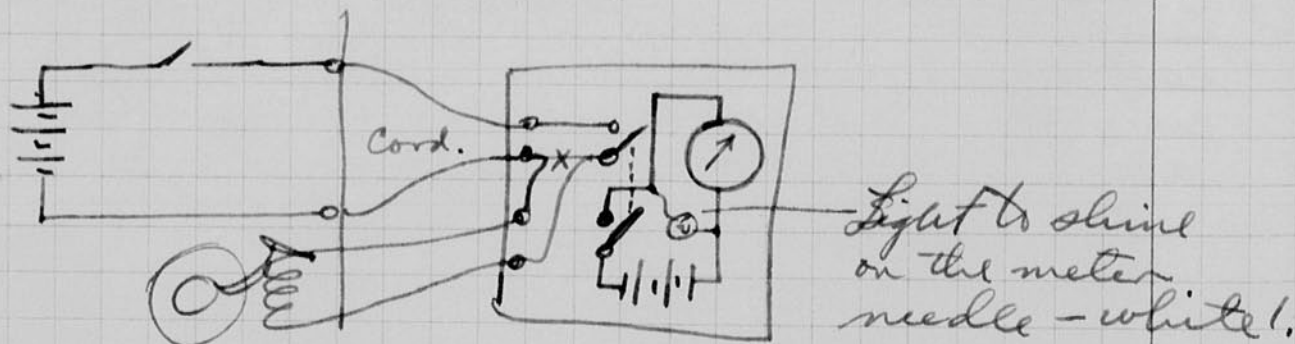
Shutter tester for flash synchron.

I set up the following circuit and had Wiggum bring up a speed graphic for shutter test.



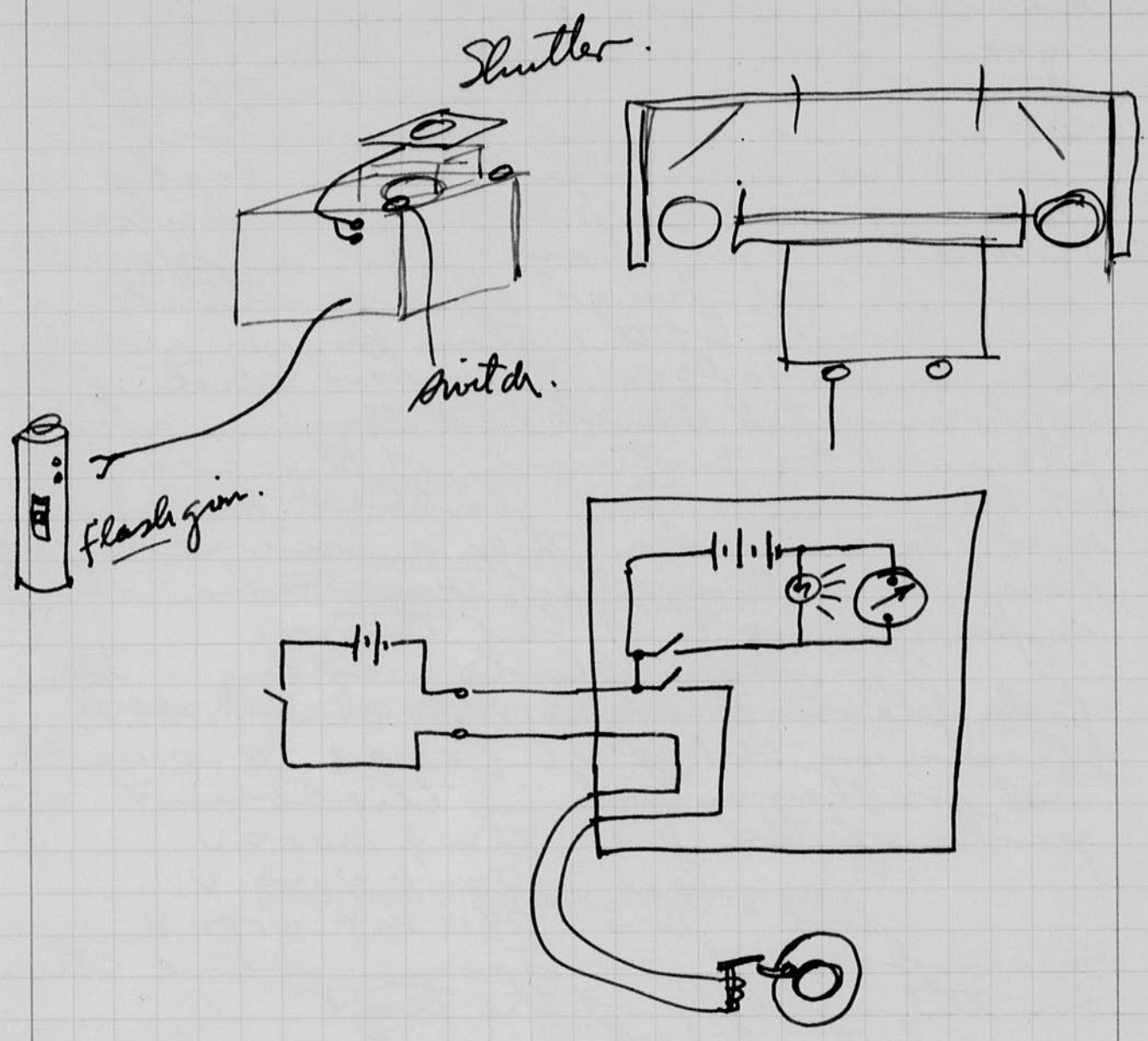
The needle of the meter was observed through the shutter and lens with the lens set for $1/200$ sec. A blurred image of the meter at $1/2$ m.a. \pm was observed when the resistance was set at about 1000 ohms.

Gerneshansen suggested a double switch which would eliminate the fast relay of page 101. The regular switch would need to be shorted or held shut.



Background black, with white numbers.

Nov 7 1945
H. E. Edgerton



Nov 12 1945 M.I.T.

Harold S. Edgerton

An exhibit of the open house type has been going since Friday Sat. noon. Some 10⁵ people have jammed through the place. Of great interest was the air-sea rescue demonstration in the Charles river with boats and planes participating. A helicopter picked up a man from a speed boat as the final demonstration.

Movies of the atom bomb were shown in 10-250. High speed shots of the experimental bomb in Arizona were followed by pictures of the crews of the planes that bombed Hiroshima and Nagasaki, then a movie of the bomb burst and at Nagasaki and a final shot of the tower.

For night photo graphing - we took photos on Nov 9 over M.I.T. showing the exhibit area. A small tent was erected in the court with parts of the D-1 75mf 4000 V.

G-1 7mf 4000 V

and D-5 2400mf 4000 V.

Examples of pictures were shown on the walls of the tent.

I started class work again with 8 students in 6.11, Nov. 5. We cover machinery and electronics.

Notebook # 16

Filming and Separation Record

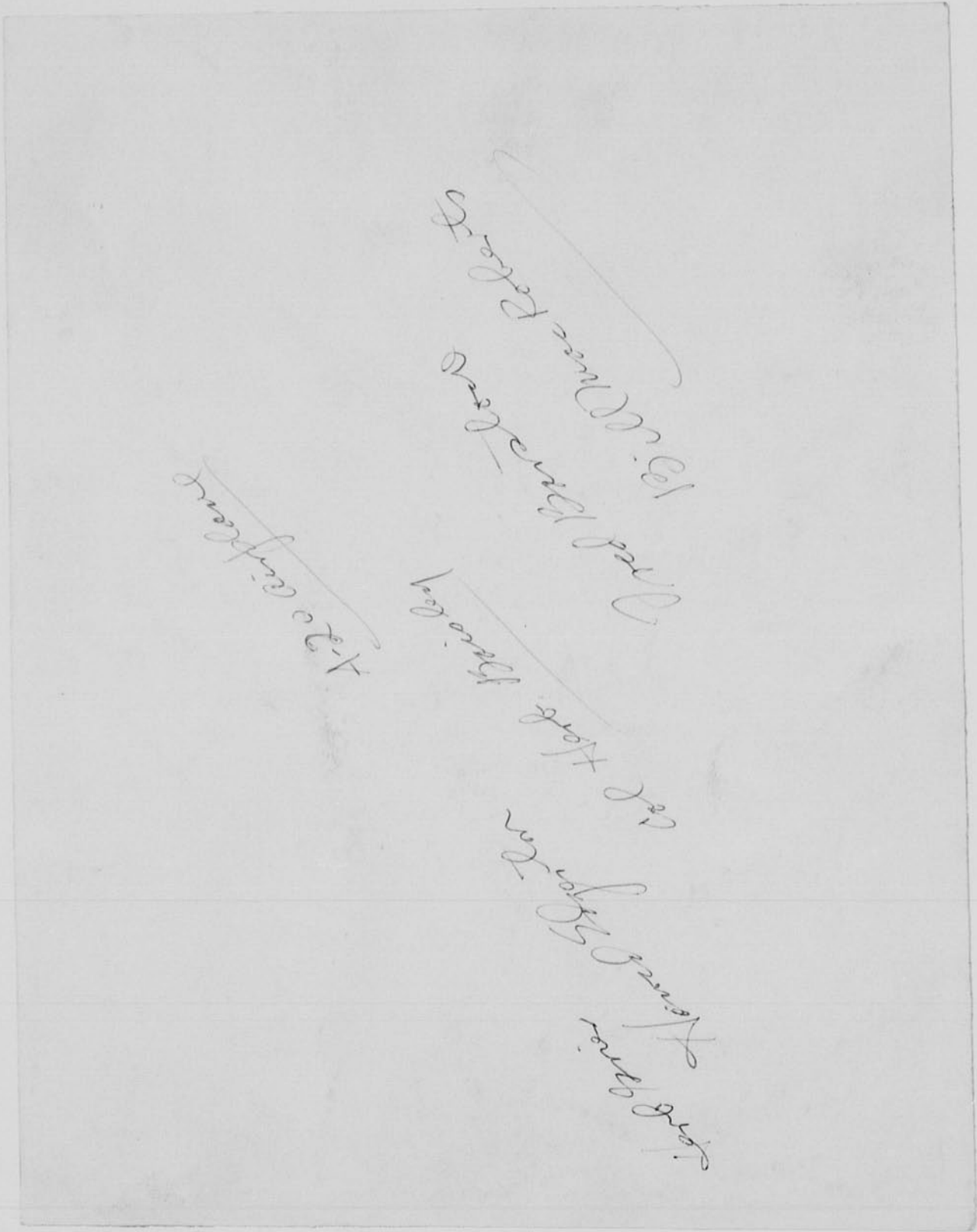
- 1 unmounted photograph(s)
- negative strip(s)
- unmounted page(s)
(notes, drawings, letters, etc.)

was/were filmed where originally located between page 106 and 107.

Item(s) now housed in accompanying folder.

Jan 17 1965 M.I.T.





1915 New Forest
Fred Marshall
New Forest

at York
Harradby

1915
Harradby
New Forest

1915
New Forest

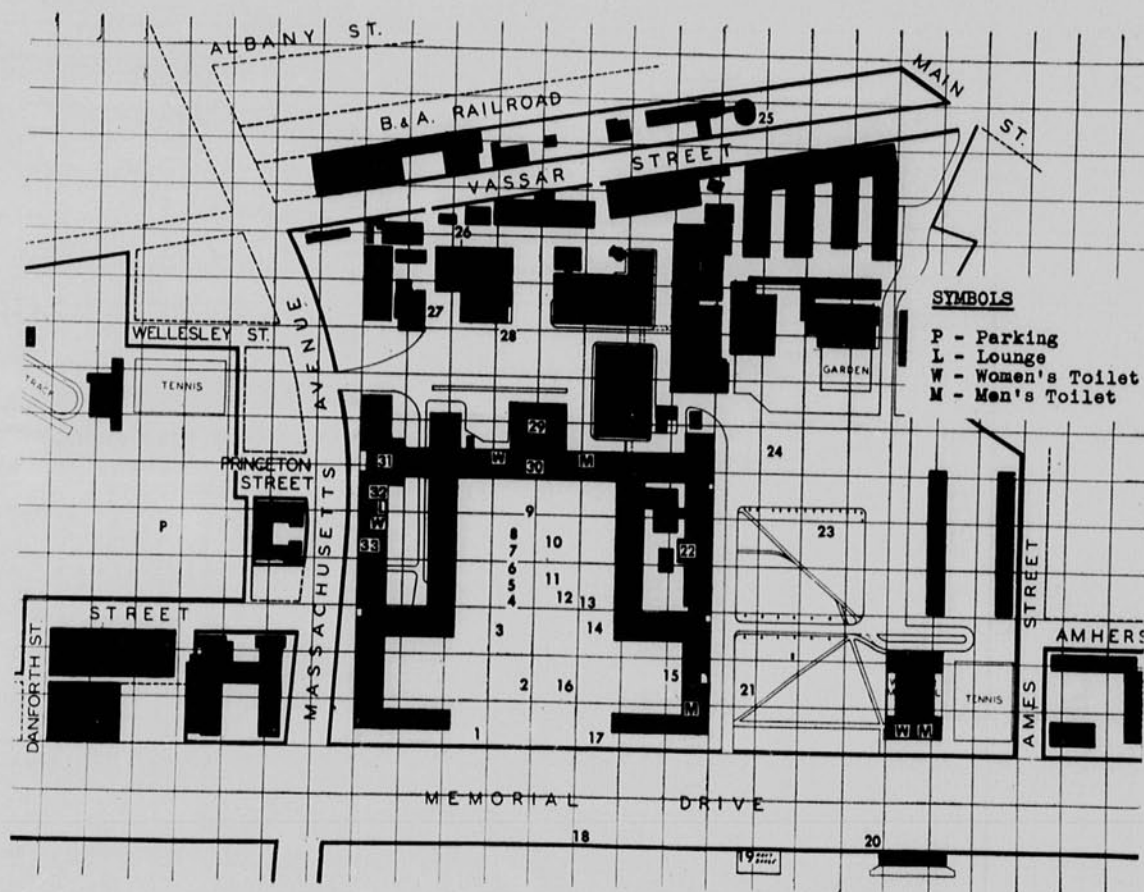
V I C T O R Y I N S C I E N C E

sponsored by
 MASSACHUSETTS WAR FINANCE COMMITTEE
 and the
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

NOV. 10-11-12, 1945

KEY TO EXHIBITS

1. Entrance
2. Radar (Directed Guns & Searchlights)
3. 40MM Director
4. Servo-Mechanisms-Aircraft Instruments
5. Guided Missiles
6. Signal Corps
7. Jet Propulsion
8. Fragible Bullets-Ordnance
9. RP-63-Aircraft
10. Miracle Harbor
11. Shock Waves
12. TBF Aircraft
13. Night Reconnaissance Photography
14. Light Beam Telephone
15. Navy Special Devices
16. V-1 Buzz Bombs
17. Exit (From Great Court)
18. Flame-Thrower Tank
19. Sonar
20. Navy Craft
21. Quartermaster Corps
22. Movies-Room 6-120
23. Helicopter Landing-Fire Fighting
24. Jet Propulsion
25. Van de Graeff-High Voltage Generator
26. High Voltage Generator
27. Wind Tunnel
28. Aircraft Engines
29. Atomic Bomb Movies 2nd Floor-Room 10-250
30. Navy Photographs-Ship Models
31. Power in the Pacific-Gun Models
32. Biology-Food Technology
33. Atomic Bomb Photographs



SYMBOLS

- P - Parking
- L - Lounge
- W - Women's Toilet
- M - Men's Toilet

In order to see all the exhibits, follow the numbers and the red arrows. When you leave the exhibit for special events, which will be announced over the public address system, it is suggested that you return to the exhibit you left and proceed in the designated order.

BUY WAR BONDS TODAY AND WIN THE PEACE

Nov. 20, 1945 M.I.T.
Harold E. Edgerton

Capt Tom Starnant. called from Washington today about flying the D-3 to Florida for service tests. He was under the opinion that it was not necessary to make these tests since the D-3 was similar to the D-5.

It may be that 28 D-5 units will be needed for partially outfitting 5 squadrons of night fighters.

2" long 2 mm I.D.
50 cm X-ray
↓

Ed Noel was here yesterday to talk about flash lamps. He was given samples of the data that Barstow took on the short tube.

Nov. 22, 1945. Calc. of flash tubes. Pressure and Stress.
assume
Argon filled tube 20" long 6 cm pressure
0.6 cm O.D. .4 cm I.D.

molecules per cubic cc at 20°C and 60 mm pressure

$$n = \text{Loschmidt number} \left(\frac{P}{760} \right) \frac{273}{T}$$

$$= 2.7 \times 10^{19} \left(\frac{60}{760} \right) \frac{273}{293} = 0.2 \times 10^{19} \text{ molecules per cubic cm.}$$

$$V = \text{Volume of tube} = 0.2^2 \pi 20 \times 2.54 = 6.38 \text{ cubic cm.}$$

$$\text{Total molecules} = V n = 1.27 \times 10^{19} \text{ molecules.}$$

$$\text{weight} = 1.27 \times 10^{19} \frac{1.66 \times 10^{-24} \times 40}{60} = 0.0842 \times 10^{-5} \text{ grams.}$$

Cobine P. 23.

$$* \text{ m.f.p.} = 10. \times 10^{-6} \frac{760}{60} = 1.27 \times 10^{-6} \text{ cm.}$$

$$* \text{ molecule r.m.s. velocity} = 4.13 \times 10^4 \sqrt{\frac{293}{273}} = 4.2 \times 10^4 \text{ cm/sec.}$$

the specific heat of argon gas is 0.133 cal. per gram.

$$WT \times S (t_2 - t_1) = \text{calories input.}$$

$$(t_2 - t_1) = \text{temperature rise.}$$

Consider 100 mf at 2000 volts and assume that all the energy discharges into the flash lamp.

$$\text{Energy in joules} = \frac{CE^2}{2} = \frac{100 \cdot 2000^2 \times 10^{-6}}{2} = 200 \text{ watt sec.}$$

$$4.18 \text{ watt sec} = 1 \text{ calorie}$$

$$\frac{200}{4.18} = 47.8 \text{ calories}$$

Solve for gas temperature assuming that entire energy goes into the gas

Dist. Cont. tables:
 $S = 20.9$ at 15° .

argm. per joule.

$$(t_2 - t_1) = \frac{\text{Calories input}}{\text{wt} \times S}$$

$$= \frac{47.8}{84.2 \times 1133 \times 10^{-5}} = 4.27 \times 10^5 \text{ degrees}$$

$$\text{pressure} = nkT$$

$$\begin{aligned} \text{Initial } p &= 0.2 \times 10^{19} \cdot 1.3708 \cdot 293 \times 10^{-16} \\ &= 2500 \times 10^3 \\ &= 80. \times 10^3 \text{ dynes per cm}^2 \\ \text{mm} &= \text{dynes / sq cm} \times \frac{1}{1335} \\ p &= \text{mm.} \\ &= 60 \text{ mm checks. } \checkmark \end{aligned}$$

at a temperature of 4.27×10^5 degrees K.

$$p = 60 \frac{4.27 \times 10^5}{293} = .872 \times 10^5 \text{ mm.}$$

$$p = \frac{1}{760} \cdot .872 \times 10^5 = 115.0 \text{ atmospheres} \quad \begin{matrix} \times 14.7 \\ = 1690 \text{ #sq inch} \end{matrix}$$

$$\text{area of cross section} = 1 \times .4 = .4 \text{ sq cm.}$$

per unit length

$$p = 115 \times .4 = 46.0 \text{ atmospheres per unit length}$$

$$\text{area of tube wall per unit length} = 2 \times .1 \times 1 = .2$$

$$\text{Unit pressure} = \frac{1690 \times .4}{.2} = 3380 \text{ lbs per sq inch. } \checkmark \text{ sq cm}$$

$$= \frac{230 \times 15 \times 2.54^2}{14400} = 22200 \text{ lbs per sq inch.}$$



$$(t_2 - t_1) = \frac{W}{wt \times S} = \frac{\frac{CE^2}{2} \times \frac{1}{4.18}}{\underbrace{r^2 \pi l}_{\text{vol}} \times m_H M \times \left(\frac{P_1}{P_0}\right) \left(\frac{T_0}{T}\right) S}$$

r = tube radius in cm.

l = tube length in cm.

N = Loschmidt no = ~~2.7~~ 2.7×10^{19} molecules/cm³

$(t_2 - t_1)$ = temp rise of gas. °C

W = $\left(\frac{CE^2}{2} \times \frac{1}{4.18}\right)$ energy in calories.

m_H = mass of hydrogen molecule

= 1.66×10^{-24} grams.

M = molecular weight

$\left\{ \begin{array}{l} A = 39.94 \\ Kr = 83.7 \\ Xe = 131.3 \\ Ne = 20.18. \end{array} \right.$

S = specific heat

S for Argon

" " Argon = 0.133 cal./gram.

" " Krypton

" " Xenon

$\frac{P_1}{P_0}$ = ratio of pressure in the tube

before discharge to N.P. $P_0 = 760$ mm

$\frac{T_0}{T}$ = ratio of temperature (Kelvin) of the gas

before discharge to N.T. $T_0 = 273$

$$\left(\frac{P_0}{P_1}\right) \left(\frac{T_0}{T}\right) r^2 \pi l N m_H M = wt \text{ in grams of gas in the tube}$$

$$\frac{1.3708 \times 10^{-16} \cdot 1.45 \times 10^{-5}}{8.36 \cdot 3.1416 \cdot 1.66 \times 10^{-24}} = \frac{1.98 \times 10^{-21}}{43.7 \times 10^{-24}} = 0.453 \times 10 = 45.3$$

$$.437 \times 10^{-22}$$

Max Palmer (N.Y.)
called. just back
from France. He was
the 155 Radar office.
Joe Condon. Photo office.
90 Wm J. Bourke
Phil, Pa.
2838
Agata St

address

pressure in dynes per sq. cm. = $n k T_2$

where n = concentration in molecules per cubic cm.
 $= N \left(\frac{P_1}{P_0} \right) \left(\frac{T_0}{T} \right)$

$T_2 = (t_2 - t_1) + 273$ degrees Kelvin.

$\approx (t_2 - t_1)$ since this is large compared to 273.

Pressure per unit length = $n k T_2 2r$ dynes per cm length.

Stress in wall material = $\frac{(n k T_2 2r)}{2a}$ dynes per sq. cm.
 per cm of length.

where a = wall thickness

To convert to pounds per square inch.

Stress = $\left(\frac{\text{dynes per sq cm}}{1333760} \right) \left(\frac{15}{1333760} \right) \frac{\text{baryes}}{\text{sq cm}}$

dynes $\times 2.248 \times 10^{-6}$ = pounds.

baryes $\times 1.45 \times 10^{-5}$ = pounds per sq inch.

Wall Stress = (baryes) 1.45×10^{-5}

$$= \frac{n k T_2 2r}{2a} \quad 1.45 \times 10^{-5}$$

$$= n k \left(\frac{C E^2 \frac{1}{2 \times 4.8}}{r \pi l \left(N m M \sqrt{\frac{P_1}{P_0} \frac{T}{T_0}} \right) S} \right) \frac{2r}{2a} \quad 1.45 \times 10^{-5}$$

$$= \frac{k C E^2 \frac{1}{2 \times 4.18}}{r \pi l a m_h M S} \quad 1.45 \times 10^{-5}$$

$$= \frac{k \cdot 1.45 \times 10^{-5}}{2 \times 4.18 \pi m_h} \times \frac{C E^2}{r l a M S} \quad \text{pounds per sq inch}$$

$$= 45.3 \frac{C E^2}{r l a M S}$$

C = ~~current~~ pounds
 E = volts

M = molecular wt.

r = tube IR cm.

l = " length cm

a = " wall thickness cm

S = specific heat.

Checks of stress equation.

argon gas

$M = 40$

$S = 0.133$

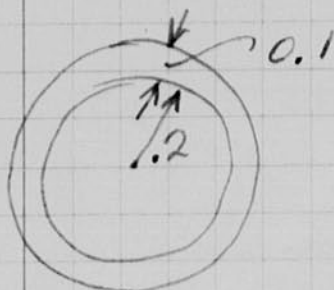
$C = 100 \times 10^{-6} \text{ farads.}$

$E = 2000 \text{ volts.}$

$r = 0.2 \text{ cm}$

$a = 0.1 \text{ cm}$

$l = 20 \times 2.54 = 50.8 \text{ cm.}$



$$\text{Stress} = 45.3 \times \frac{100 \times 10^{-6} \times 2000^4}{0.2 \times 0.1 \times 50.8 \times 40 \times 0.133} = \frac{18100}{5.41}$$

3340 #/sq inch

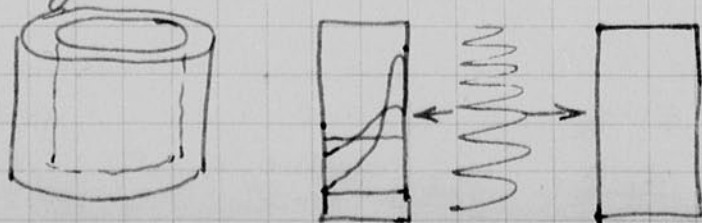
$$= \underline{33,400} \text{ pounds per sq inch.}$$

~~does not check by $\frac{1}{.15} = 6.66$ why?~~

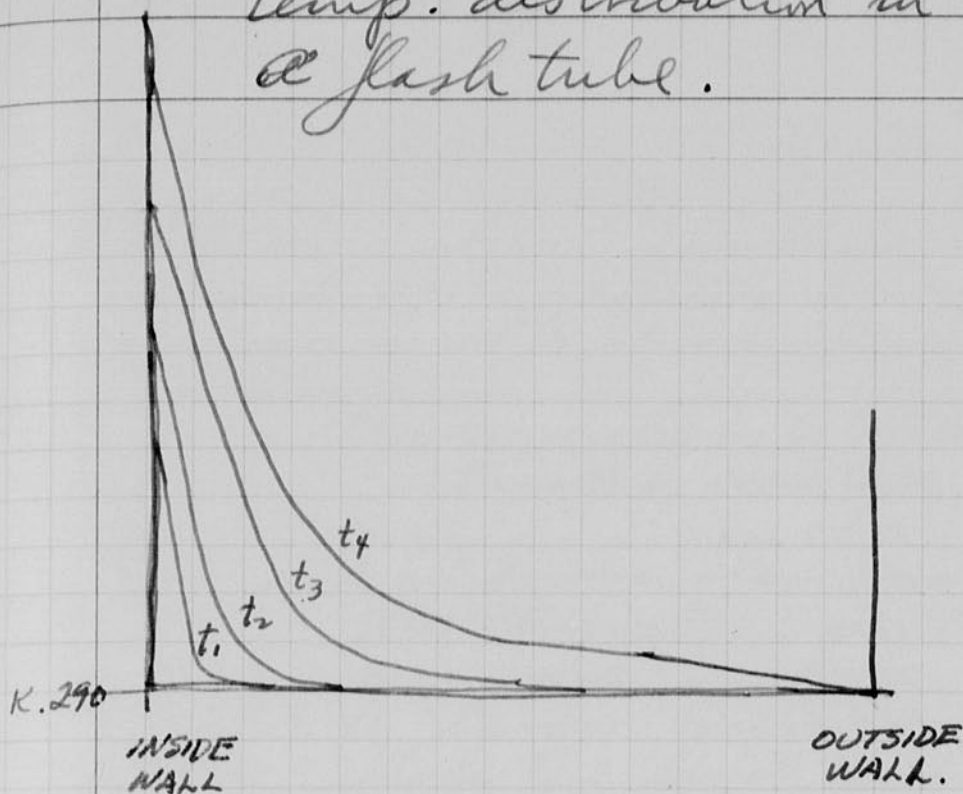
oh, now
there was an error in
p 109.

Tubes we use now do not explode and the above shows that the pressure on the glass is not excessive. ~~Short~~ Short tubes or high voltage - high capacity service have exploded, however the limit is usually crazing instead of explosion.

Crazing causes a network of small surface cracks on the inner surface of the tube. There should be some way to calculate the energy transfer to the glass wall as a function of time. I guess that crazing begins when the surface temperature reaches a temperature where the glass surface melts.



Temp. distribution in the wall of a flash tube.



Heat transfer

$$Q = K \frac{(t_2 - t_1) a T}{d}$$

p 1118 table

Heat capacity 1089

K for glass from table shows

Crown	.0025	avg. .002
flint	.002	
Soda	.0018	
Aluminium	0.514	
Copper	1.00 ±	
Argon - 0°	10000 389	
Quartz		.03 .16

Heat capacity

Crown	.161	0.15 average
flint	.117.	
Quartz		.189
Argon	.133	-180 T? p 1118.
Krypton		
Xenon		

Total volume of glass walls
 $= (3^2 - 2^2) \pi \cdot 20 \cdot \frac{2.5}{2.54} = 7.98 \text{ cm}^3$

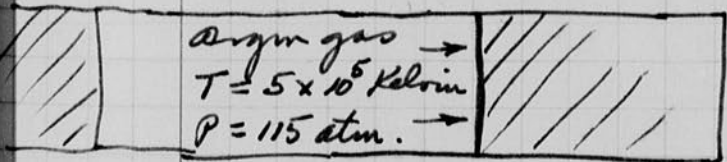
Total weight = 5 grams per cm³ × 7.98 = 40 gm.
 Heat cap = 0.15.

$$t_2 - t_1 = \frac{47.8 \text{ calories}}{40 \times 0.15} = \frac{47.8}{6} = 8^\circ \text{C.}$$

This is a lot less than the $5 \times 10^5^\circ \text{C}$ where the entire energy is calculated into the gas. p 109.

Sherwood suggests Schmidt method to calculate temp rise on surface wall.

Pyrex glass softens at 700°C .



glass walls.

Nov 24, 1947.
 James S. Egerton

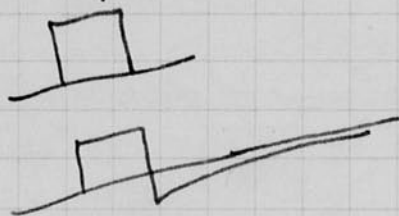
Connected Ballistic photo cell meter
 with a meter that Allen Stimpson
 brought in yesterday.

Do 41 Av 1034 Inter.

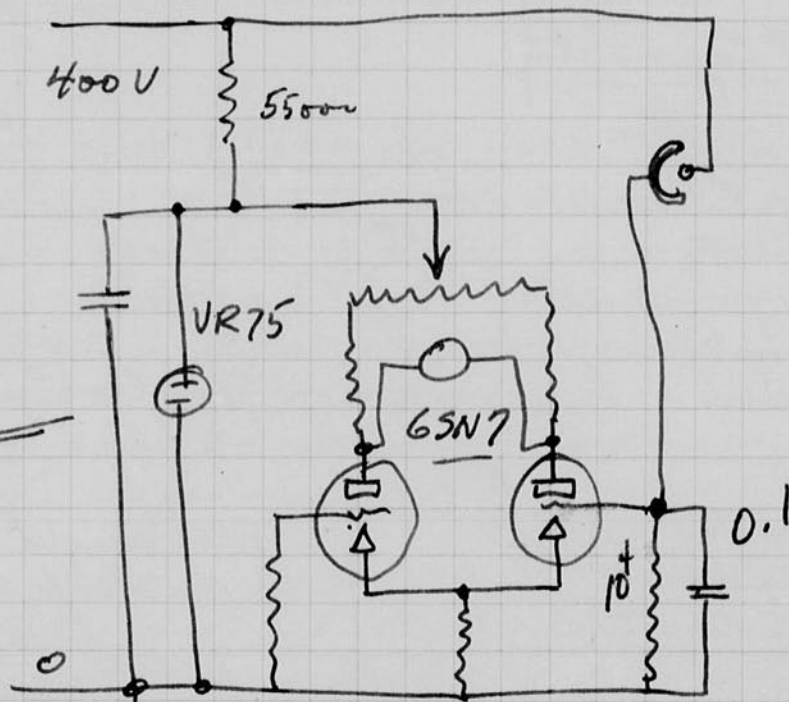
Scale $94^\circ 2.46''$

Turns	1500	
Torque	.060	Total.
F.S. current	12.22 ma.	
Resistance	1890 Ω	
Damping	none.	
Arm. wt.	.27 grams	moving system 0.429
type magnet	airciss	
Pointer	A021.	

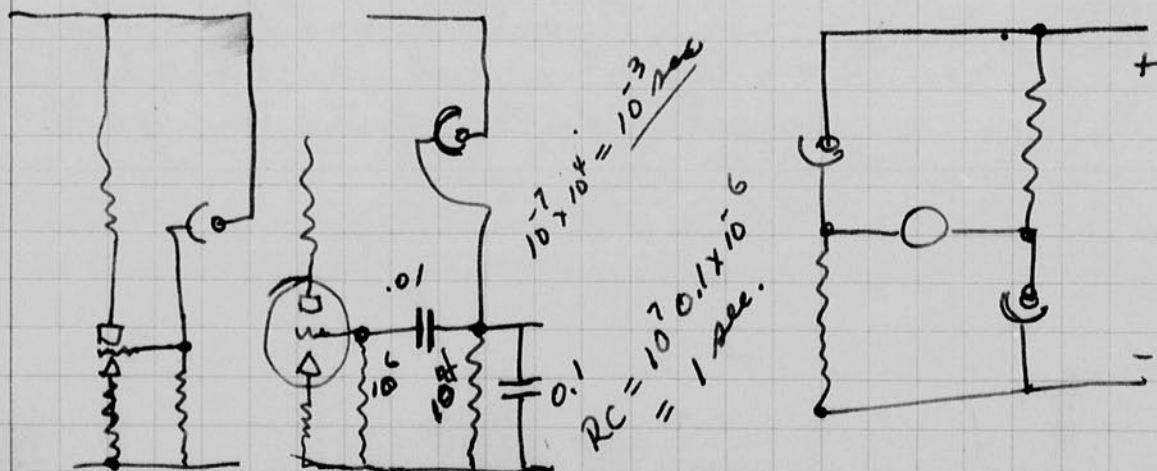
This was tried with
 Fred Barstow on
 Nov 25. Works ok
 with ordinary lights
 out.



$RC = .01 \times 10^{-6} \times 10^6 = .01 \text{ sec.}$



See p. 97



X N.G.

Nov. 26, 1945. Harold Egerton

Prof Knapp was here today from Cal. Tech. and talked to Grier, Gemeshausen and I about the high-speed flash unit at C.I.T. It was decided that further research work was to be done at M.I.T. and changes were to be recommended to the group at Pasadena.

1. Bypass choke is to be changed to a saturated core type.
2. a grid resistor may be inserted in the thyatron grid, 1000 ohms.
3. a larger condenser is to be used to block the high back from the C35 thyatron to the driver tube.

Chas. Wychoff arrived at my house from Washington on Sunday night. He returned the Jenkins camera, the fine flasher, and some strobo movie equipment.

On last Friday Nov 24 I went with Versuk to visit Hill in the electronics lab in Building 24. Versuk plans to set up a criteria for deionization of thyatrons as a master's thesis.

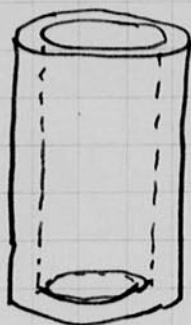
#60x17 = \$10.20 for 17 batteries ^{45V} as used by Herb Grier last night for 500V charger for portable.

Nov, 27, 1945

Harold Edgerton Flash tube for large energy.

Tubes at high energy have "crazed" surfaces due to local heating and cooling of the inner glass surface.

If the inner surface is chemically treated by dissolving the chemicals other than the SiO_2 , the surface could be made of SiO_2 .



Inner surface of tube is of SiO_2 due to dissolving of other components of glass.

A quartz SiO_2 surface should be able to take the heat without imparting crazes to the surface.

Read and understood.
 Frederick E. Barstow
 Feb. 9, 1946
 K. J. Gernsbauser
 1/9/1946

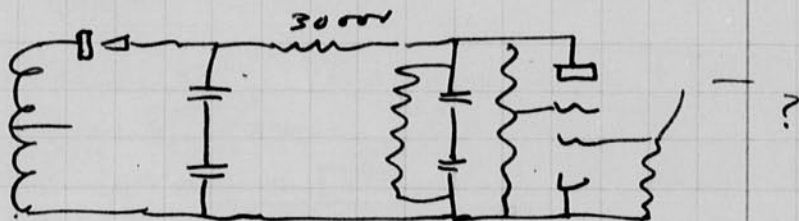
Dec. 4, 1945
 M.I.T. Harold Shapiro

Chas Wyckoff returned to Washington D.C. this noon after a week's search for living quarters. The housing situation is bad in Cambridge.

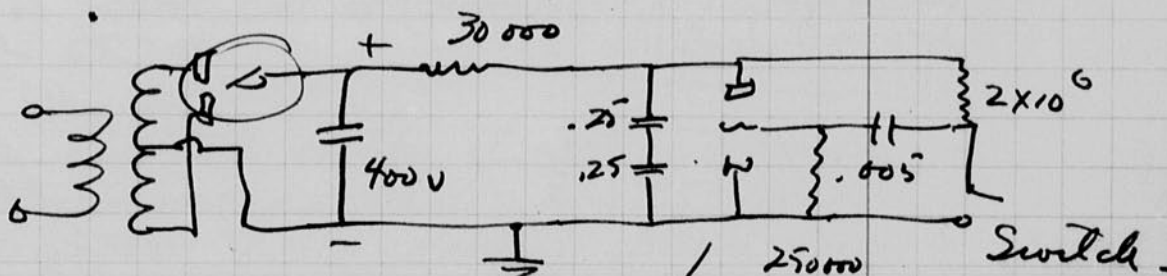
Prof Lewis Harris and [blank] brought over a sensitive thermopile (80 ohms) which we tested with the flash machine 28 mf at 2000 volts FT-14. A deflection was obtained with a galvanometer when the lamp was close to the pile. The scheme seems promising if more elements can be connected in series to give more output.

Dec. 7, 1945. Reconnected the stroboscope in Lewis Propeller Lab.

old circuit



new

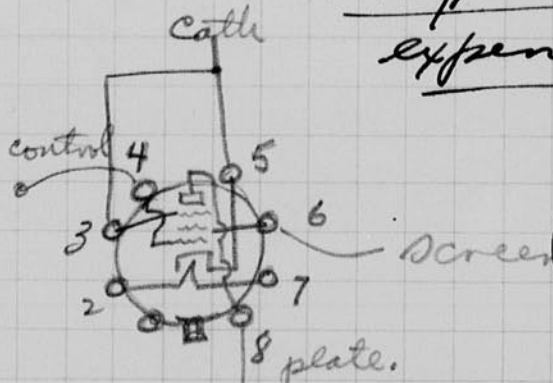
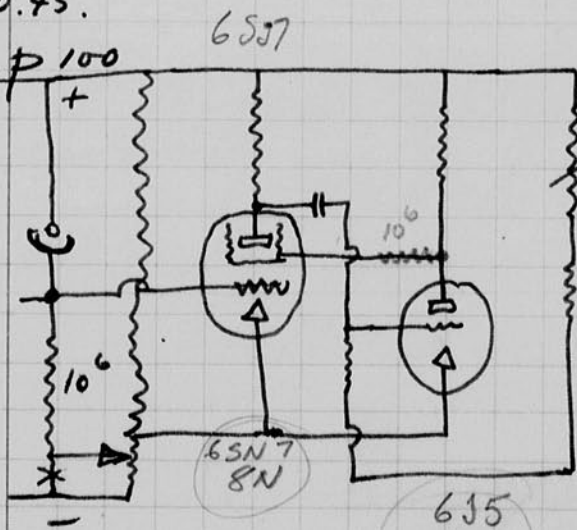


Krypton tube.
experimental.

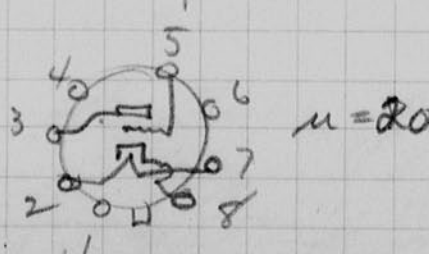
Dec 10. 45.

From p 100

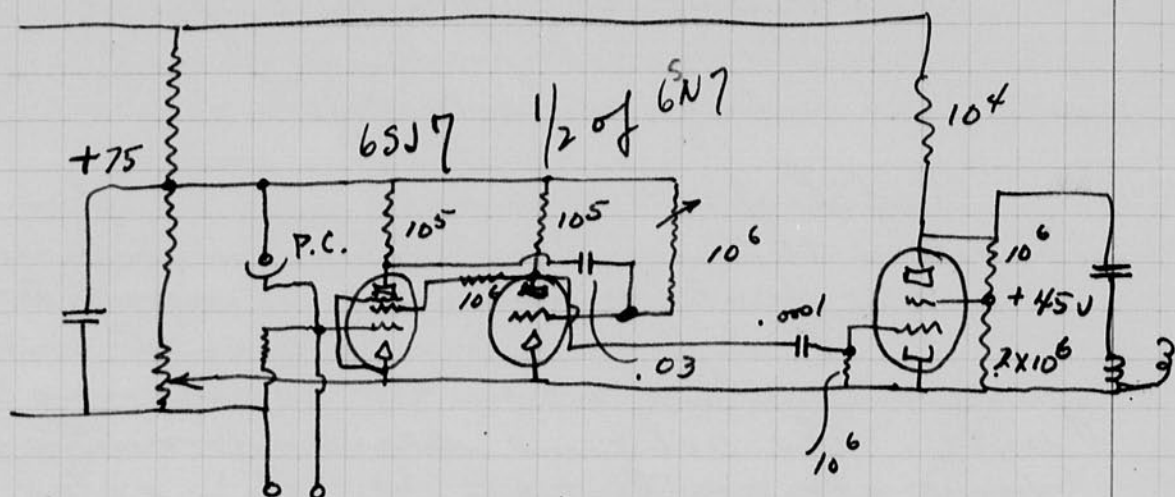
7E
 7U
 8AF
 8AJ
 8A5
 8AV
 8AY



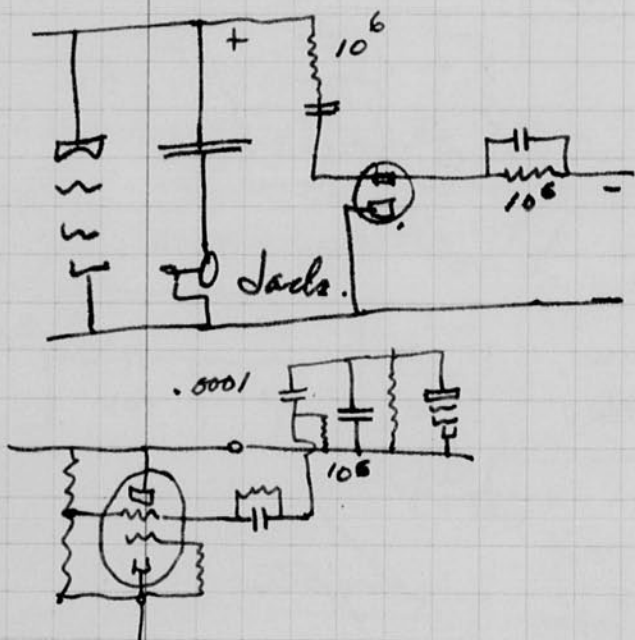
6N7 used before



118 Dec. 10, 1945. Time delay circuit cont.
 A.B. Egerton.



+ surge to start.
 crystal mike or flash sync.



a 65J7 was used as the pentode. I had to increase the 10^6 to $\frac{1}{2} \times 10^6$ in the triode plate to screen grid to get operation.

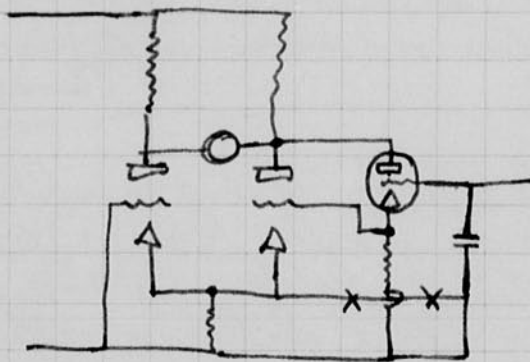
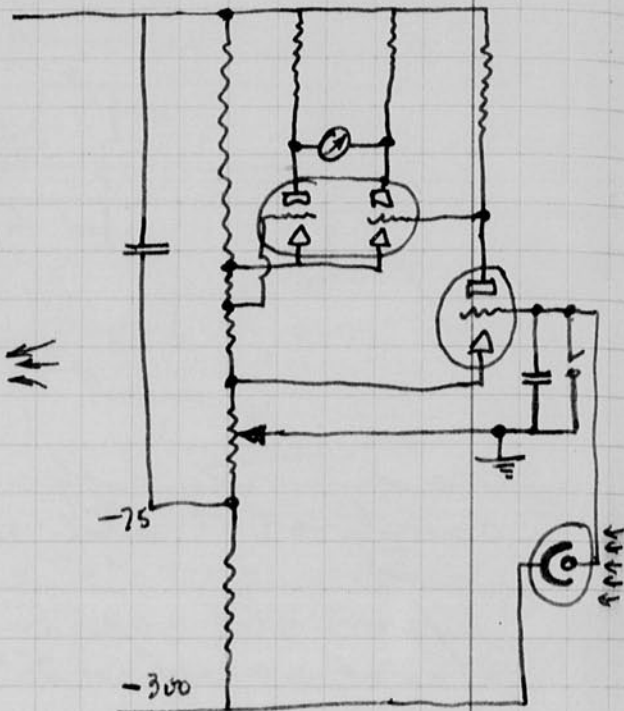
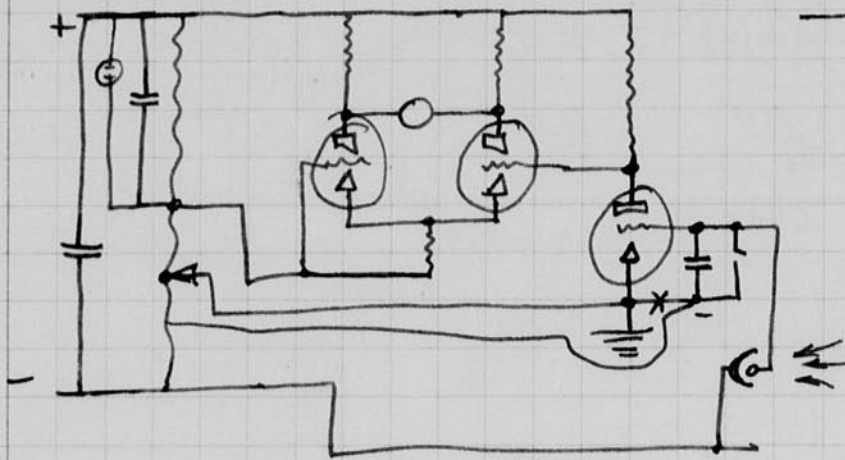
only one faster results when the surge hits the input grid.

Dec 13 1945

R.B. Edgerton

Alkerin and Marks who plan to set up a studio in Raymond's called. I introduced them to Wiggins and Jadenman for help.

AC Comparator (Light)



Time delay experiment.

$d = \frac{1}{2} a t^2$ Let $(t_1 - t_2) = .02$ sec. what is d_1 and d_2
also let $d_1 - d_2 = \frac{1}{12}$ ft.

$$(d_1 - d_2) = \frac{1}{12} = \frac{1}{2} a (t_1^2 - t_2^2) \approx \frac{1}{2} a .02$$

$$t = \sqrt{\frac{2d}{a}}$$

$$\sqrt{\frac{2}{a}} (\sqrt{d_1} - \sqrt{d_2}) = .02$$

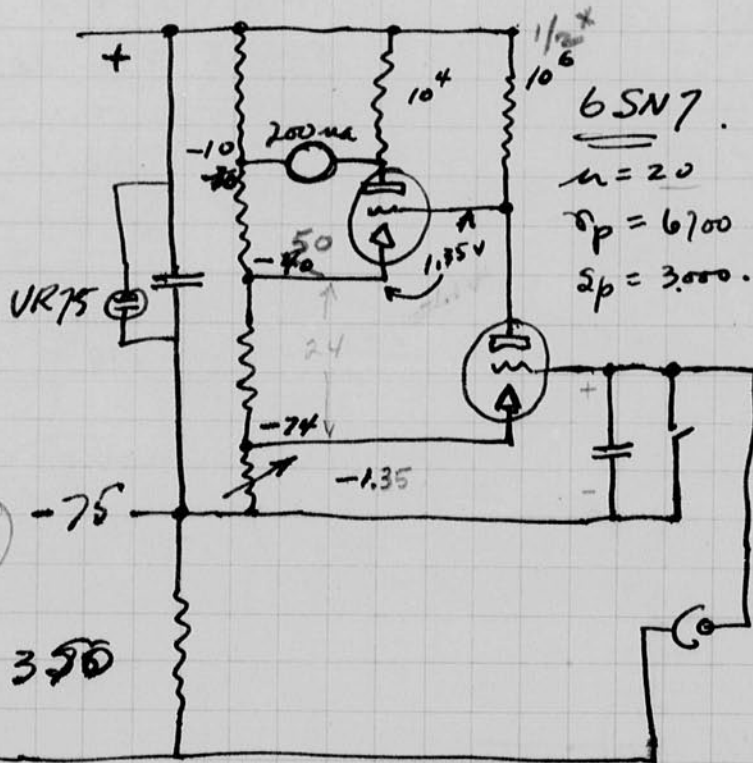
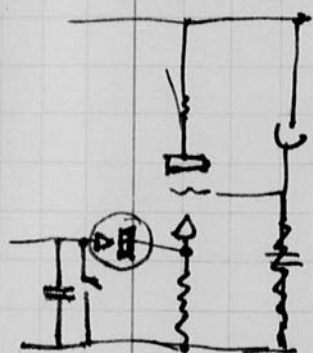
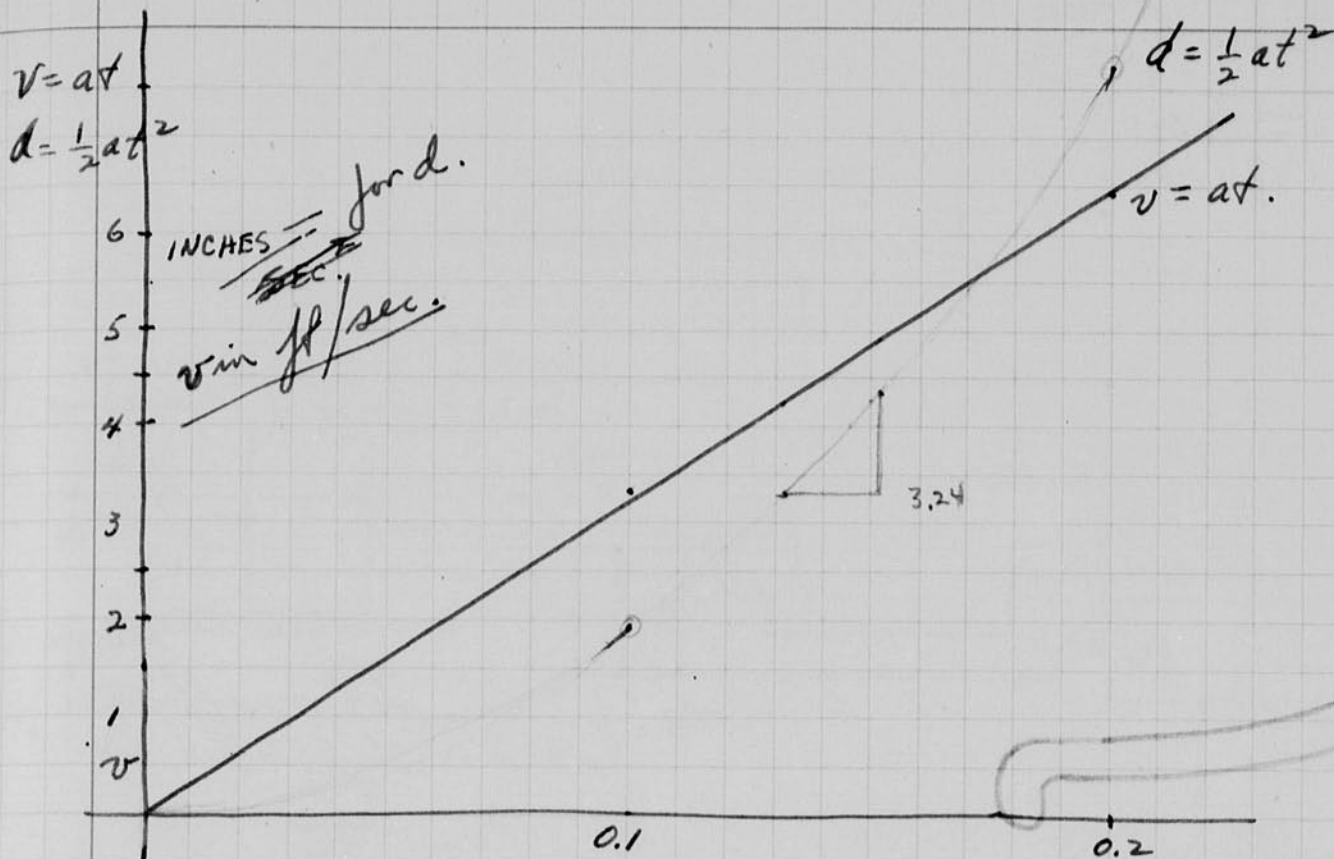
$$\sqrt{d_1} - \sqrt{d_2} = .02 \sqrt{\frac{a}{2}}$$

$$d_1 - d_2 = \frac{1}{12}$$

$$d_2 = \frac{1}{12} + d_2$$

$$d_2 = d_1 - \frac{1}{12}$$

$$\sqrt{d_1} - \sqrt{\frac{1}{12} + d_1} = .02 \sqrt{\frac{a}{2}}$$



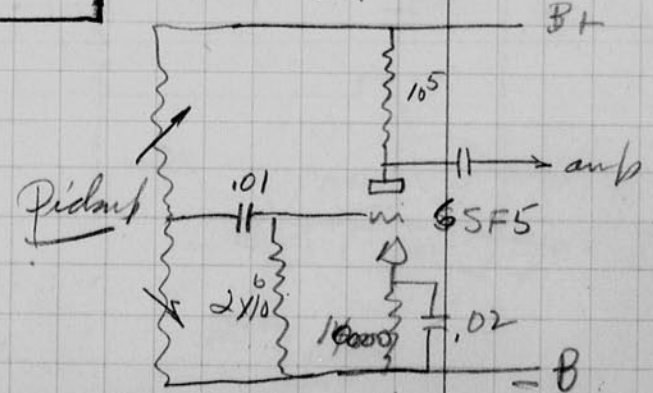
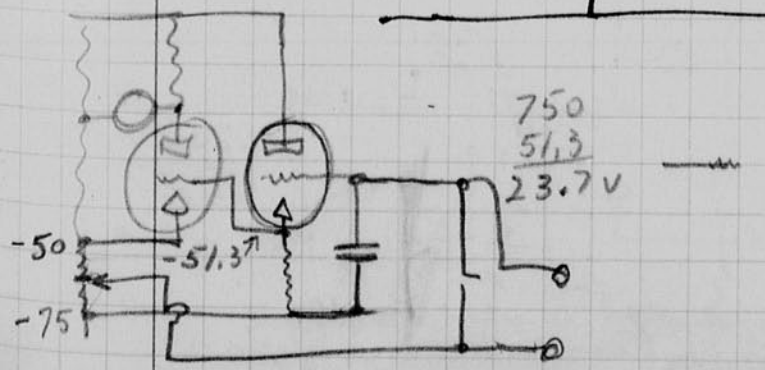
$.1 \text{ ma} \times 10^3 \times R = 50 \text{ SEC.}$
 $R = \frac{50 \times 1000}{.1} = 500,000$
 $I = \frac{10}{10^4} = 10^{-3} \text{ amp}$

$\frac{40}{10^6} = 40 \times 10^{-6}$
 $= 4 \times 10^{-5}$
 $I = 0.04 \text{ ma}$

3 ma per volt.
 0.2 ma for $\frac{3}{15}$ volt.
 .003 volts

OT VR105

Genaro amp circuit for pickups

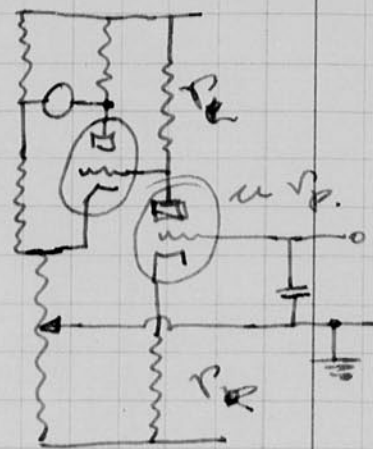
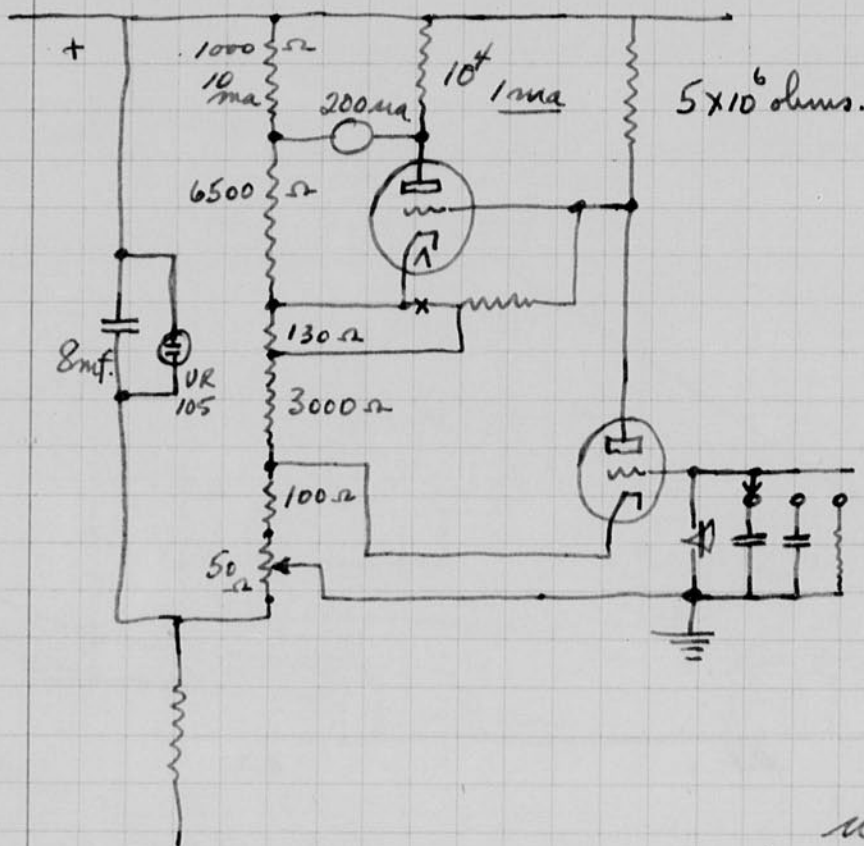


Dec. 16, 1945

Harold Edgerton

Integrating Light Meter.

.010 amp.
300. volts.
3 watts.



Let μ effective of this tube be 3.

$$\mu' = \frac{R_p \mu}{r_p + R_p + (1 + \mu) R_k}$$

Let $R_k = 10^5$

$\mu = 15$

$r_p = 10,000$

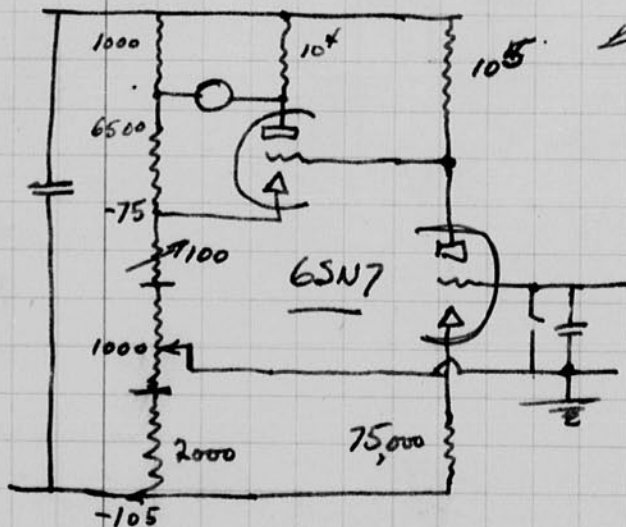
$R_k = ?$

$\mu' = 3.$

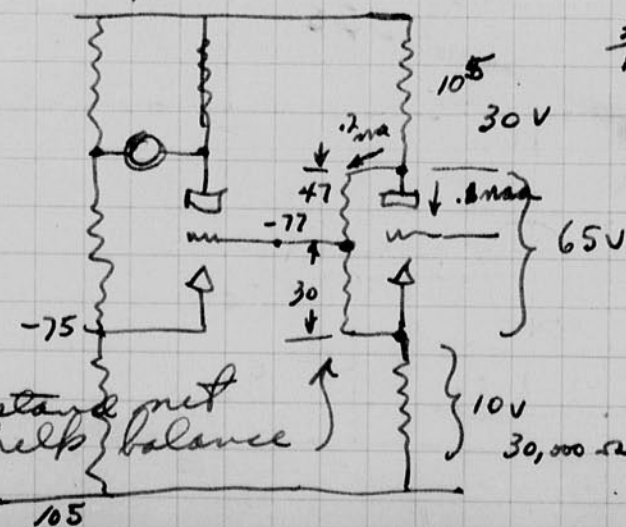
$$3 = \frac{15 \cdot 10^5}{10^4 + 10^5 + (1 + \mu) R_k}$$

$$3(10^5 + 16 R_k) = 15 \times 10^5$$

$$R_k = \frac{15 \times 10^5 - 3 \times 10^5}{16} = \frac{12 \times 10^5}{16} = \frac{3}{4} \times 10^5 = 750,000.$$



This circuit may not balance for zero since the plate voltage may be too positive.



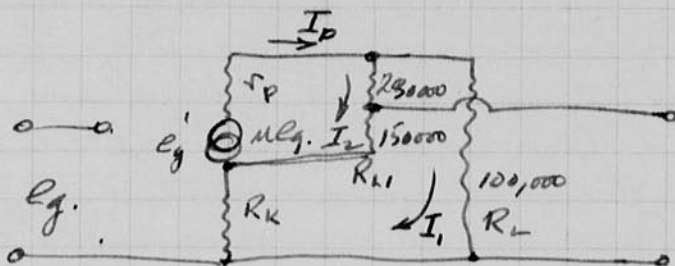
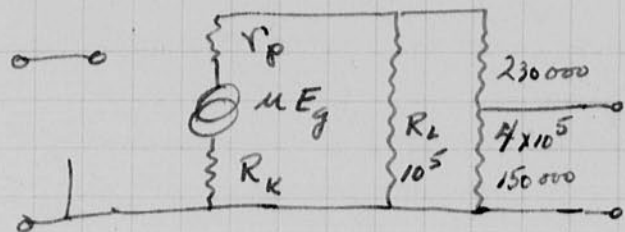
$$\frac{30}{10^5} = .00030 \text{ amps} = 3 \text{ ma.}$$

$$\frac{72}{.2 \times 10^{-3}} =$$

$$\frac{3800}{232,000} = 150,000$$

Resistor net to help balance

effective amplification of the first tube.



1st stage.

~~450~~ -2.2 0
 $E_p = 52V$ -2.1 200 ma.
 8V on load.

2 stages .35V for 200ma.

$$I_p = I_1 + I_2$$

$$I_2 \approx \frac{\mu e_g'}{r_p + 38,000}$$

$$I_p = \frac{\mu e_g'}{r_p + \frac{R_L \times R_{L1}(1 + \frac{R_k}{R_L})}{R_L + R_{L1} + R_k}}$$

neglect the network.

$$n' = \frac{\mu R_L}{r_p + R_L + (1 + \mu)R_k}$$

$$= \frac{15}{20} \frac{10^5}{10^5 + (16) 30,000} = 2.54$$

$$\frac{480,000}{110,000} = 4.36$$

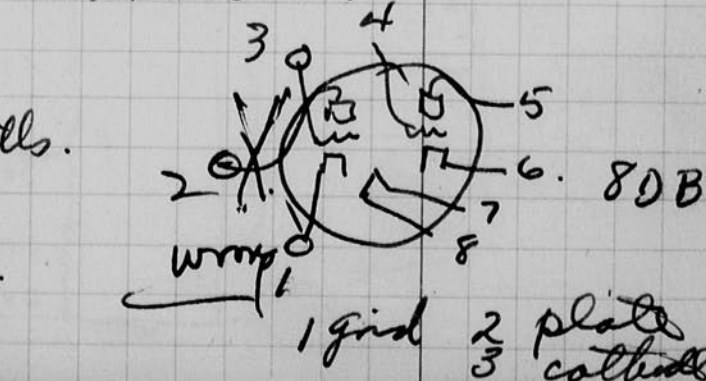
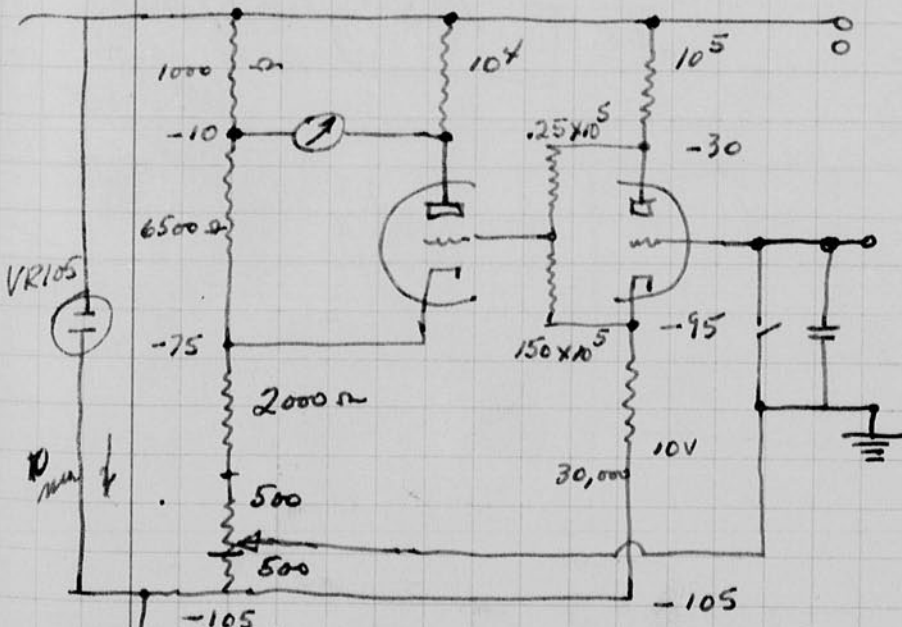
$$\frac{480,000}{590,000} = 0.81$$

the actual amp. will be 1/2 more due to effect of resistance net on self bias.
 (2) less due to resistance split.

Tube conditions

$E_p = 65V$
 $I_p = 0.1 ma$
 $E_b = -1. ?$

If E_b is close to -.9 or less, there may be electron grid current which will be excessive.



$$\frac{245}{.011} = 22300 \Omega$$

assume 10 ma in glow

$$\frac{245}{.021} \approx 11,000 \text{ ohms}$$

$$\frac{65^2}{65.00} = .65 \text{ watts}$$

$$\frac{245^2}{10^4} = 6 \text{ watts}$$

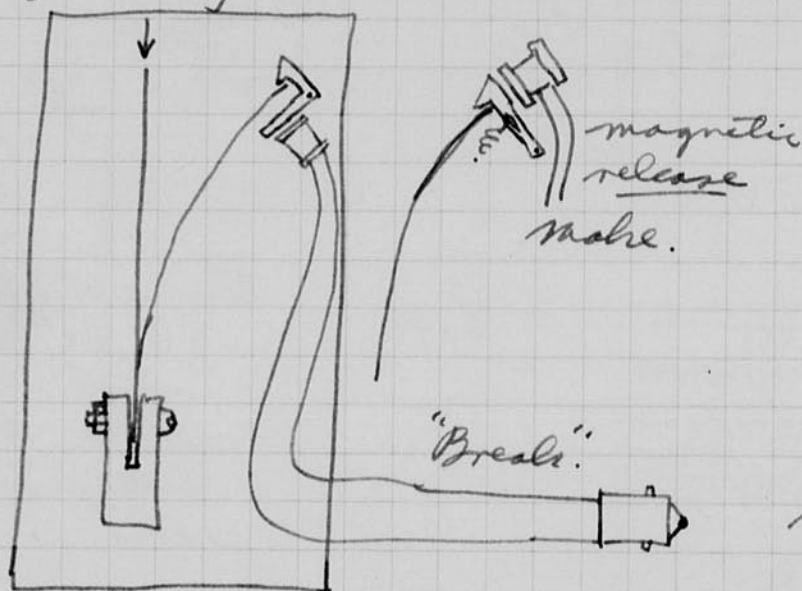
-350V

1 grid 2 plate 3 cathode

Dec 16 1945
Harold Edgerton.

Flash bulb-Synchronizer tester.

The method described shows a mechanical method of testing a shutter for synchronism. The time delay element is a spring cantilever spring that is released by the trip current of the shutter. A permanent magnet holds the spring and is released by the trip current of there is a catch that releases the spring at the desired moment.

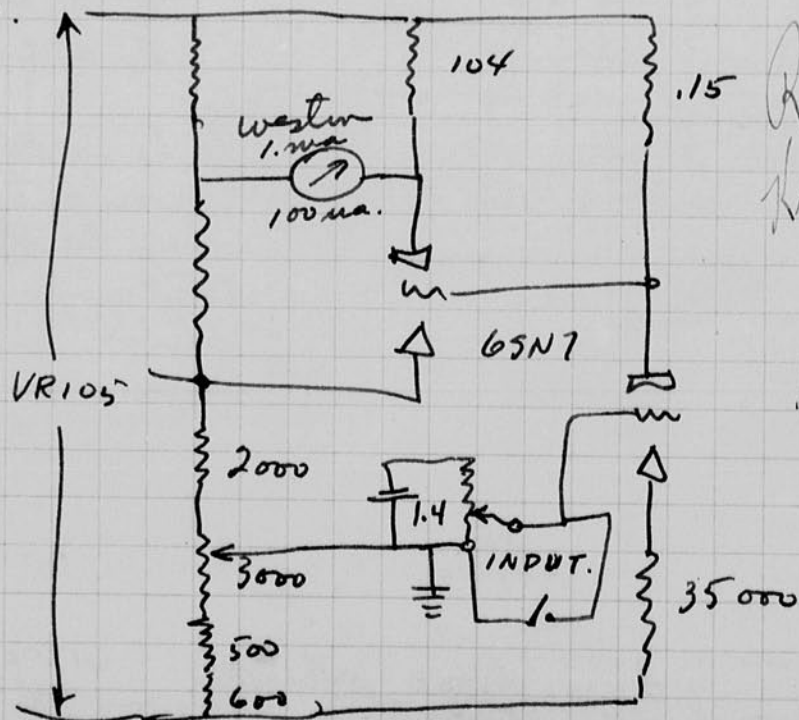


The spring should be tensioned so that one cycle is covered in .08 seconds. The zero at .02 seconds will then be opposite the arrow.

10x35w 3.5w.

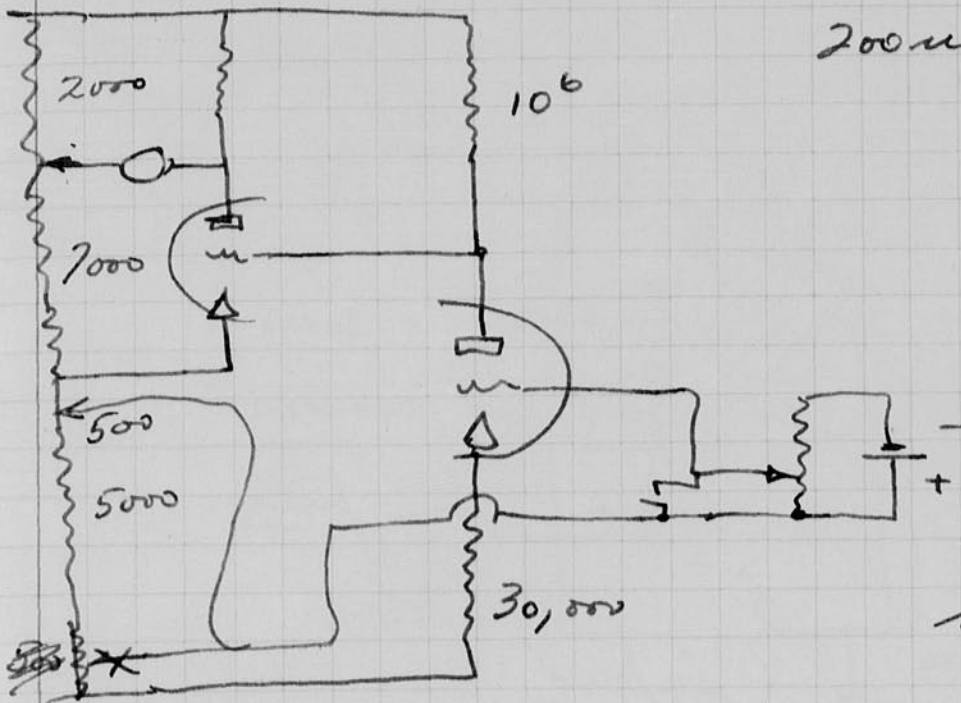
$$\frac{1}{.08} = 12.5 \text{ cycles/sec.}$$

Dec. 17, 1945.



Read + understood
Herbert J. Green
Dec. 16, 1945
12-17-45

Cont.
Circuit changed to.



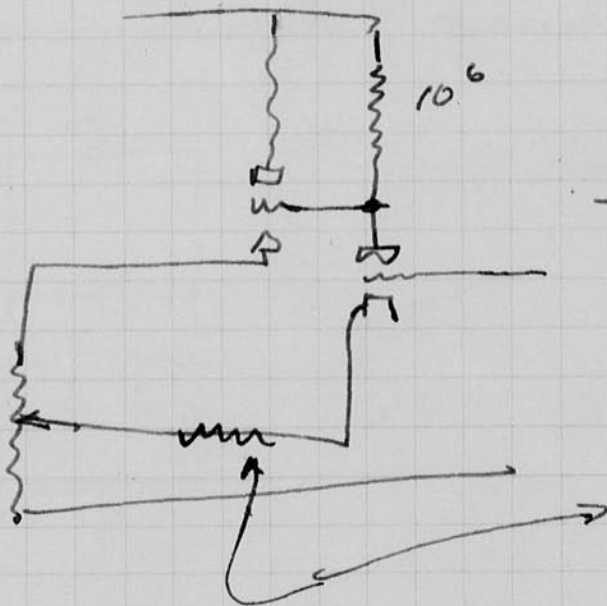
200 μ a - 0.25 volts.

$$u = \frac{\mu R_L}{R_L + R_g (1 + \mu)}$$

$$= \frac{30,000}{30,000 + 16 \times 180,000}$$

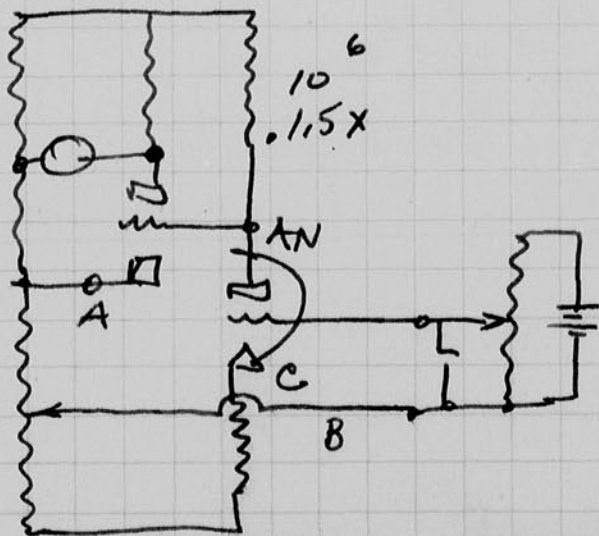
$$= \frac{30,000}{30,000 + 2,880,000}$$

$$= \frac{30,000}{2,910,000}$$



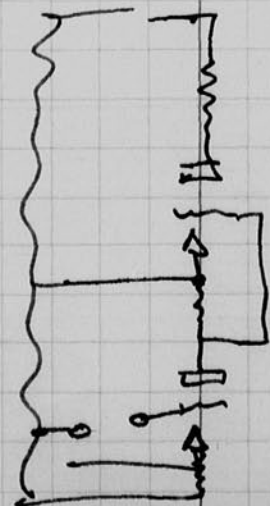
This gives 600 μ a with .05 volts. It is too sensitive! Balance drifts badly.

5000 ohms added here.
200 μ a - 1025 volts input.



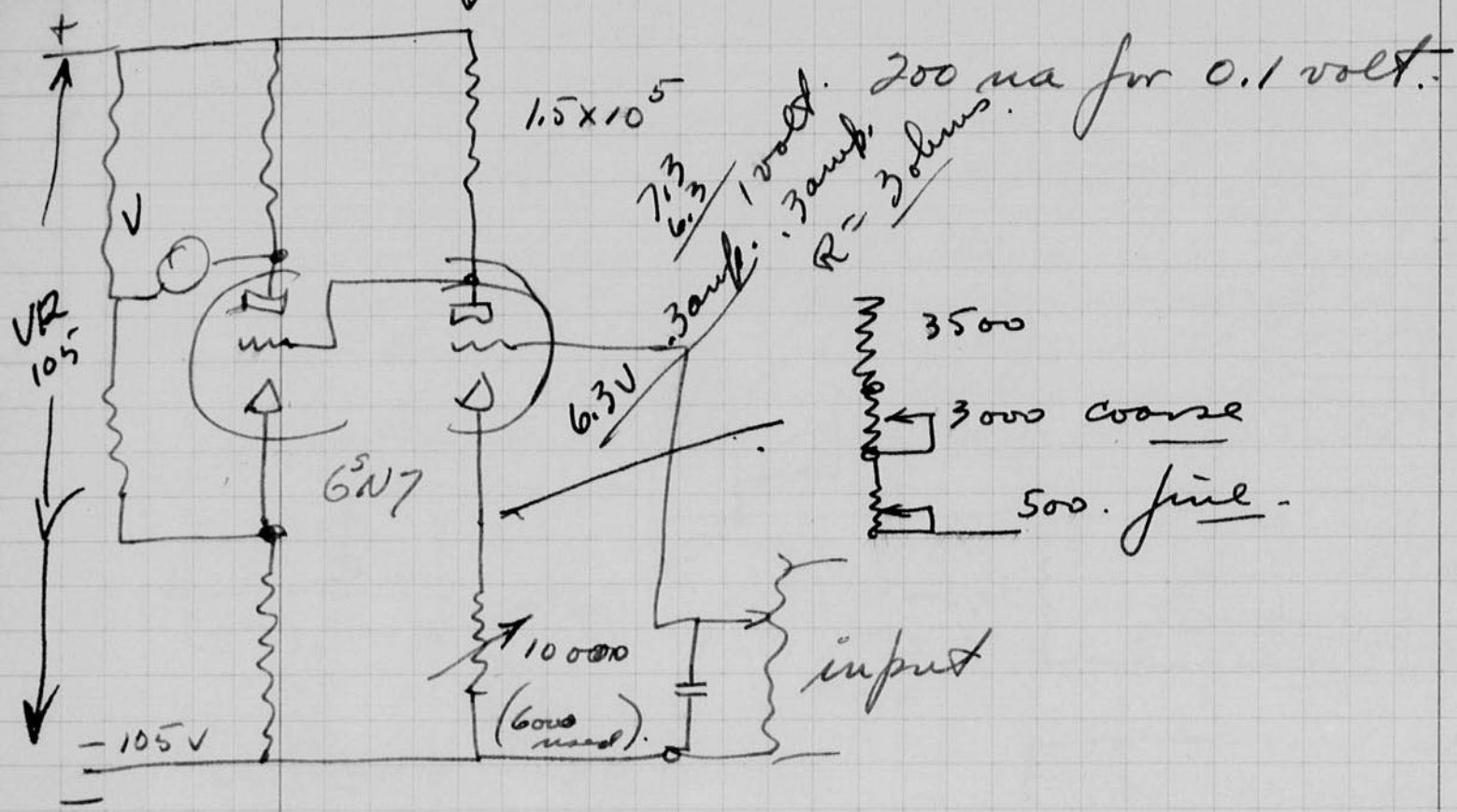
RCA Volt ohmmeter shows

- A-B 0
- A-C -3.5
- A-AN -3.5 ?



stability
with volts;
NG.

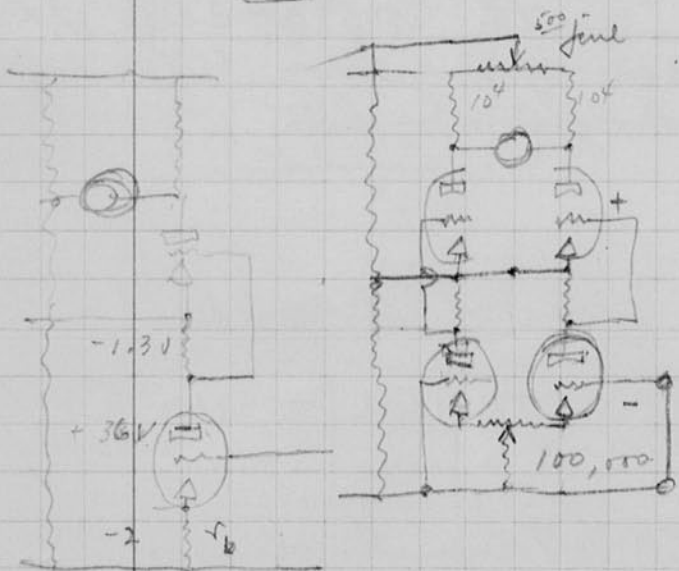
110	160 ma.	114
115	15 ma.	114
120	-100	114



1.3 volts.

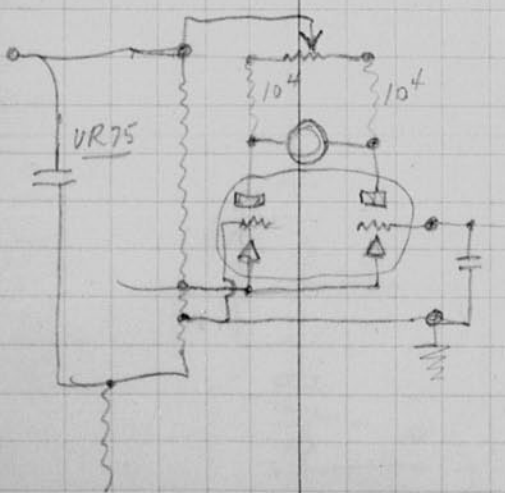
$\mu = 15$

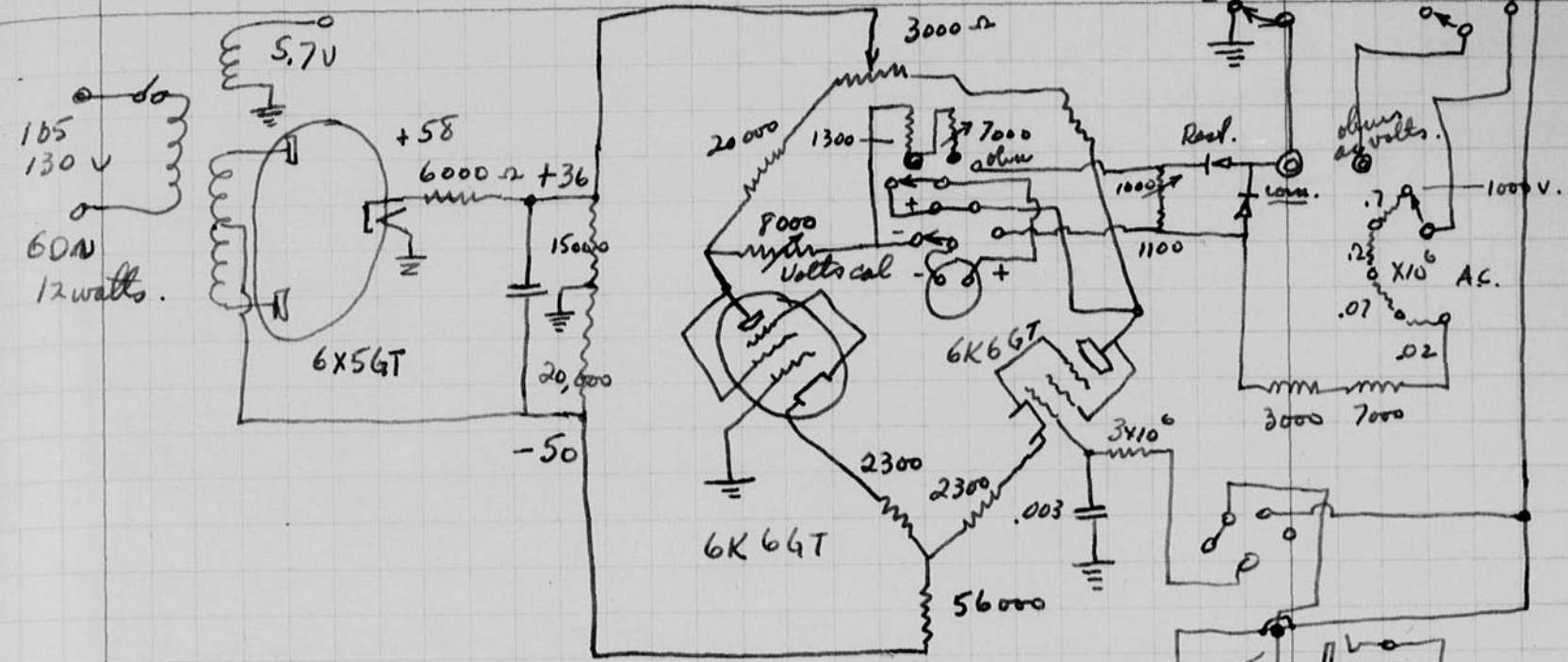
$r_p = 10,000$



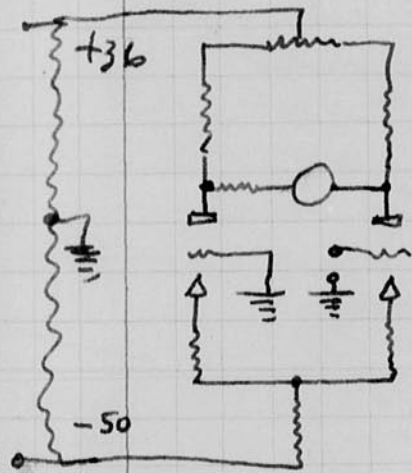
Let $i_p = 10^{-6}$ amp.
 $\frac{2.0 \text{ volts}}{10^{-6}} = 2 \times 10^6 \text{ ohms.}$
 $i_p = 10^{-5}$ amps
 $R = 2 \times 10^5 \text{ ohms.} = 200,000 \text{ ohms.}$
 $10^{-5} \times 6000 = .006000 \text{ volts.}$

V gain of four needed. plus filament comp.

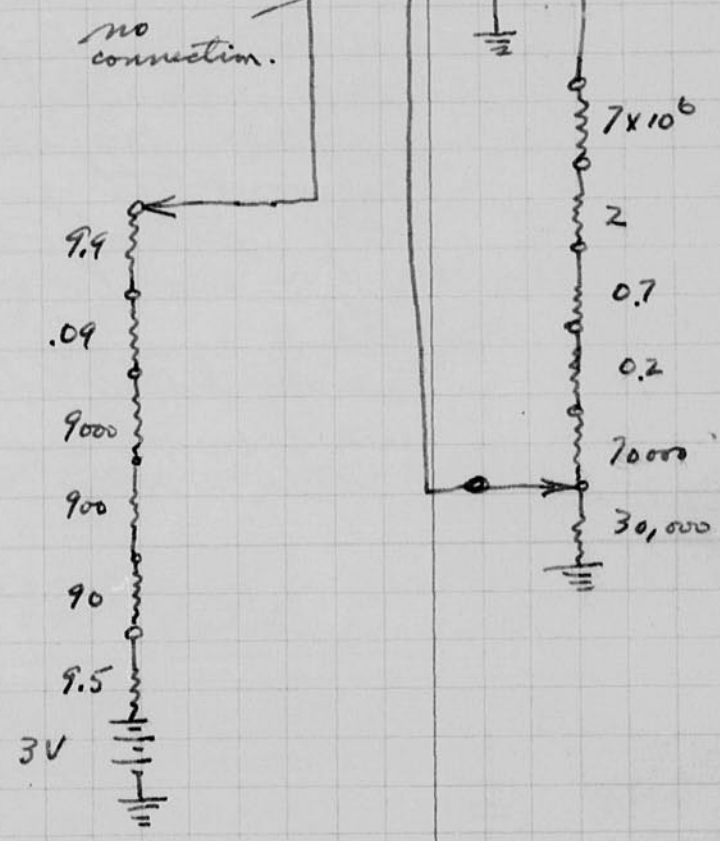




? 1300 ohms in "+" position corrects for tube characteristics



3 volt scale.

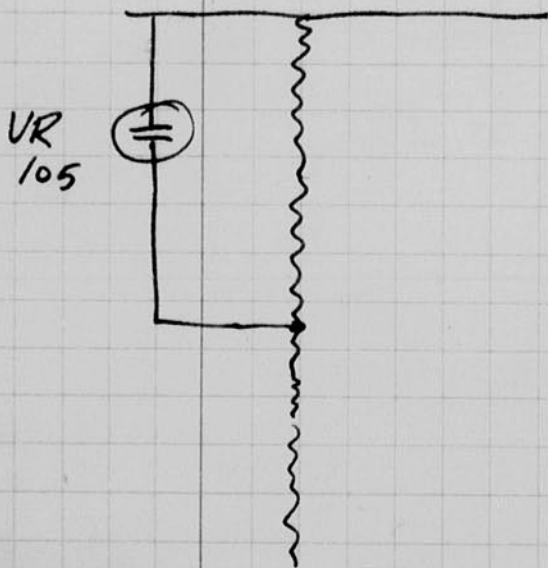


Dec. 18, 1945
Harold Edgerton.

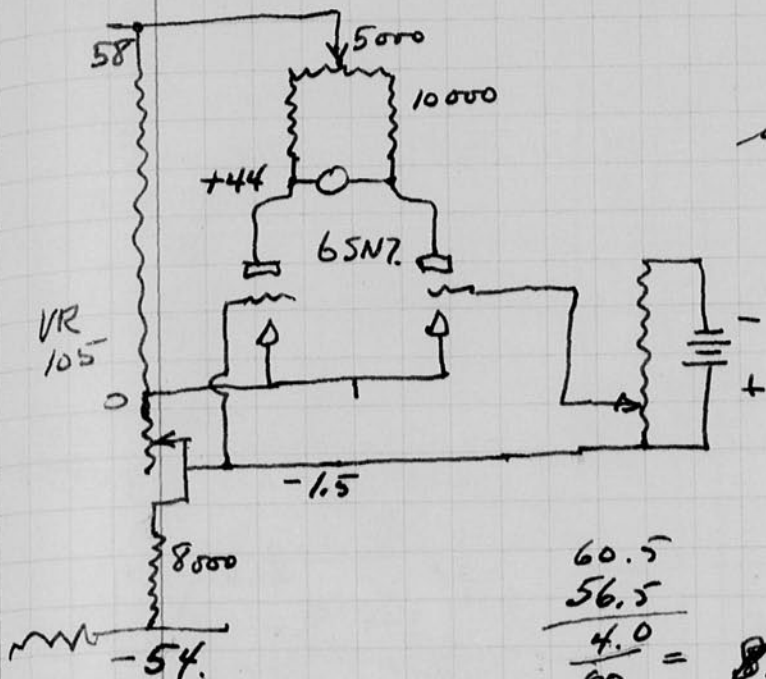
Conference this morning at G.K. in
Richmond's office with Thiessen,
Sylvania Belms and Road.
Gemeshausen Grier and myself.

We discussed the names, Strobotac,
Strobolux and Strobotum. Hygrade
will cease to use the first two names.
They will not distribute the
648 Strobolux lamp. The Strobotum
will be sold under the RMA
number 1R 21 (?).

Road mentioned the Sylvania
might wish to sell a Stroboscope
job #25. Richmond agreed that
this would be satisfactory as long
as the price did not reach
more than $\frac{1}{3}$ of the price of
the Strobotac. Sylvania will
approach us for a license if
they wish to go ahead and we
will take it up with G.K. since
we have an exclusive agreement
with G.K.



Sens. 0.18 volts - 100 ma. 115 volts



ma.	I. grid	I. Grid 0.1	E _{input}
25	→	58.5	105
2	←		
			125.
			125.

↑ when ~~set~~ went off scale negative for 20 m set ± then settled down at

$$\frac{60.5}{60} = 8.70 \text{ with } 105 - 125 \text{ change.}$$

The regulated voltage is about ~~125~~ 115 and holds ~~at~~ 115 ± 1 for 105 to 125. The change in sensitivity must be due to the change in filament temperature?

The plate voltage changes from 47 at 105 to 43 at 125 due to increased filament temperature.

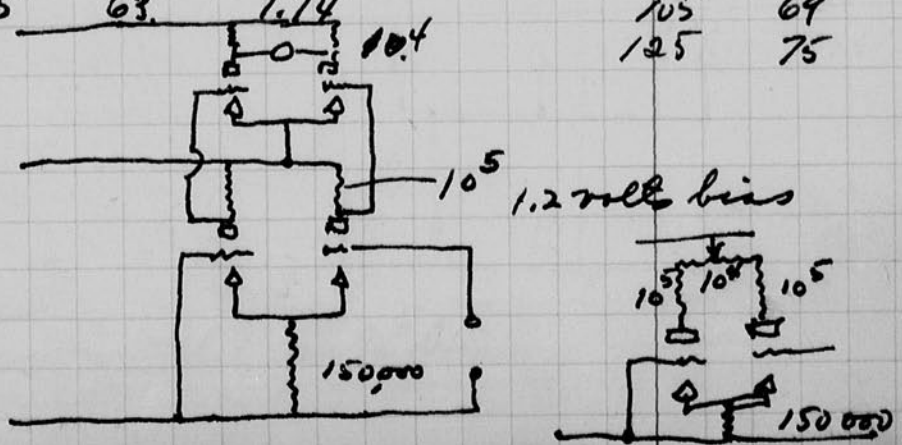
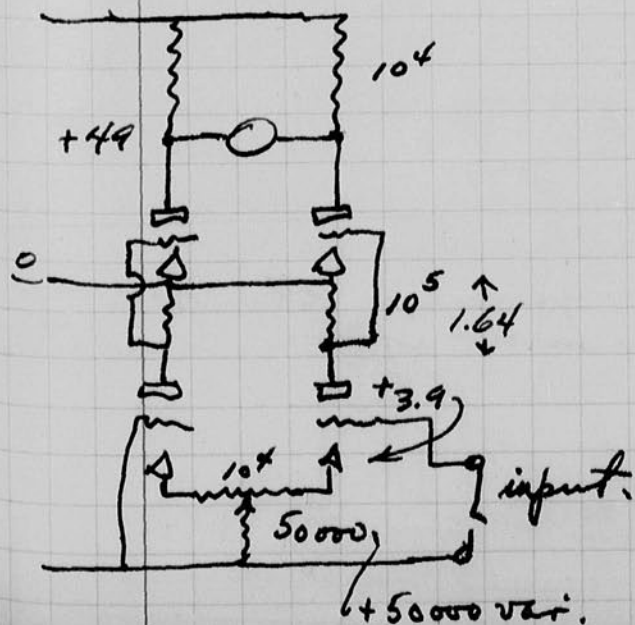
Compensation, change bias to hold E_p = const.

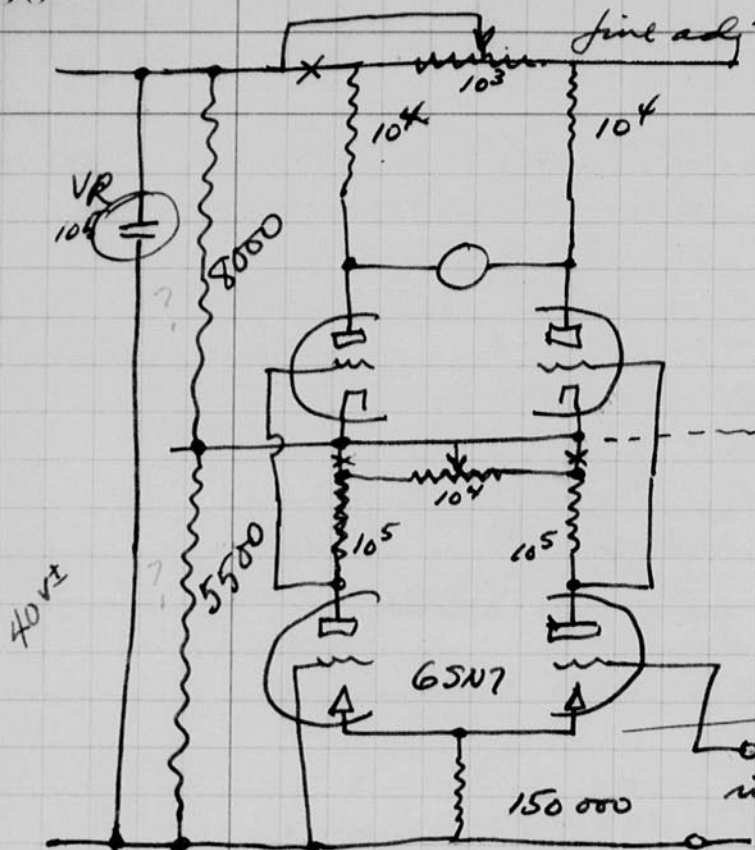
V	ma/0.1	E _p	E _b	Grid
105V	57.5	45.5	-1.48	1.48
125	57.	*45.5	-1.74	1.50

} .26 change of grid volts reqd. for compensation.

Sens. 115 volt. 200 ma for 0.105v.

V	ma/0.05v.	E _p
115	65	1.64
125	68	1.64
105	63	1.74





ac.	105	125
+ 58	58.5	58.

44	45	43
----	----	----

10^4 variable should be 2×10^4

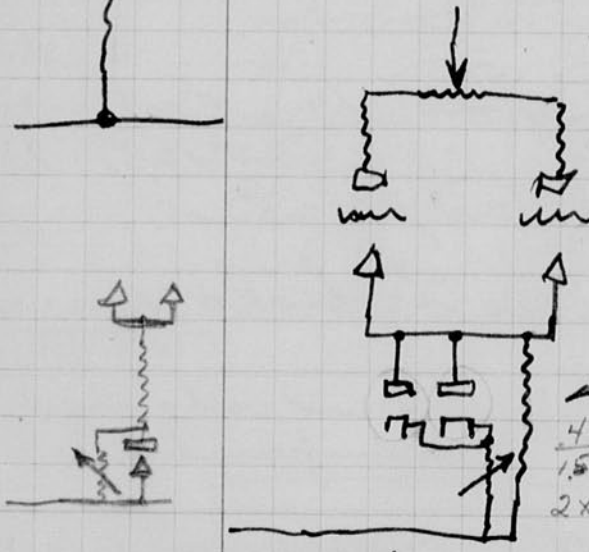
- 1.3	- 1.15	→ 1.23
	1.23	→ 1.33

0.1 change

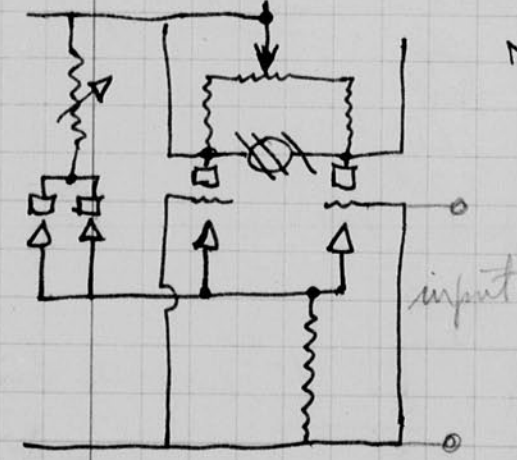
- 51.5	51	51.5
	39.5	
- 54.5	54	54.5

4.2 bias

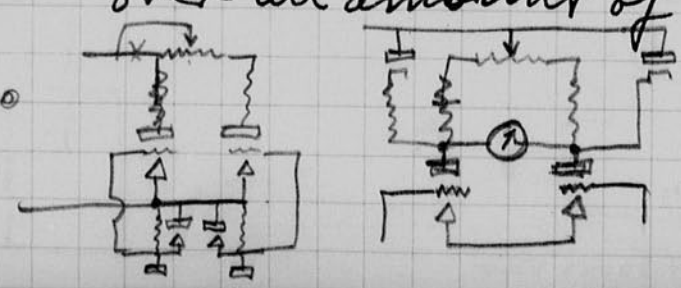
71	<u>71.</u>	<u>75-76</u>
---------------	------------	--------------

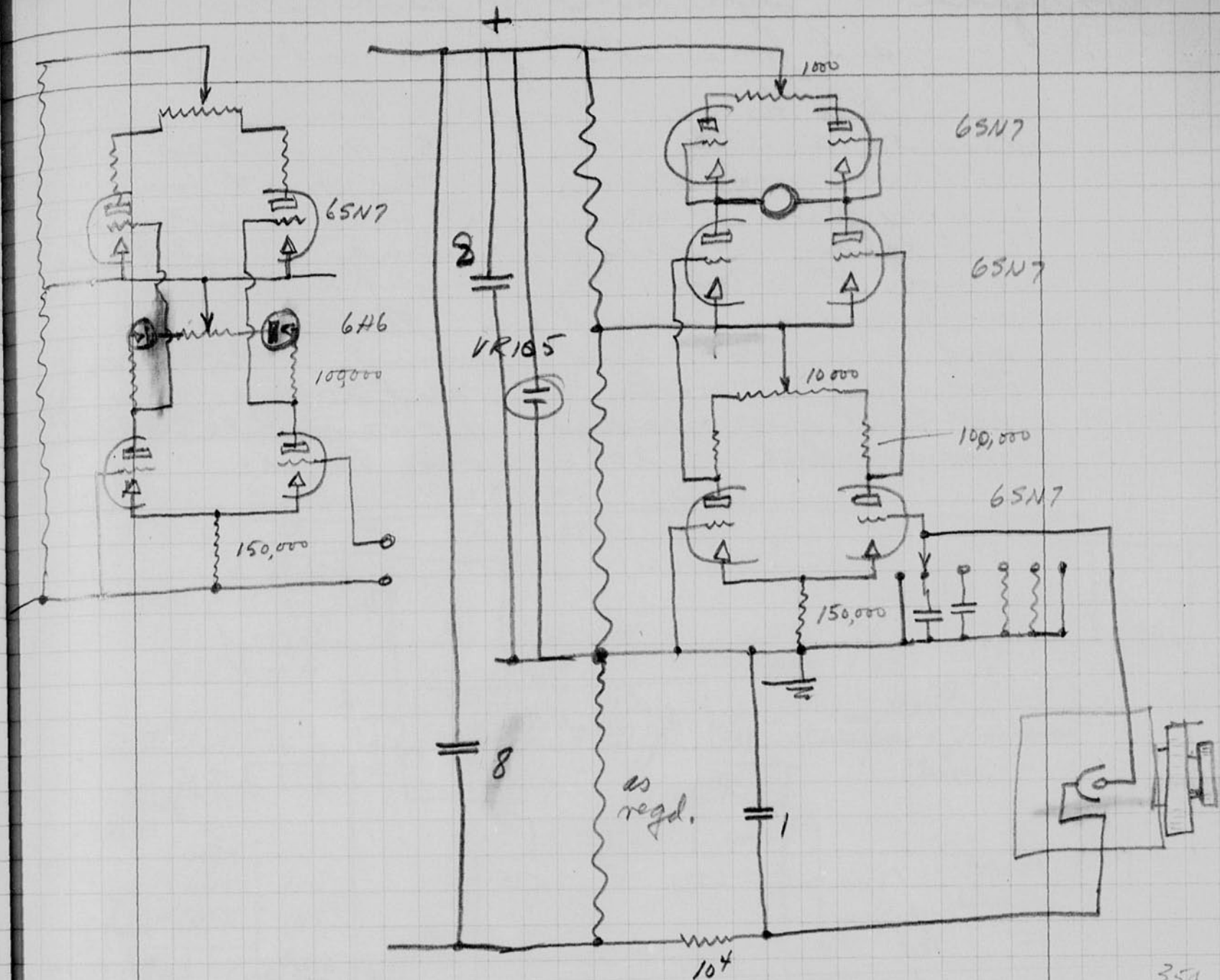


Compensation for cathode temperature variation. The diode will change its characteristics due to cathode heating and will leave bias unchanged for the



This is the wrong way for the compensation? If so it could be put in as shown opposite. The variable resistor gives a control over the amount of compensation.





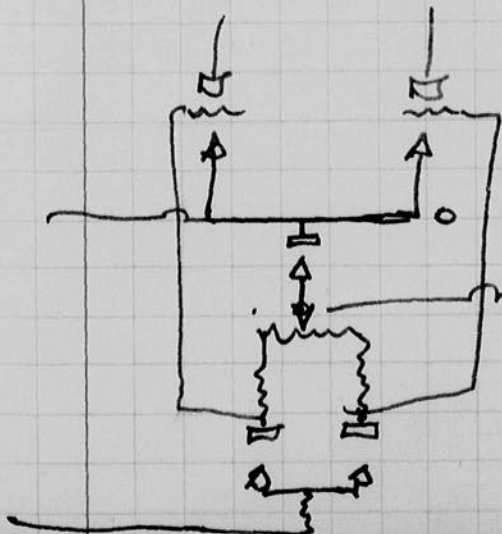
Dec 20 1945 connected as above with 6SN7 as plate resistor.

		E_p
125V	79 μ a	44.5
105	69.	45.

The performance is worse with this combination.

	$S_{ens.}$
125.	87.
105	100.

	e_f	e_g
125V	1.1	1.27
105	1.19	1.29



this point is $.73 + .!$ with 125
+ .55 105

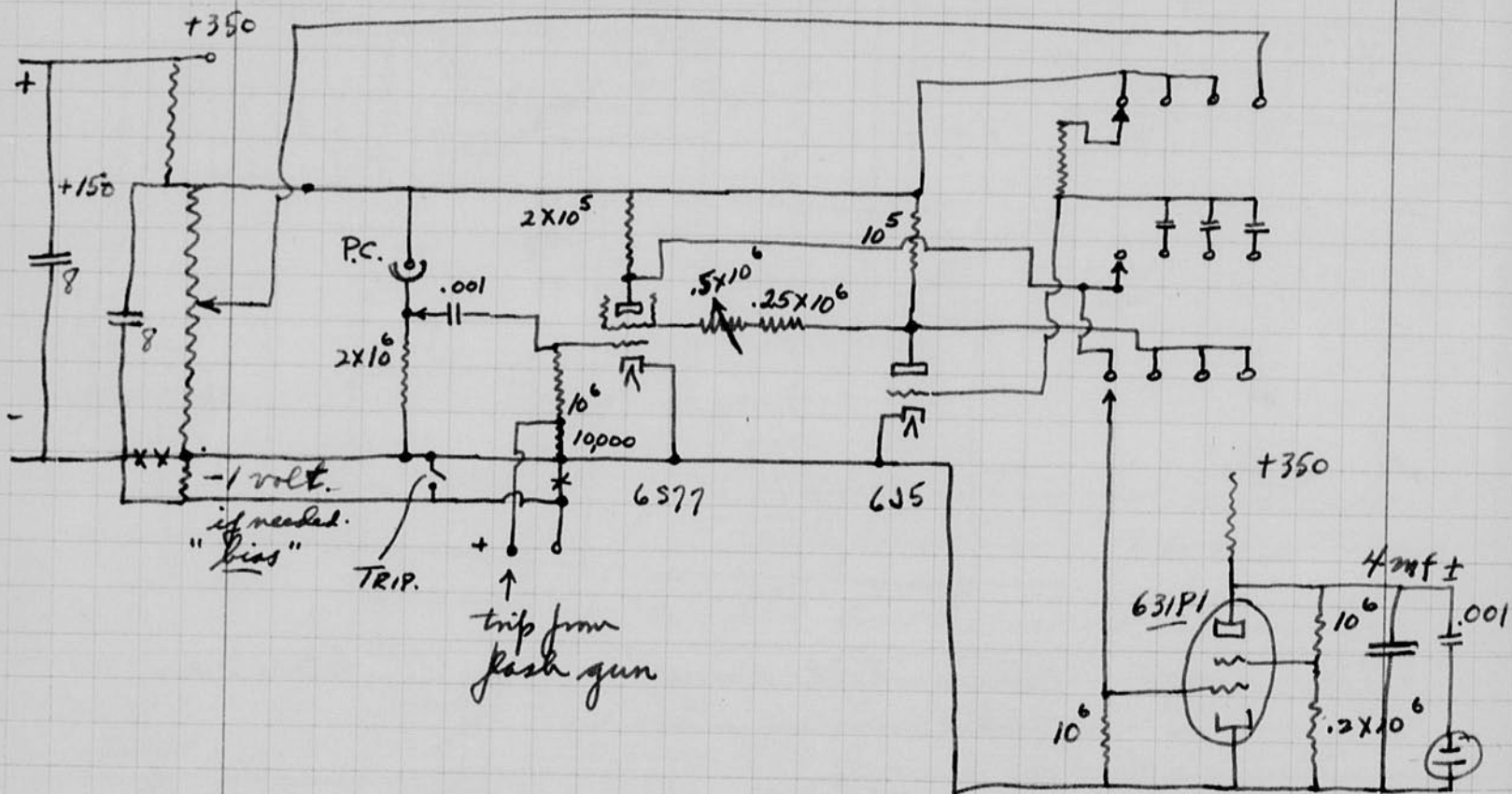
I put additional resistors across the self bias 0.5 and 1. megohm.

cont on p 133

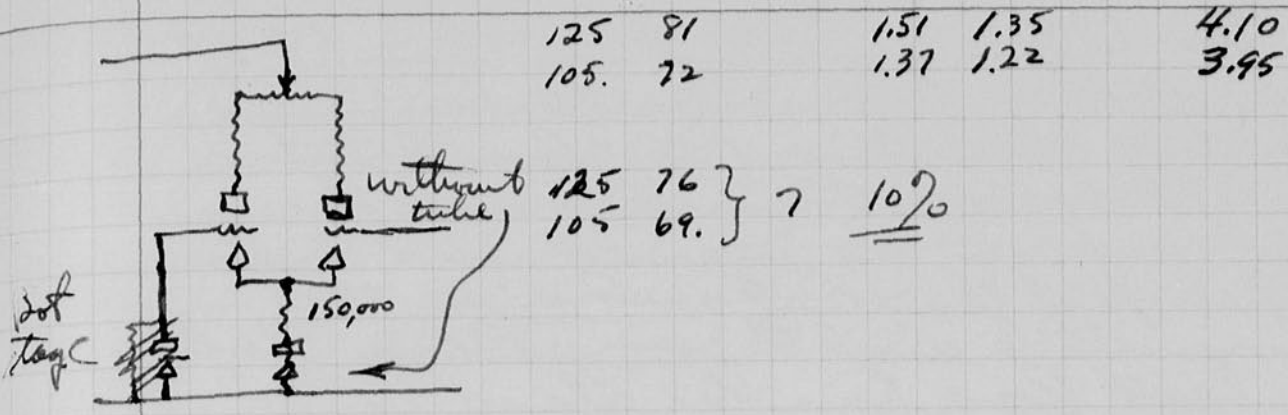
AS Edgerton

Syn. tester for flash bulbs.
and for electric flash. cont from p 119.

It is now proposed to have a decade switch with 0, 5, 10, and 20 milliseconds delay on the first four points. Then there may be an adjustable time delay or selected times might be used. Other times that might be interesting would be $\frac{1}{2}$ m.s. 50 · 100 and 200 400 and 1 second. (ten values). For shutter work 0, 5, and 20 are all that are needed. For variable try a max value of 200 or even 500 μ s.

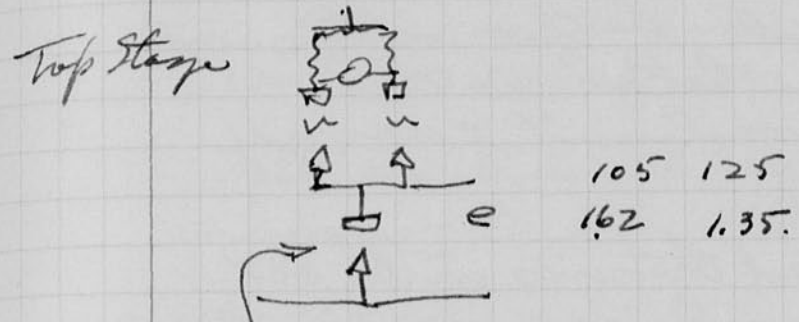


Female Jones
plug for
Kohatun trip.



125	81	1.51	1.35	4.10
105	72	1.37	1.22	3.95

125	76	} 7	<u>10%</u>
105	69		



105	125
162	1.35

250 ohm shunt added $e_g =$

1.54	1.66	125
1.47	1.63	105

Sen.
72.
60

Without the glow regulator tube the sen goes from 75 to 65

65N7 e_g

	-1.65	125	
	-1.47	105	
	+1.2	125	
	+1.95	105	
	-1.44	125	.16
	-1.28	105	
	-.77	125	.10
	-.67	105	
	-.77	125	

Dec 24, 1945
A. B. Edgerton.

Radiant Energy of a flash lamp.

The following method was thought of during a discussion several days ago with Prof. Allis. First the lamp is flashed in a calorimeter and the total energy is measured. Then the lamp is flashed outside the calorimeter and then put in before the heat loss from the glass is conducted outward. The ratio of the difference to the total is the percent unit of radiant energy or the efficiency η .



Large mouthed thermos with oil.

Initial temperature of oil 24.01 degrees C.

Lamp flashed outside and then dunked in oil. 2000 V 128 mf. FT-1

Temp = 24.36°
about 203 minutes are required for equalization

Lamp in oil and flashed T = 24.90°

$$\eta = \frac{24.90 - 24.36}{24.36 - 24.01} = \frac{.54}{.35} = 1.54$$

Start	24.85	.45
After flash outside the thermos	25.30	.55
" " inside	25.85	$\eta = \frac{.5}{.56} = .89$

1/2 hr later

Start	25.50	} .60
Inside	26.10	
Outside	26.40	

Amount of oil reduced about 25%.

Start	26.2	} .4
Inside	26.95	
Outside	27.3	

$$\eta = \frac{.4}{.75} = .53$$

Dec 22 1945

David Edgerton.

135

Summary of Light meter circuit study.

Ballistic type without shutter - This type ¹¹⁴ p 95-97 is not practical since the continuous light causes so much variation. The meter that I used had a one second time of oscillation which is too short for that purpose. I have dropped this type of meter for the time being.

A.C. type - double amp. tube for sensitive instrument.
p 120 121 122-126, 129-131, 133.

① The double twin tube arrangement is required to compensate for voltage and tube changes.

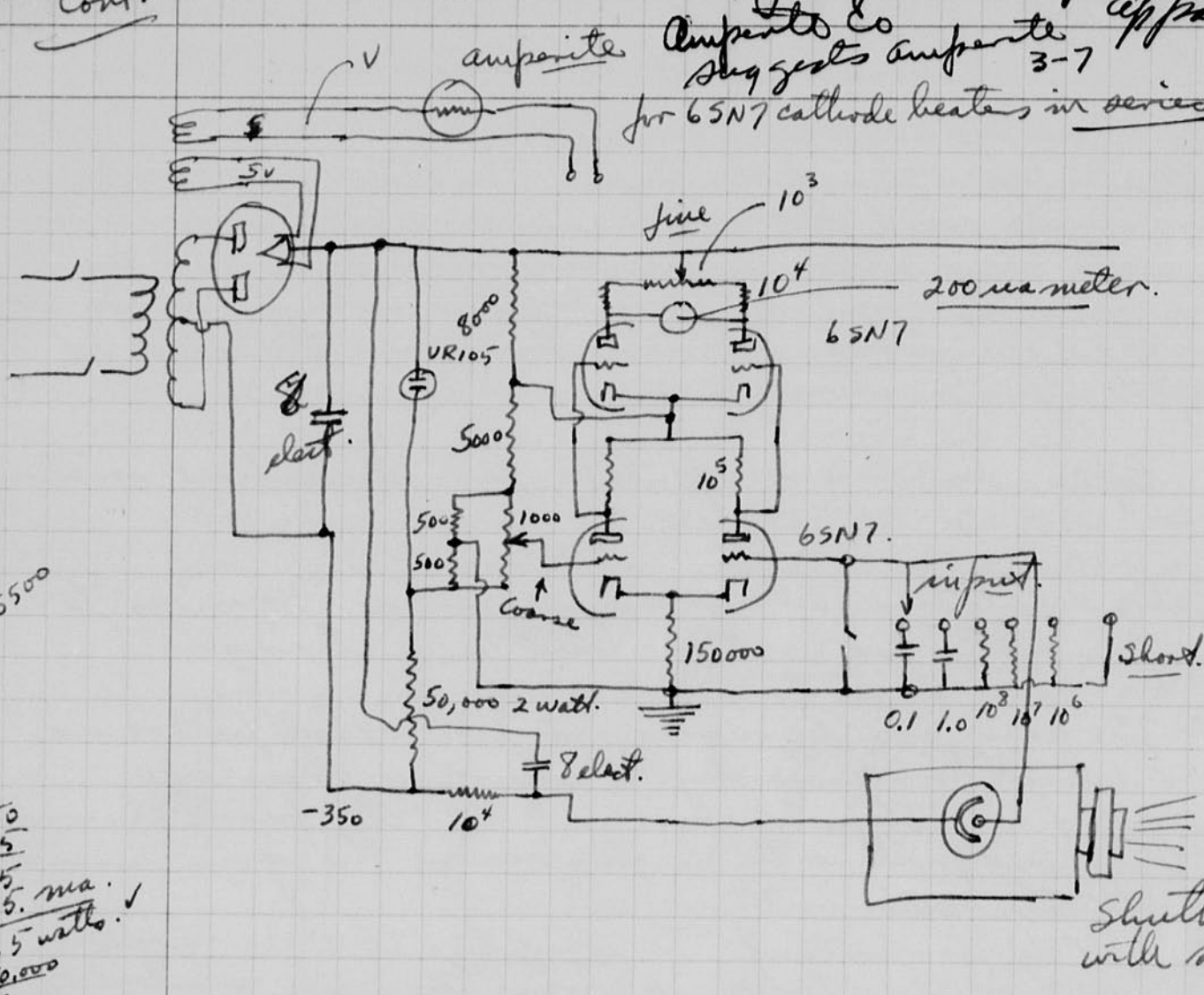
② The gain can be increased from .4 volt for 200 μ a to 0.1 volt for 200 μ a by the use of a pre stage amplifier. This is done at $1/10$ the plate current of the output tube to decrease the grid current due to ion current.

③ It is important to stabilize the cathode current of the tubes. 10% variation in stability sense is obtained when the voltage varies from 120 to 105.

④ Voltage stabilizer of the plate supply is desired. I used a VR 105 with success.

See following page for complete diagram as finally evolved.

Final circuit for flash light meas. apparatus.



45 5500

$$\frac{350}{105} = 245 \text{ ma.}$$

$$\frac{245 \cdot .005}{1.225} = 1.225 \text{ watts.}$$

$$\frac{1.225}{50,000} = 245$$

6.3 - 5.7
 6.3 \times 5.9
 300 - 281 ma.

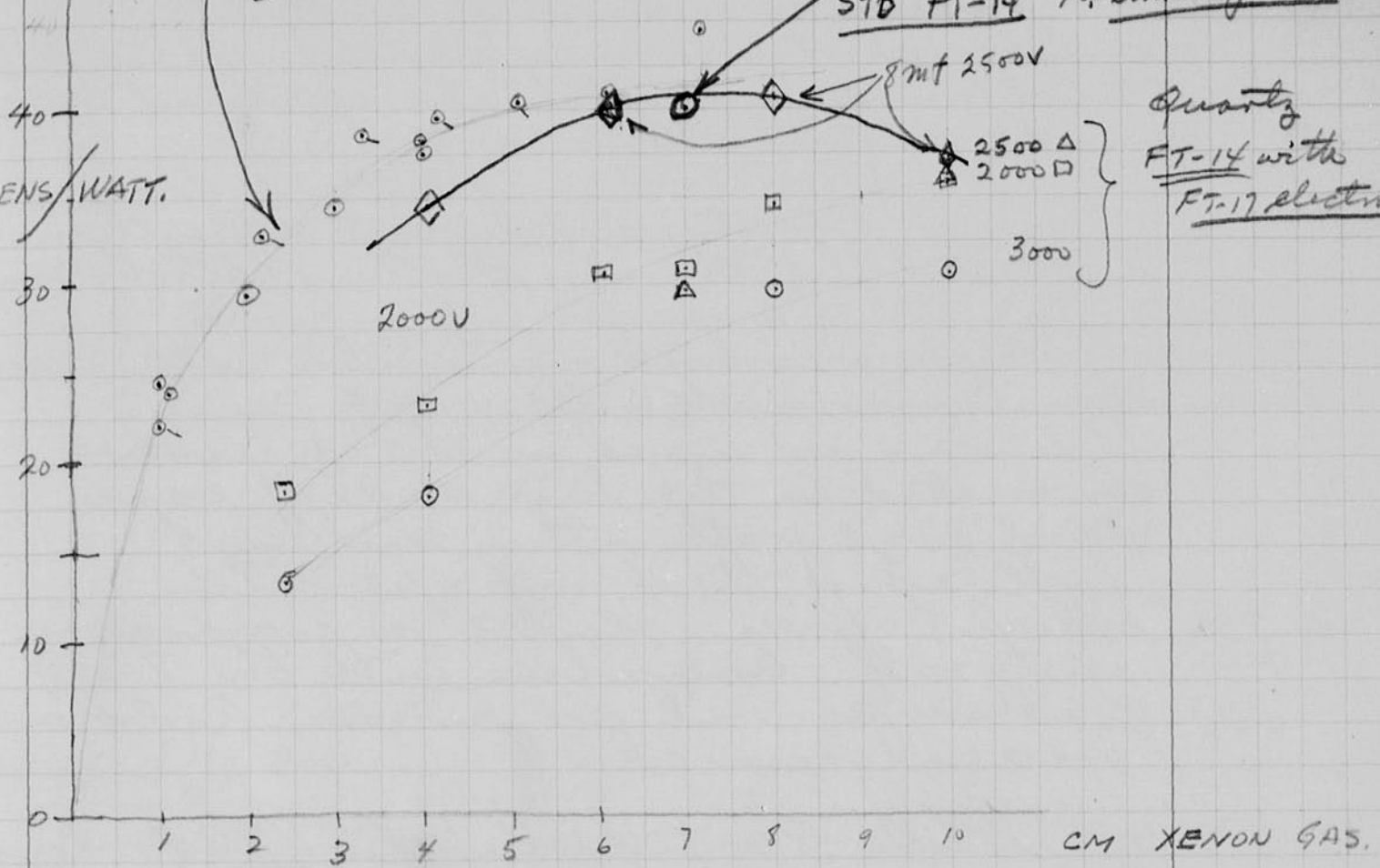
$$\frac{300 \text{ ma}}{20 \text{ ma}} = 280 \text{ 6SN7 Heater.}$$

$$\frac{5.9}{.020} = 295 \text{ ohms.}$$
 in parallel with each cathode heater.
 then stabilize for 300 ma.

FT-14 No 2
 Ref at 2000V 103 mt. 40 lum/watt.

STD FT-14 400 lumens per watt.

LUMENS/WATT.



Quartz
 FT-14 with
 FT-17 electrodes

Jan. 11, 1945

Herold E. Edgerton

I was called to Aurora ^{nebr.} on Dec. 27 by a serious operation on my mother. I returned to Boston on Jan 6 after she appeared to be on the way to health.

Grier Barstow and I visited Ray them and tested the Warner Brothers stroboscope.

There was hold over trouble with 8 mf. Operation was ok with 4 mf. Series inductors as used in the D-1 were connected in the high side of each discharge path. This did not influence the 4 mf operation except for a slight increase in out put. Operation with the 8 mf was improved as far as hold over was concerned.

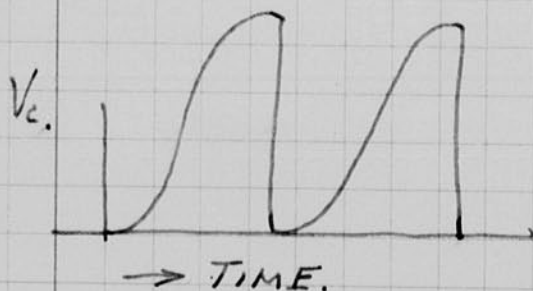
With 8 mf the lamps hold over after a 30 second \pm operation. More air might help this situation.

Measured AC input with 4 mf at 48 cycles. Both lamps firing at once.

226 volts. } 1650 volt amp.
7.3 amperes.

D.C. - 1300 volts.

The oscillograph showed that the timing of the charging cycle was ok.



$$\frac{247}{4 \frac{2600}{2}} = \frac{247}{5200} = 18.3 \text{ amp.}$$

If the lamp effy $n = 26$ lumens/flash
4mf / 2600 volts.

$$Q = \frac{CE^2}{2} 26 = \frac{4 \times 10^{-6} \cdot 2.6 \times 10^6}{2} 26 = 135 \text{ lumen/sec.}$$

$$\frac{200}{135} \times 4 = 5.95 \text{ mf.}$$

If the capacity is increased to 6mf the light output will be 200 lumen/sec per flash and the lamp should be able to run continuously without overheating.

$$\begin{aligned} \text{Exposure factor } d \times f &= K \sqrt{\frac{CE^2}{2} n} \sqrt{M} \\ &= 80 \cdot \sqrt{\frac{200}{14.1}} \sqrt{M} = \underline{113.} \sqrt{M}. \end{aligned}$$

$$f \parallel \sqrt{\frac{20 \text{ ft.}}{200}}$$

Jan. 12, 1945. Further experiments were made yesterday on the Warner Brothers' movie equipment.

$$\text{Reflector factor} = \frac{135 \times 4}{50} = \underline{10.8} \quad \text{D-1 reflector with FT-24.}$$

Light output with 4mf at 48 cycles (one flash measured).

$$\frac{50}{1} \frac{Q_1}{Q_s} = \frac{M_1}{M_s} \left(\frac{d_1}{d_s}\right)^2 \left(\frac{f_1}{f_s}\right)^2 = \frac{50}{97 \times \frac{144}{23}} \left(\frac{68.5}{120}\right)^2 \left(\frac{5.6}{5.6}\right)^2$$

$$= .0825 \quad .325$$

$$Q_s = \frac{CE^2}{2} 40$$

$$= \frac{103 \cdot 2 \cdot 120^2}{2 \cdot 40} = 9250$$

lumen/sec.

$$Q_1 = Q_s \times .0825 \cdot 325$$

$$= 9250 \cdot 0.0267 = 247 \text{ lumen/sec.}$$

These tests were made on super xx film at 15 ft at f 4.5, 8, 16, and 32. The f 4.5 and 8 were ok. $15 \times f 5.6 = 84$ guide factor. The negs. were developed in D 192 for 5 minutes at 70°.

Jan 14 1946. *ABD*

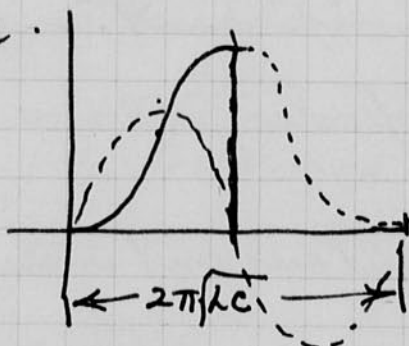
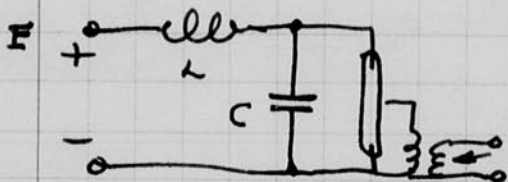
Comstock called in the morning to discuss air port lighting with flash tubes. It appears that experiments have been made at $1\frac{1}{2}$ sec intervals with Sylvania equipment. The intensity seems to be o.k. but the rate should be increased. There was no halo around the light in haze weather. 40 lights are required for a runway with wave synchronization.

I suggested 3 flashes per second as a good value to use.

Carlson and Snyder called. We went to Raytheon to inspect the Warner Bros flash unit. The efficiency appears to be about 90% with choke charging.

I had dinner with Carlson and Snyder at the Parke house, after which we discussed flash lamps and circuits.

Choke charging.



$$\frac{1}{f} \leq \pi\sqrt{LC}$$

$$I_{max} = \sqrt{\frac{C}{L}} E \text{ for choke rating.}$$

$$\text{flash freq.} = \frac{1}{\pi\sqrt{LC}}$$

$$L = \frac{1}{f^2 \pi^2 C} \text{ henries.}$$

Jan 16 1946
A.E. Egerton.

Power Limitation and frequency Limitation. of flash tubes.

141

An experiment was made with a FT-14 tube to determine its power rating. $C = \frac{1}{4} \text{ mfd}$ $V = 2000$
 $f = 120 \text{ cycles}$. After 20 or 30 seconds the spark punctured a hole in the glass tubing. The loading at this level corresponds to about 60 watts into the lamp $P = (CE^2/2) f$

At 30 cycles this lamp runs continuously without difficulty. A charging resistor of 5000 ohms was used for this experiment.

$$f = P \left(\frac{2}{CE^2} \right) = \frac{15 \times 2}{4 \times C}$$

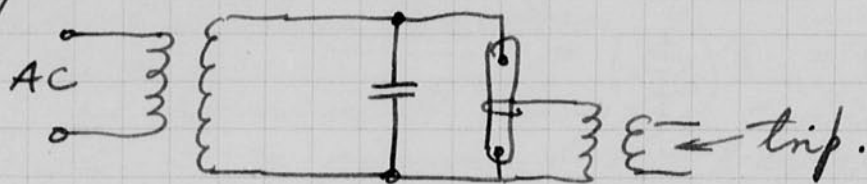
C	f	T
.25	30 cyc. per sec.	.033
.5	15	.066
1.	7.5	.133
2	3.75	.267
4	1.88	.532
8	.935	1.07
16	.467	2.14
32	.233	4.30
64	.116	8.60
128	.058	17.2

Jan 21 1946.
H.C. Egerton.

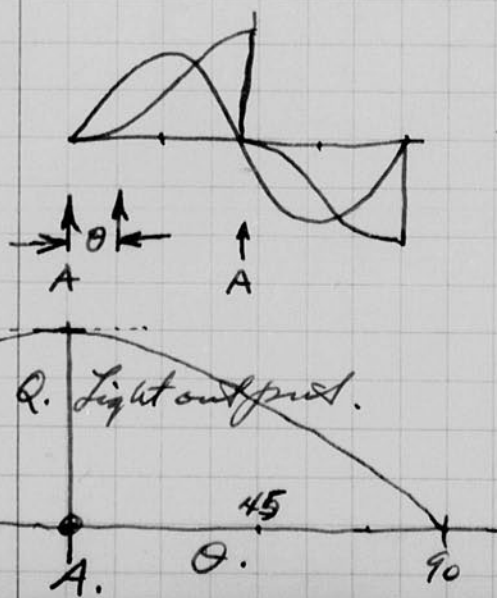
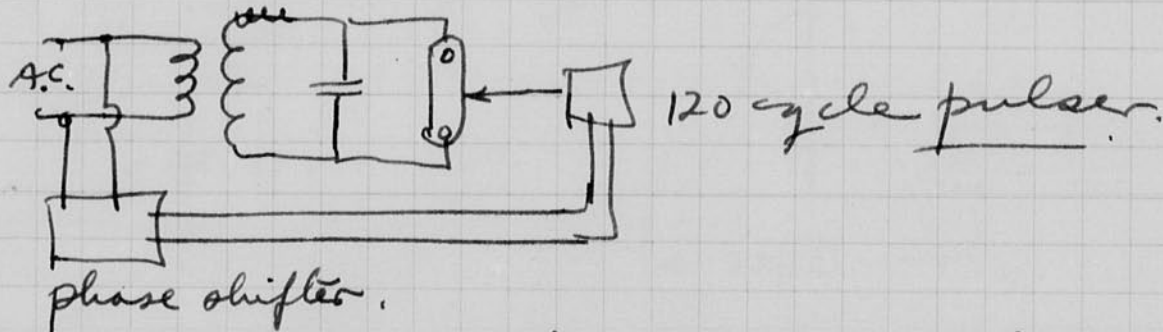
Flash Lamp intensity adjustment.

There are to be many uses of xenon flash lamps because of the high efficiency and the desirable color.

An efficient method of regulation of intensity is desired for some of these applications. One such method is described here which is efficient since no power is consumed in the system.



The method is to flash the lamp at different phases with respect to the ac input. In this way the charge on the condenser will have different values depending upon the ac transient.



The maximum output is obtained by firing the lamp at the zero of the cycle. A. The output will decrease with the angle of firing.

Read & understood
1-21-46
Herbert B. Grier

Feb. 9, 1946.

Hazel Edgerton.

Yesterday I arranged for Kern to show his electric earriings to Eugene Stevers of the Stevens Arnold Co in Boston. I saw a demonstration of the earriings at my home on Jan 25 at which time my 611 class of which Walt Kern is a member were guests at dinner. A mercury switch was discussed at the time for flashing the lights at temporarily. This was shown to me this morning by Kern. I witnessed a description this morning.

On Feb 11 the case on the static invention is scheduled to be heard in Washington. Frank and Bowles will be experts.



Mr. & Mrs. Eugene Klein

"Deaf" Smith.
the cowboy
photographer.

See p. 134.

A DIRECT METHOD OF MEASURING THE RADIANT ENERGY OUTPUT OF AN ELECTRICAL-
FLASHLAMP

The radiant energy from an electrical-flashlamp can be measured directly by the following calorimetric experiment where two measurements of temperature rise are made of oil in a thermos bottle. For the first experiment, the flashlamp is flashed under the oil and a reading of the temperature rise, Δt_1 , is made after the oil has reached an equilibrium temperature with the flashlamp. Here the entire energy, $CE^2/2$, that entered the lamp is used to produce heat since the radiation is absorbed by the walls and by the oil. A second temperature rise, Δt_2 , is measured by flashing the lamp outside of the thermos bottle and then dunking it in the oil before any of the conduction heat inside the bulb can escape. Since the radiant energy is not absorbed in the oil for this second experiment, the temperature rise will be due to energy that does not radiate.

The output of radiant energy is then,

$$(\Delta t_1 - \Delta t_2)K = W \text{ joules}$$

where Δt_1 is the temperature rise of the calorimeter when the lamp is flashed in the oil,

Δt_2 is the temperature rise of the calorimeter when the lamp is flashed outside the calorimeter and quickly inserted,

K is the heat capacity of the system, and since

$$\Delta t_1 K = CE^2/2 = \text{energy in joules from the condenser,}$$

$$(\Delta t_1 - \Delta t_2) \frac{CE^2}{2\Delta t_1} = W \text{ joules.}$$

Likewise the efficiency of the lamp to produce radiant energy is

$$\frac{\Delta t_1 - \Delta t_2}{\Delta t_1} = \eta \text{ (numeric)}$$

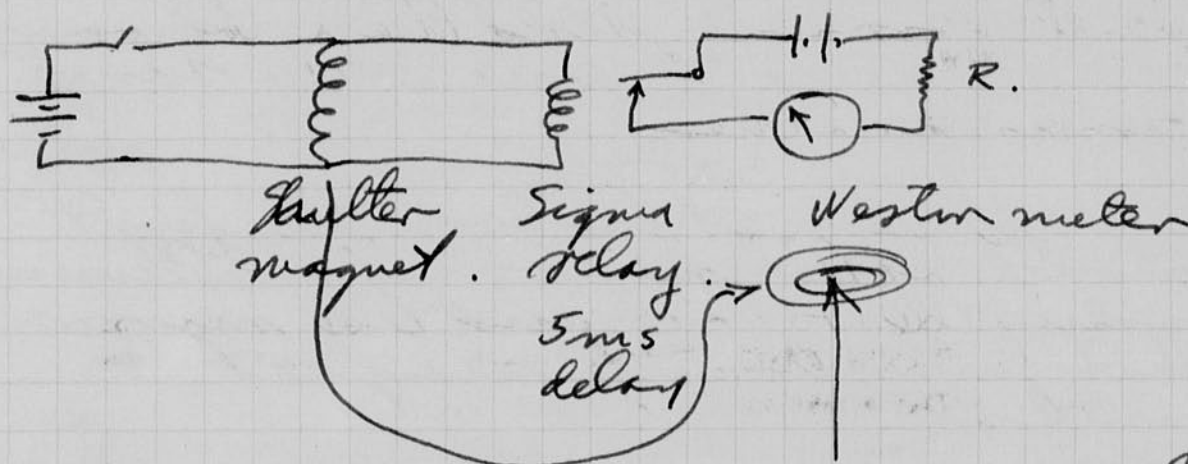
For a typical flash lamp such as the Kodatron FT-2 the efficiency is 25 to 50 per cent for the first experiments that have been performed. Accuracy of the experiment is limited by the temperature rise reading which was about one degree centigrade. The experiment needs to be repeated with a smaller quantity of oil and greater energy so that the temperature rise can be more accurately observed.

Harold E. Edgerton
February 8, 1946

Feb 15 1946
Howard E. Edgerton

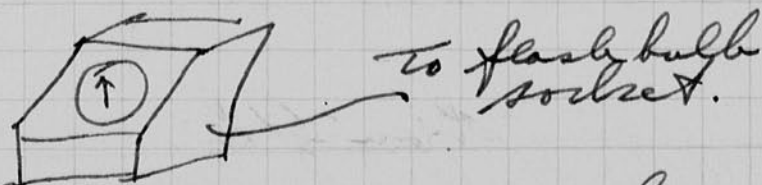
145

Mr. Broadhead of the Weston Inst. Co. brought in two experimental meters about a month or so ago. One of these was a blade face oil lamp indicator with a wide white pointer. This was for use in the flash bulb synchronizer that is described on p 101. The device was connected up with the sigma relay and tried the same day that the meter was obtained. It worked very well.



The meter needle is observed through the shutter when it snaps. I adjusted the resistance R so that the reading was 20 for 20 milliseconds delay.

Nigam then took the equipment down to photo service and after using it some, as is, rebuilt it into a box with a sliding top.



I was down to see him this morning. Apparently the device is working fine.

Nigam wants a continuously adjustable time delay on the electronic device with the shroton tube. See page 132 for the step adjustment method.

March 4, 1946

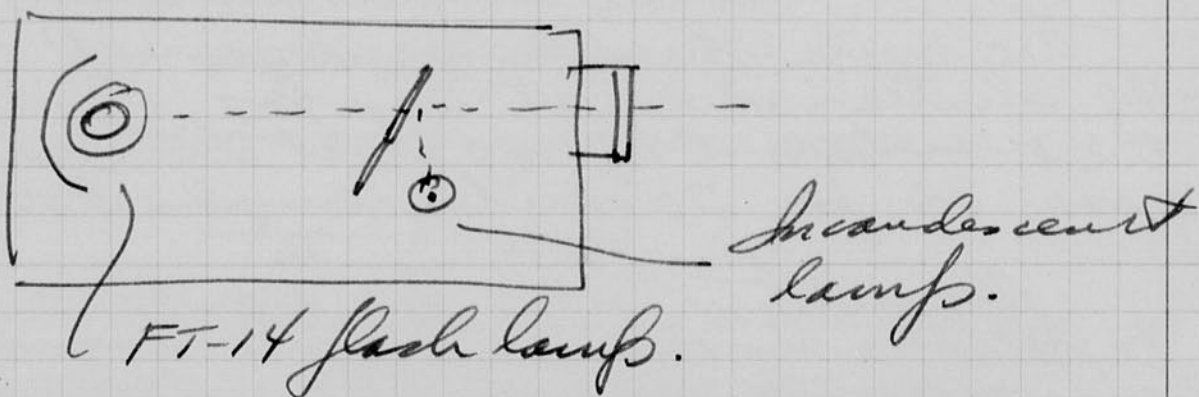
Harold & Edgerton.

Starnout, Cordon, and Martin arrived yesterday and were out to my house last night.

I was at the Technifinish lab on Feb 27 at Rochester and at Eastman on Feb 25 to work on the design of the studio and flash unit.

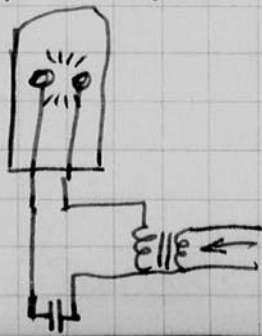
at Technifinish, discussed flash equipment with E.A. Edwards and Bill Brown. I told them, he would give them a license on the same terms as others.

I saw at Eastman, the first model of the microscope illuminator using the FT-14 and the mirror that moved with magnet control.



This needs the ~~FT~~ gap tube of the type that I made some time ago.

Series triggering should be very useful for this type of lamps.



Registration today at M.I.T. for the new term.

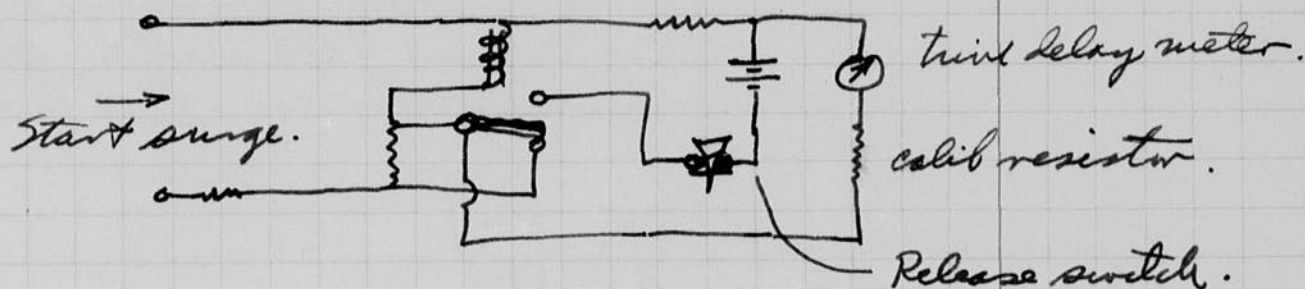
Jack McMurray arrived last night from Syracuse N.Y.

Cont. The magnet synchronizer for photoflash bulbs was tested at great length at the E.K. Co. It did not work on the shutter contacts since they only close for two m.s. I need a relay that self-closes with a contactor so that time can be read.

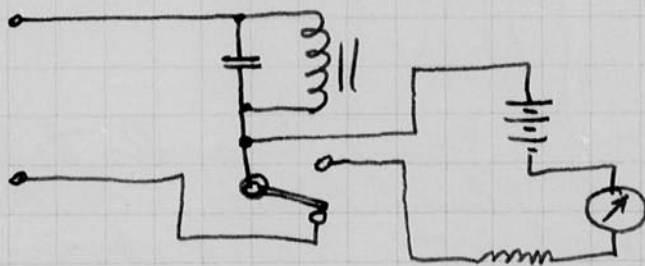
Born, Muntch, Fink, were at Eastman for the tests.

The self-closed contact relay needs a release after .05 seconds, otherwise the battery will be run down. Possibly a condenser of the low-voltage electrolytic type would do the job.

Hold in circuit with release switch.



Condenser to keep relay closed for .05 seconds.



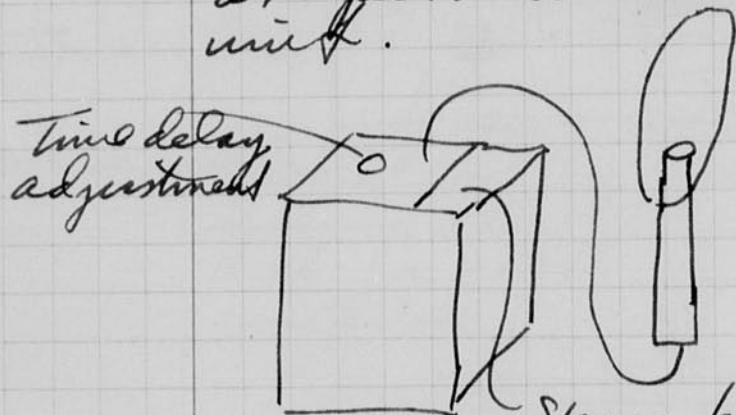
March 5, 1946.

Hendy & Edgerton.

Last night at 5pm, Peck and Hendy brought in an ac operated flash unit for Starnum, Condor, and Martin to inspect. Brewster also saw the unit.

There was no flash bulb available so we put in a 40 FT-14 and helped kick it off with a spark coil.

The unit has 12mf at 4000 volts with a relay to connect the condenser to the lamp. All cords are permanently connected to the unit.



Space for cords to lamp, ac, shutter and flash trip. A top, hinged, covers the unit. The price has not been determined but will be less than \$200. Total weight 18 pounds.

Peck also brought in an exposure meter for measuring light.

March 10 1946 Two classes this term 6.19 and 6.632 so I guess I will be plenty busy.

Jack McMoran has been here a week at M.I.T. as a sophomore in architecture. He is living with us.

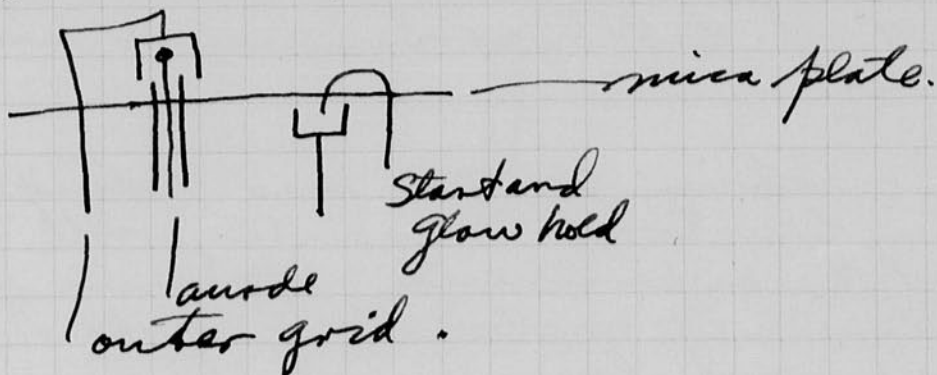
Hunter from Toronto is to help in 6.632. Edwards from Tech finished my portable one—the weekend to take pictures of his children.

Fixed copy
13 lbs

March 15 1946.

J. E. Elyotson.

Small central strobiliform came in from
Hoggrad today. miniature base.



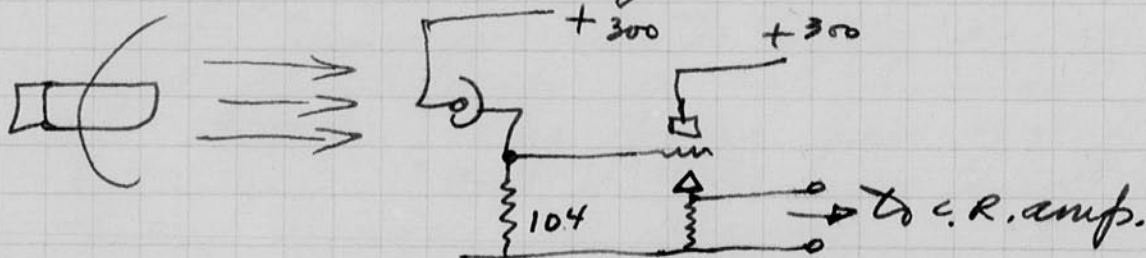
R.E. Edg
Mar. 21, 1946.

Meeting of Basic Research group
in Bldg 20 with Stratton at 11 today.
Discussed policy and financial
support of lab by government and
industry.

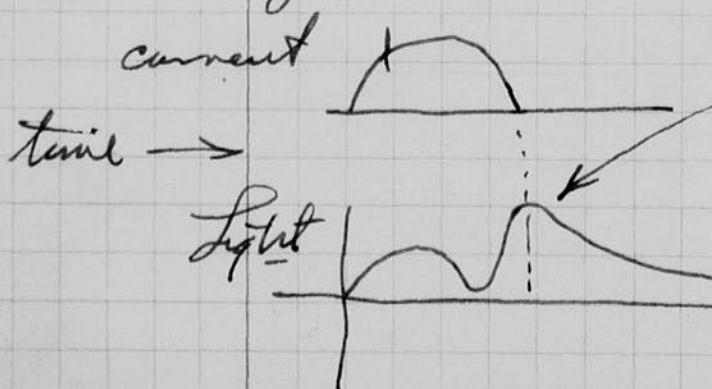
Our lab in 20-236 has 7 students.
K. Hunter from Toronto is assisting with the
setup of the experiments. Dynamic gaseous
conduction experiments are the ones
that we are working on at the moment.
Students. Linnell brothers.

Wong.
Chisholm.
Jof.
Versuh.
French.

I set up a stroboscope to observe the
light output with a photocell



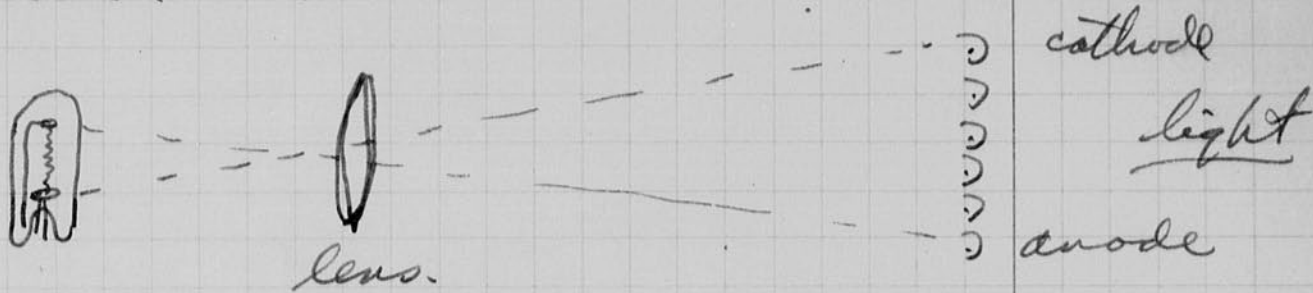
The oscillograph showed most of the
light after the current ceased. Of
particular interest is the fact that
the ~~current drops~~ light drops to
zero and then rises



note peak is reached about
current zero.

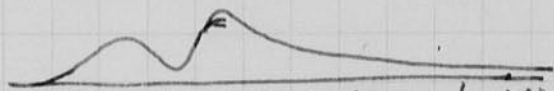
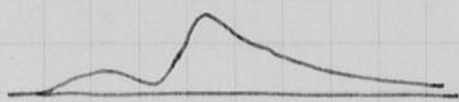
Cont.

a lens was set up yesterday to project different parts of the arc into the photo tube.



There was a difference in the two pictures.

The relative sizes of the first and second peaks were different.



Mar 22 1946 conf with ^{Morade MM} ~~B...~~, Muzze, Hubbard & Gelling.

Synctron

normal

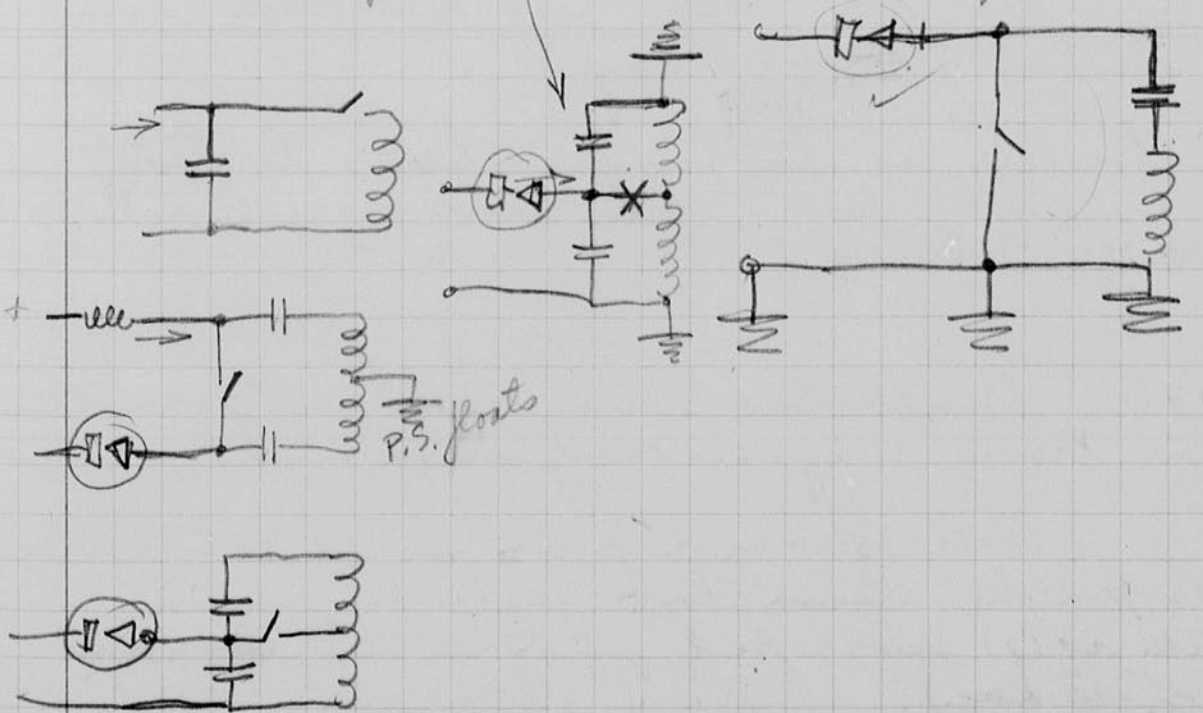
"super"

z_p

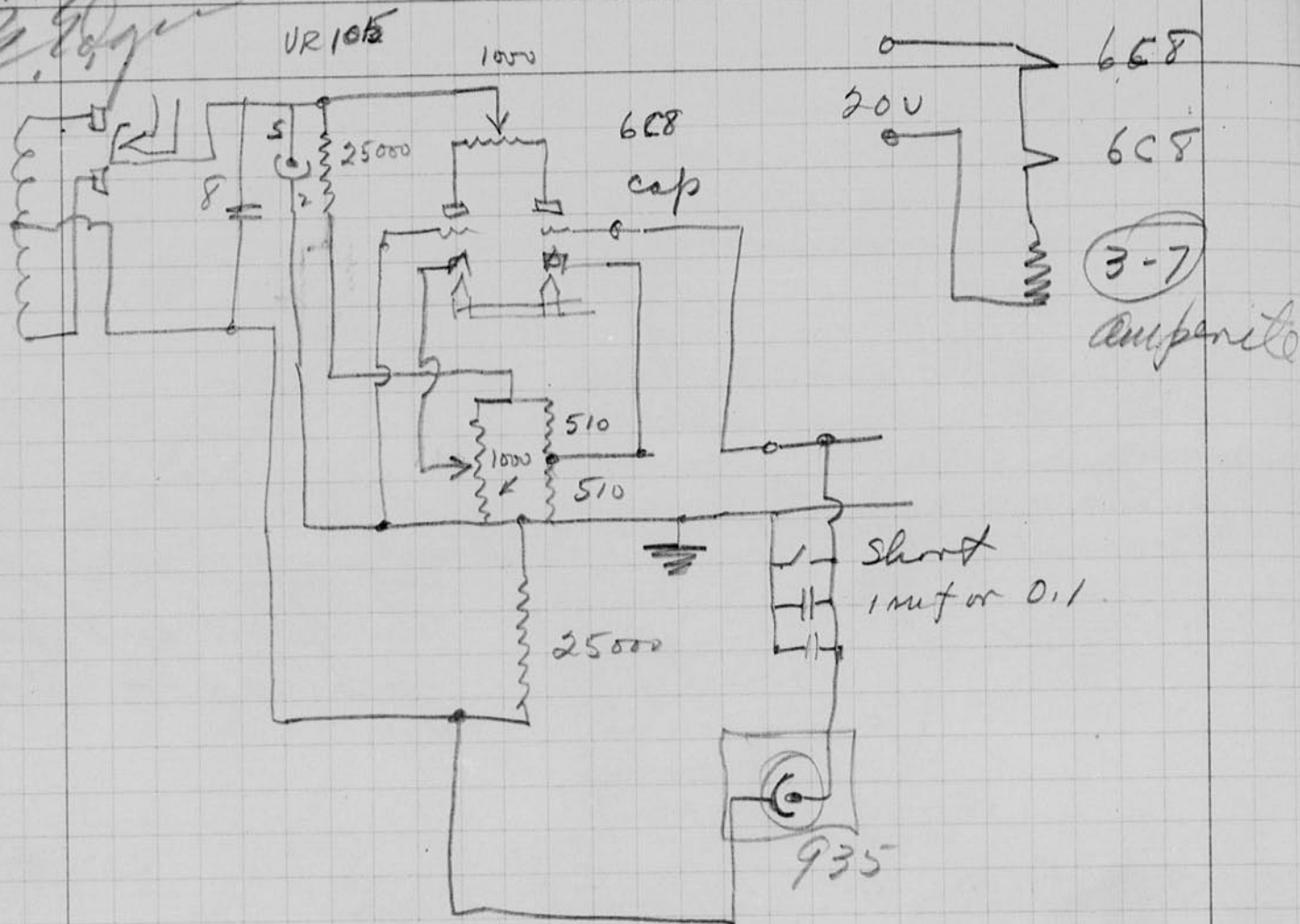
avg

~~V_p~~

3000	6000
100	50
8500	17,000



Mar 24 1946
 R. G. ...



March 27 1946.

Herb and Dennis returned from Los Alamos on Mar. 25.

Started glasses today.

French is starting a thesis to test components for a beta and synchrotron for M.I.T. Getting.

Mar. 30, 1946 Inspected new proposed quarters in Bwing Bldg 20. May move next summer.

Took 35 mm movies in the Schlieren setup in the steam lab yesterday with Walkers (?) Developed pics in the Aero. lab (Prof. Mc Kay.)

Took Bob and Jack McMurran to the M.I.T. Pool for a swim.

Low Devonport. 1814.

Setting. 2 Basins APN 7 to APN-21 for night plant to plane. Huff.

Bart. Mills MEW

1051

