

HAROLD E. EDGERTON

PAPERS

MC 25

Series III

Laboratory Notebooks

Number 23

Dated April 19, 1955 to Dec. 19, 1956

Massachusetts Institute of Technology

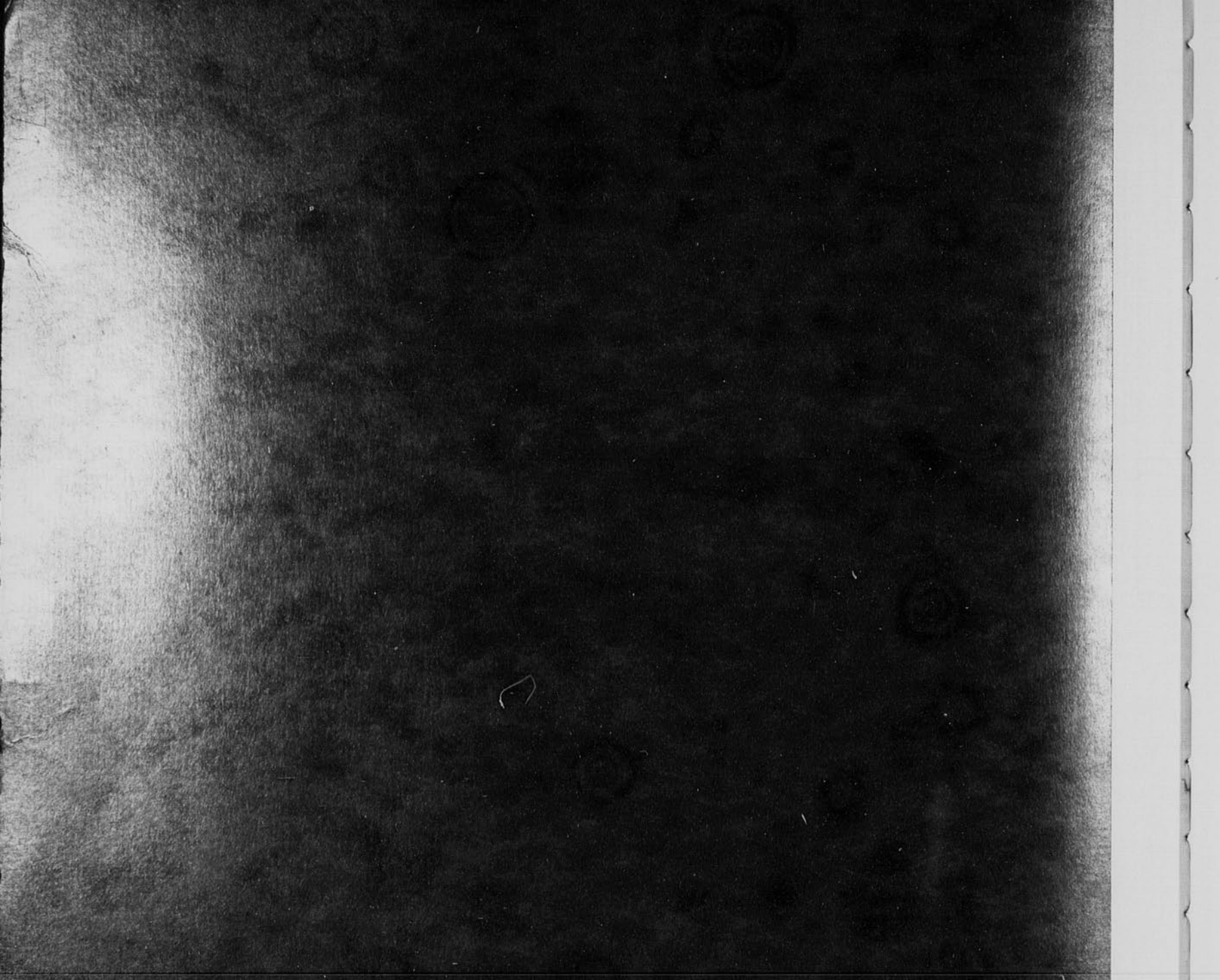
COMPUTATION BOOK

| NAME | Number |
|--------------------|--------|
| HAROLD E. EDGERTON | 23. |

MIT 20D102
CAMBRIDGE MASS

Course.....

Used from APRIL 19 1955, to DEC 19. 1956.



Book 23.

Harold E. Edgerton
205 School St Belmont Mass.

M.I.T. 20 D 102
Cambridge Mass.

Started April 19 1955

April 19 1955
Harold Edgerton

Experiment with a stroboscope.

1

A few tests were made on a high pressure flash tube of low input. The tube was 1 mm in diam and 1/4" long, in Vycor with FX-1 type of sintered electrodes.



I first tested it with 0.6 mfd at 2000 volts at 10 per second. After several hours there was some darkening and the tube missed badly. Then I put ~~an~~ an additional 0.7 mfd in parallel and gave it a few flashes. This extra energy blew out the deposit in the capillary.

Next I reduced the input to 0.1 mfd at 2KV. The light was located in a 5" diam reflector with a 1 inch focal length. The spot of out of focus light appeared as a square of about 4" on a side at one foot. The light intensity was non uniform but probably satisfactory.

The light was measured with the Teclatronix and a 935 scope phototube.

Strobosc. .045 volts peak \times 7. us = .315 units

Xenon. 120. volts " @ 1.5 = 180 units.

Ratio is about 600!!

Xenon has ~~0.4~~ 0.4 watt sec. per flash
Neon has 0.6 " " " "

The visual ratio is not as high as 600 due to the color of the light and the sensitivity of the phototube. In any case the xenon light is much stronger than the neon.

The FT-118 flash tube with 0.6 mfd at 2KV is very inefficient.

I feel that a tube without end cavities would be good for flash work. The pressure could be lower.

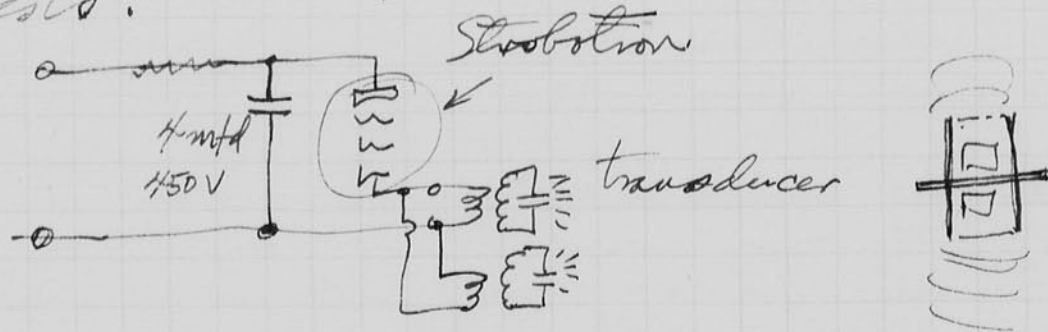
Underwater Cameras

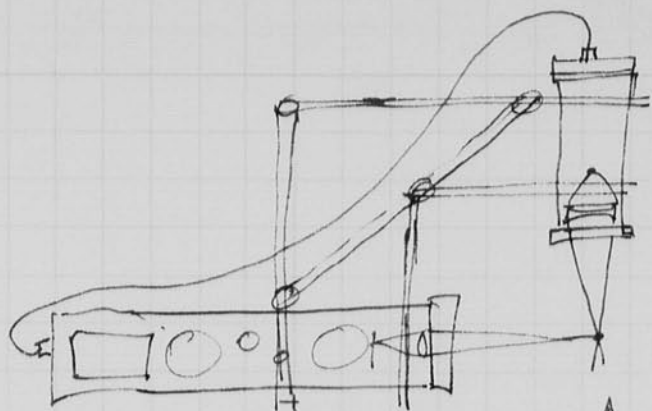
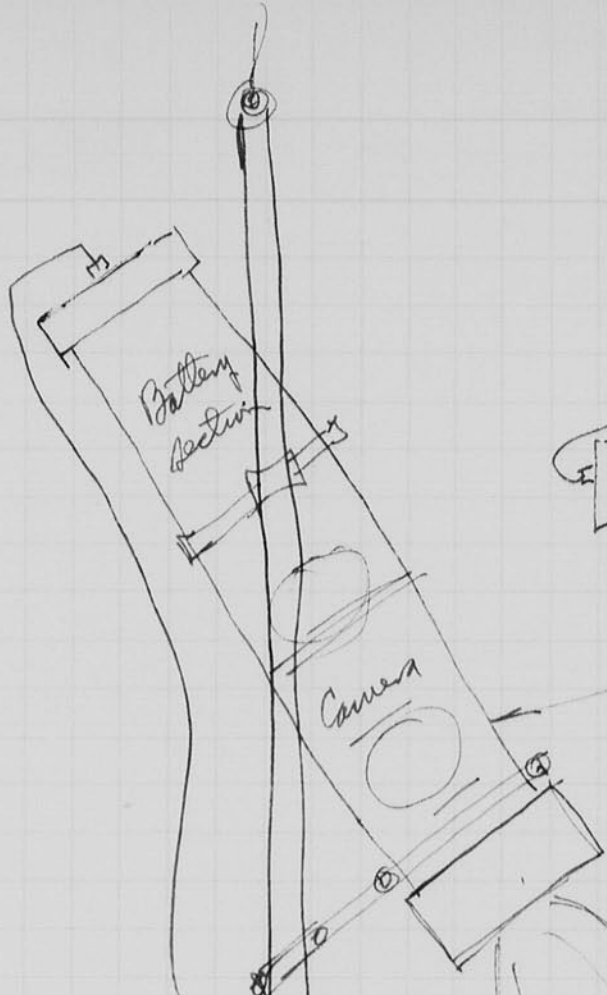
A popular account of the cameras (underwater) appeared in the April National Geographic magazine. I have spent the past two summers with Cousteau on the "Calypso" in the Mediterranean.

We also have plans for the coming summer. I am making a camera and sonar for use in the deep spot near Greece. This spot is over 4000 meters deep. Although we have a cable of steel for this job, I plan to experiment with nylon of about $\frac{1}{4}$ inch. This nylon weights practically nothing in water as contrasted to steel which is about as heavy as in the air. For great depths the nylon should be just the thing.

Spide Brown and Bob Hartman are working out the mathematics of the problem. Bill Westell has been helping some. Mr. Chase of the Sampson Co, Shirley Mass, has been designing the nylon rope for us. A 5000 yard piece is being made now for test.

Dick Ward and Tom Smith are testing a new Edo Transducer of submergible type with up and down direction elements. These students visited Edo plant where Geo Fender helped them make some tests.



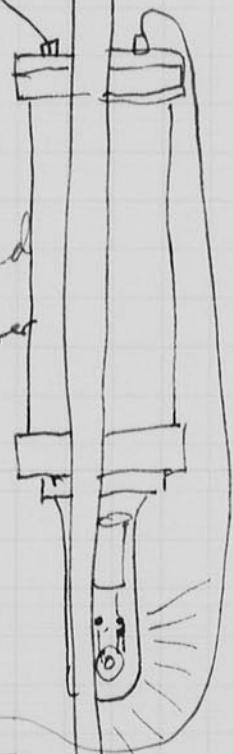


100 foot ~~magnesium~~ reel of 35 mm film.

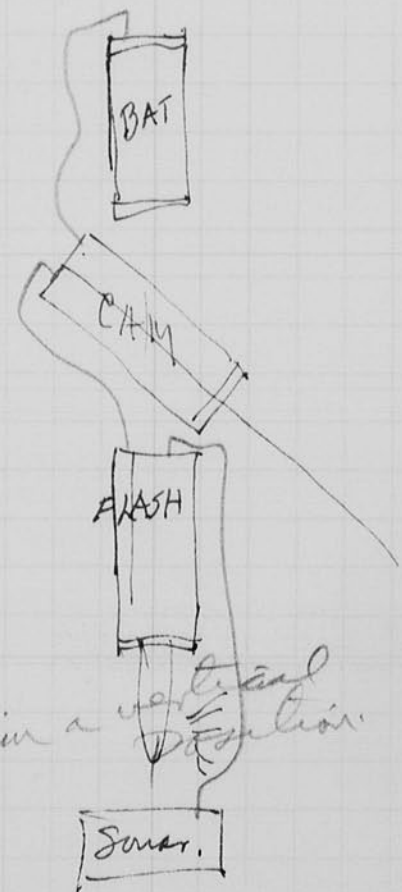
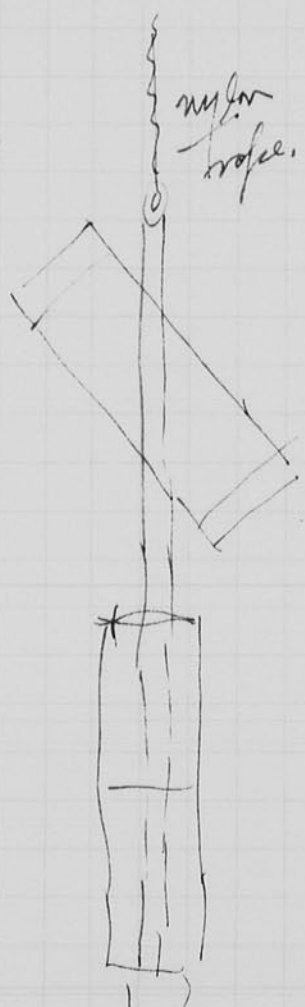
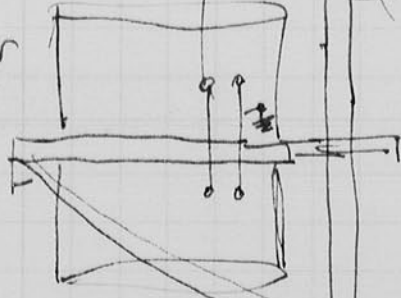
Closeup photograph of small objects in the sea. A short exposure is important.

I found that blurs were causing trouble last year!

100 W.S. Electronic flash supply and Sonar driver



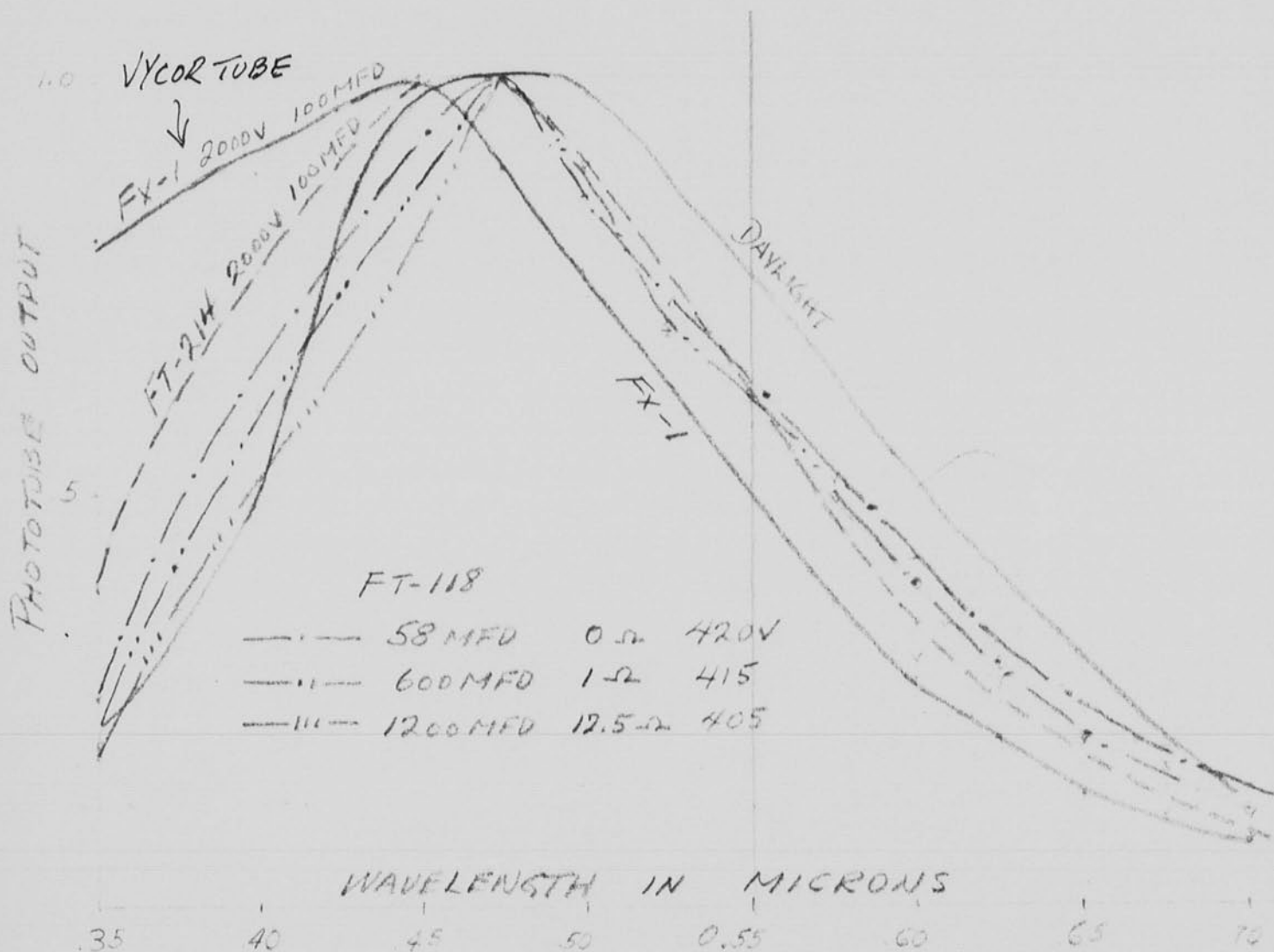
Sonar



Post to go around to hold the assembly in a vertical position.

Bottom of the sea.

Data taken by Roy Swanson
 on April 18 1955 20D102
 B&F Monochromator and 926 P.C.



note shift in Blue response with operation of the sensor. This will be worked out in terms of dimensions and loading.

May 1, 1955.

Harold Dugston.

I was in Chicago with Hoodley and Wychroff on April 21 (Mary Lou's birthday).
With Hoodley a paper on underwater cameras was presented to the SMPTE.
Then with Wychroff a paper on the electronic flash sensitometer,
was also given.

EG&G had a showing of equipment at Smith's one day show
at the Kenmore Hotel.

I visited Cleveland on April 22 to see the E.E. Co.

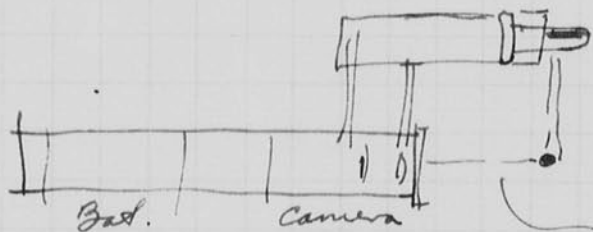
On Sat. Apr. 23 I talked to the PMA technical group at
the Powers Hotel in the evening.

Sylvania had a dinner Apr 27 at the Algonquin Club
at which I attended.

I gave a talk Apr. 28 at the Boston Camera Club
to the nature series - Subject - Underwater photography.

This morning at 7 am - Communion and Breakfast
for men. Some 5000 turned out.

Closeup camera design.



Short-flash lamp.

photos 1/2 size or 1 to 1 or 3:1. ?
optional.

10" = min distance to subject.

May 14, 1955
 David Denton.

The capacitors (sprague 22D9 and 22D10) have a longer flash than the 22D4! I called Chertok. He is going to make some samples with extra tabs and with low resistance electrolyte.

Progress is being made on the deep anodes, sensor, and nylon line. I hope to have the lot on a ship June 17 from N.Y. for Marseille.

John Brown & ^{Bob} Hartman are working on the nylon rope.

Dick Ward and Smith are doing the spectro experiments.

Bill MacRobert is wiring up the strobes and cameras.

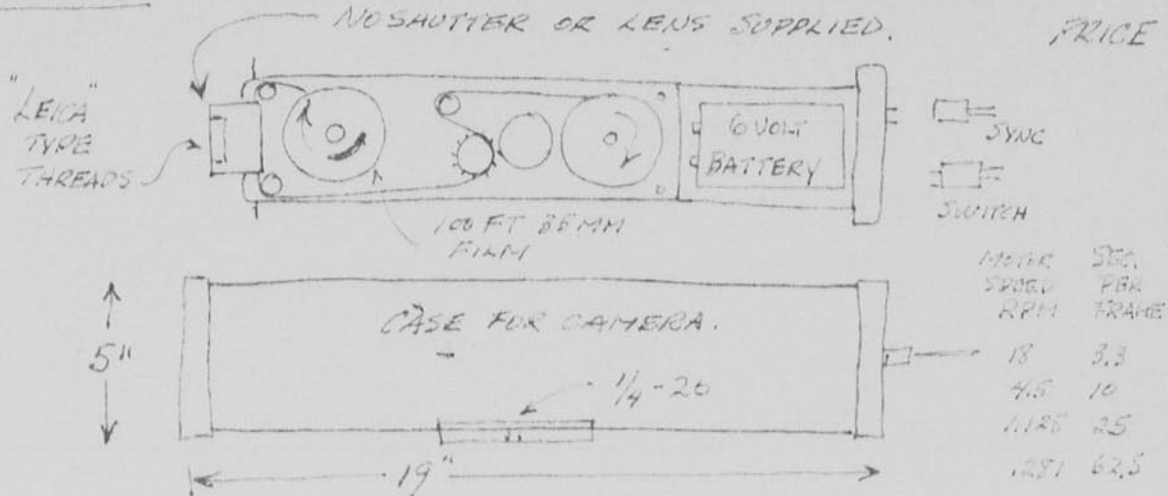
EDGERTON GERMESHAUSEN & GRIER,
160 BROOKLINE AVE BOSTON MASS.

INLINE CAMERAS
35MM FILM, 100 FT.
PRELIMINARY DATA.
APRIL 30 1955 A.E.E.

MODEL NO. 1.

BASIC FILM MOVING MECHANISM & CASE
NO SHUTTER OR LENS SUPPLIED.

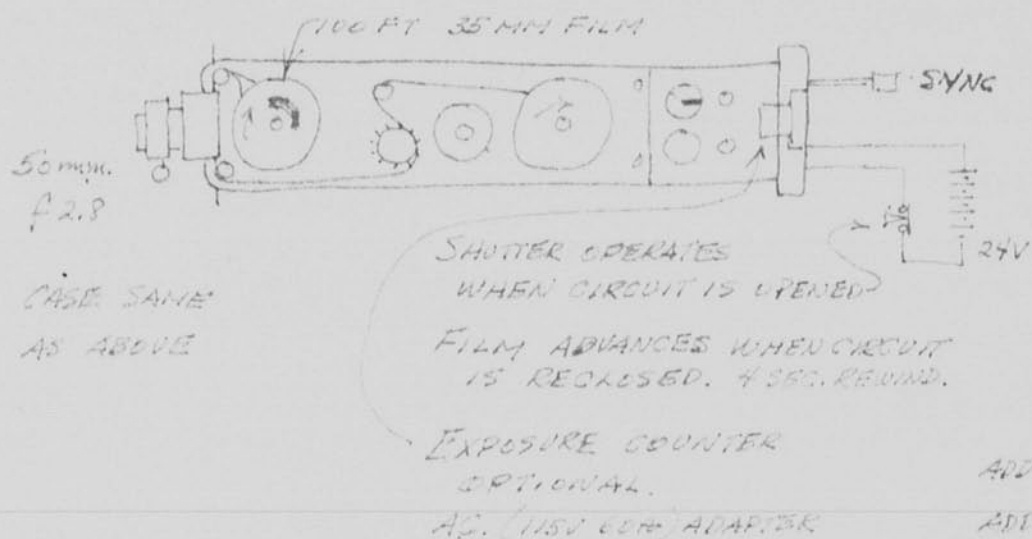
PRICE \$ 350



MODEL 2.

CAMERA WITH SHUTTER AND
FILM ADVANCE 24 V. D.C.

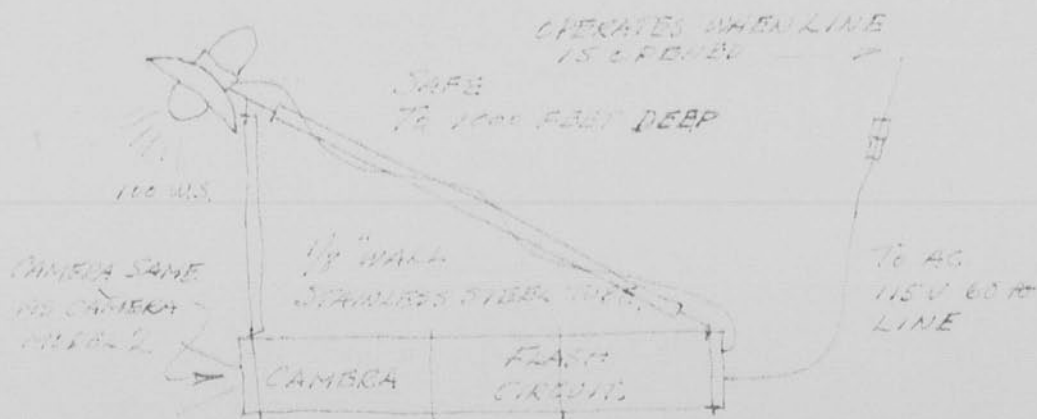
PRICE \$ 650



MODEL 3.

UNDERWATER CAMERA

PRICE \$ 2000.



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H. S. Robertson
May 24 1955. Term just ended:

Tom Smith and Dick Ward. Sonar thesis. Rebuilt Eds.

Jack Brown - Bob Hartman Camera lowering problem.
with nylon string.

Geo. LeCompt. Xenon lamp tests and theory.

Chas. Rodwell - Exposure meter with neon bulb.

Joe Watson - Thyatron controlled flashes.

Francis Mullin - Starting of a Xenon tube } did not
complete
write up at
end of term.

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The Dufur (De Fur) Ango (Ango) is a small, rugged, waterproof camera with a lens that can be retracted into the camera body. The camera is powered by a 300mAh battery and has a flash that can be used in a variety of ways. The camera is available in black and white and color models. The price is \$149.50.

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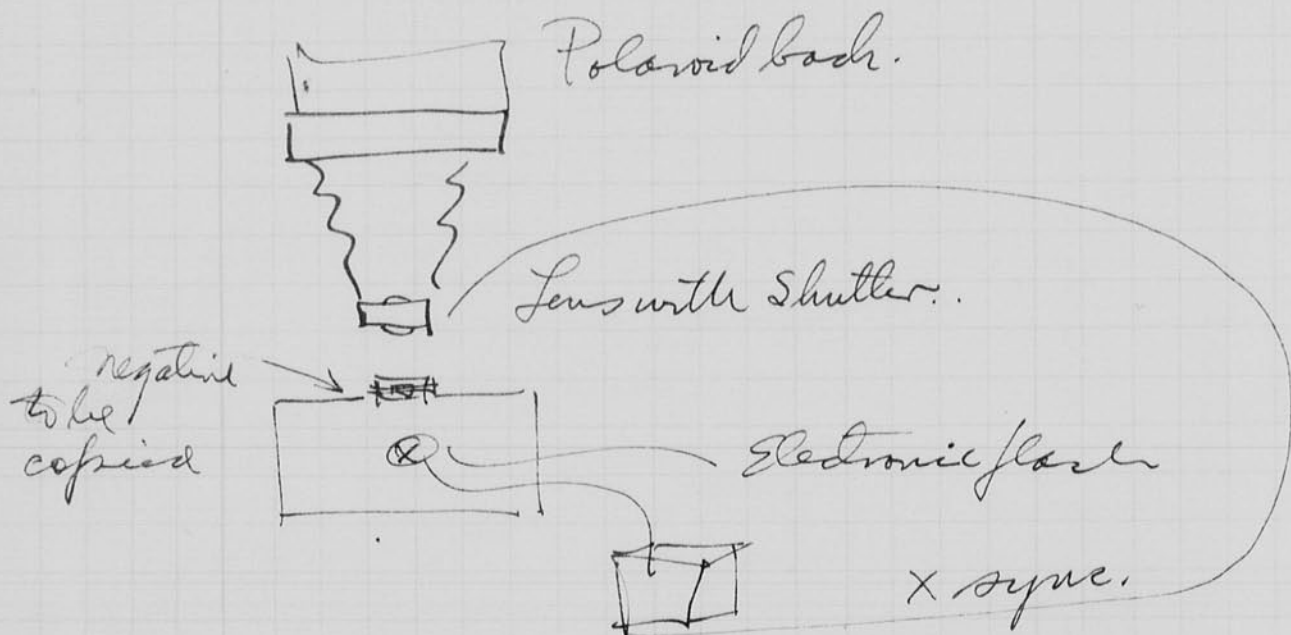
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June 2 1955
Harold Edgerton.

This morning Dwight Merrill of Polaroid was in to give me curves of speed and time for our fastax on 115 rolls. The curves show a film speed of 120 feet/sec. (4500 frames/sec) and a 0.4 sec running time for 100 ft. This fastax does not have a prism.

I told Dwight about the color slide copier that I mentioned to Wydroff last week. This machine would be sold to stores to copy Kodachrome. A Polaroid film would be used on the top to do the copying instantaneously. With flash the work could be done in a 'lighted' room.



This is based on Charlie's equipment for copying XEC films in Black and White.

The equipment could be used by the customer in the store or by an operator. It would sell a lot of Polaroid film!

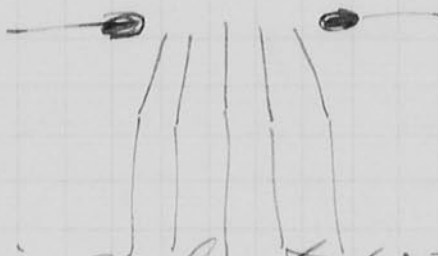


June 3 1955
Herold Edgerton

13

Demershausen brought over his gap tube last week for tests. The data is in the "light" book. Efficiency is almost the same as other tubes.

This tube is in xenon at 1 atmosphere, a series of thin wires stabilize the starting of the arc.



Starting is good at 600 volts (or more). Some misses at lower voltage. The lamp seems to work fine at high frequencies. The light is white end of short duration.



A magneto optic
shutter plate
of the arc over of
a 500 watt
projection bulb
Taken for G.E.

14 August 14 1955
Harold Edgerton.

Janice Dixon is one year old today. Hickory U.C.

I returned Aug 11 from London. The summer has been spent on the Calypso on an underwater project. Reports of the activities were recorded in a series of letters to Dr. John La Sorce at the National Geographic Society, who sponsored the project. I left the Calypso in Piraeus Greece.

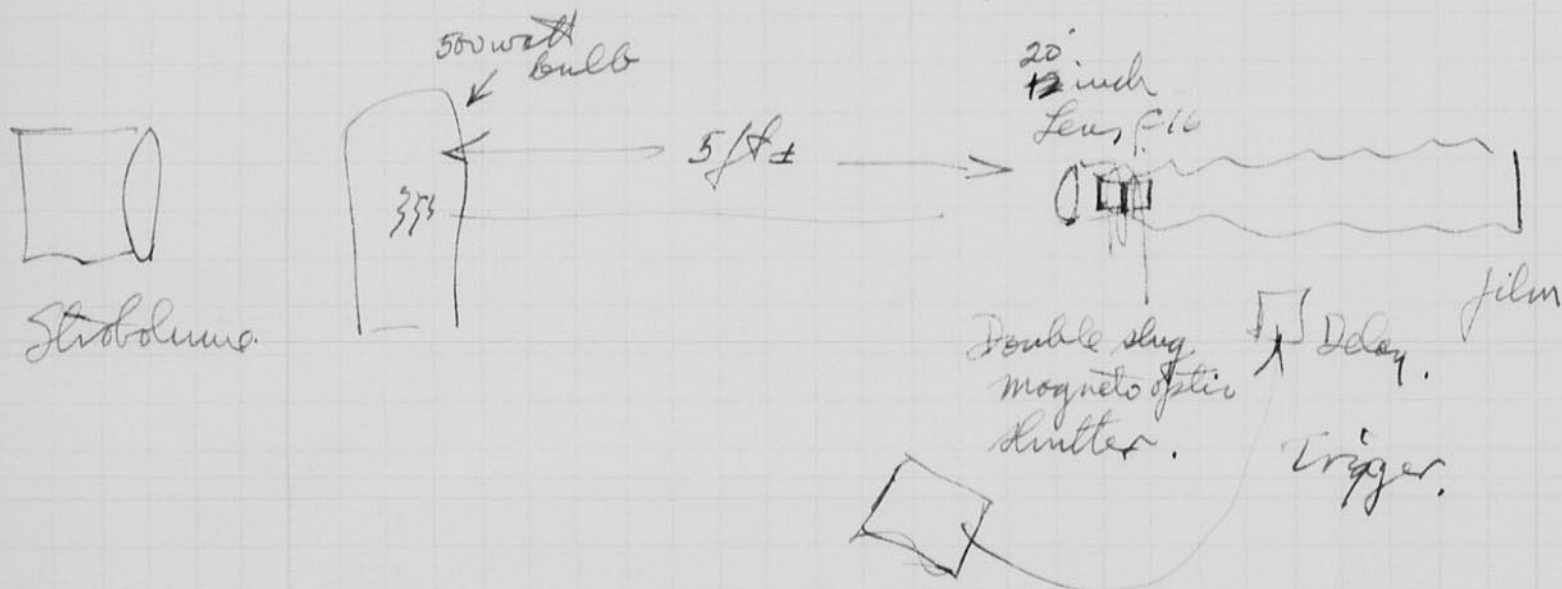
A camera with sonar was used at 4400 meters to photograph the bottom off Greece.

My son, Bob, took over the operation of the cameras when I left. Bob will return in September, His school is late in starting this year due to some complications. This was good.

August 15, 1955.

Tests were started yesterday on the 500 watt projection bulbs as sent by Dick Blount.

3200°K Projection

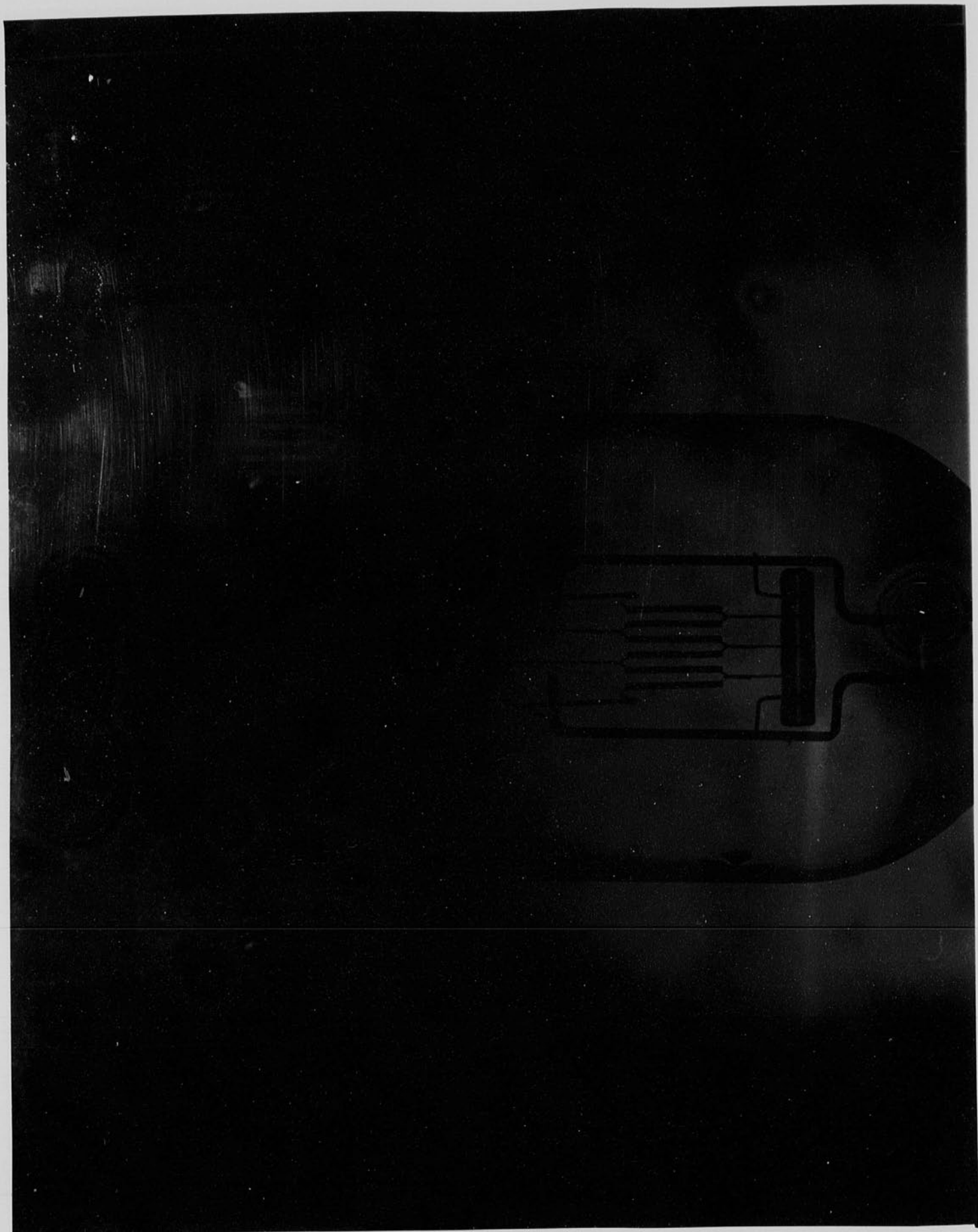


after some tests where I did not obtain triggering from the arc (using a simple phototube) I then used our black box trigger. This could be too sensitive.

Final test. Phototube distance 18" lens at 6" Delay at 30 - (120 ns).

Bulb A

| Bulb B. | Photocell gain | Delay. | Remarks |
|----------|----------------|----------------------|-----------------|
| | 4 | 250 μ s. \pm . | Exploded wires. |
| Bulb C. | " | " | " |
| D | " | " | Did not arc |
| E | " | " | arc |
| F | " | 200. | arc |



Sept 3 1955 M.I.T.

Harold E. Edgerton.

Recent travels.

Aug 16 Sam to New York to process negatives of summer.
at Deluxe Lab. New York.

17 Chicago at the Phot. Assoc. convention at
the Hilton Hotel.

Big 12"
Rain →
in Belmont.

18 "

19. To Grand Island and Aurora to visit parents.

20 Aurora

21 to Boston via United

23 Left for Washington D.C.

24. Nat. Geo. way.

25 David Taylor Model Basin

Left for Wilmington

Dinner with Greenwalt - Robinsons.

26 Worked on flash with Greenwalt.

Import mech div with Johnson
Aberdeen - Bob Kent.

27 Arrived in Hickory N.C. to see daughter
Mrs. Chas. Dixon and family - inc Janice 1 year old.

28 Hickory

29. Navy Hydro office. Jaffe. Dean.

F.B.I. Parsons.

At Belvoir John Johnson Kessler Klein

Nat. Geo Mag to pick up prints

30 Aberdeen and all day with Sultanoft

31. New York to see Mrs. MacDonnan at noon

Bill Edgerton in apt.

stayed with
Fogues in Wash
stayed in
Wilmington
with Robinsons

Sept. 1. Ret'd to Boston.



Flash unit for Greenwell.
Sept 3 1955.

Desired characteristics

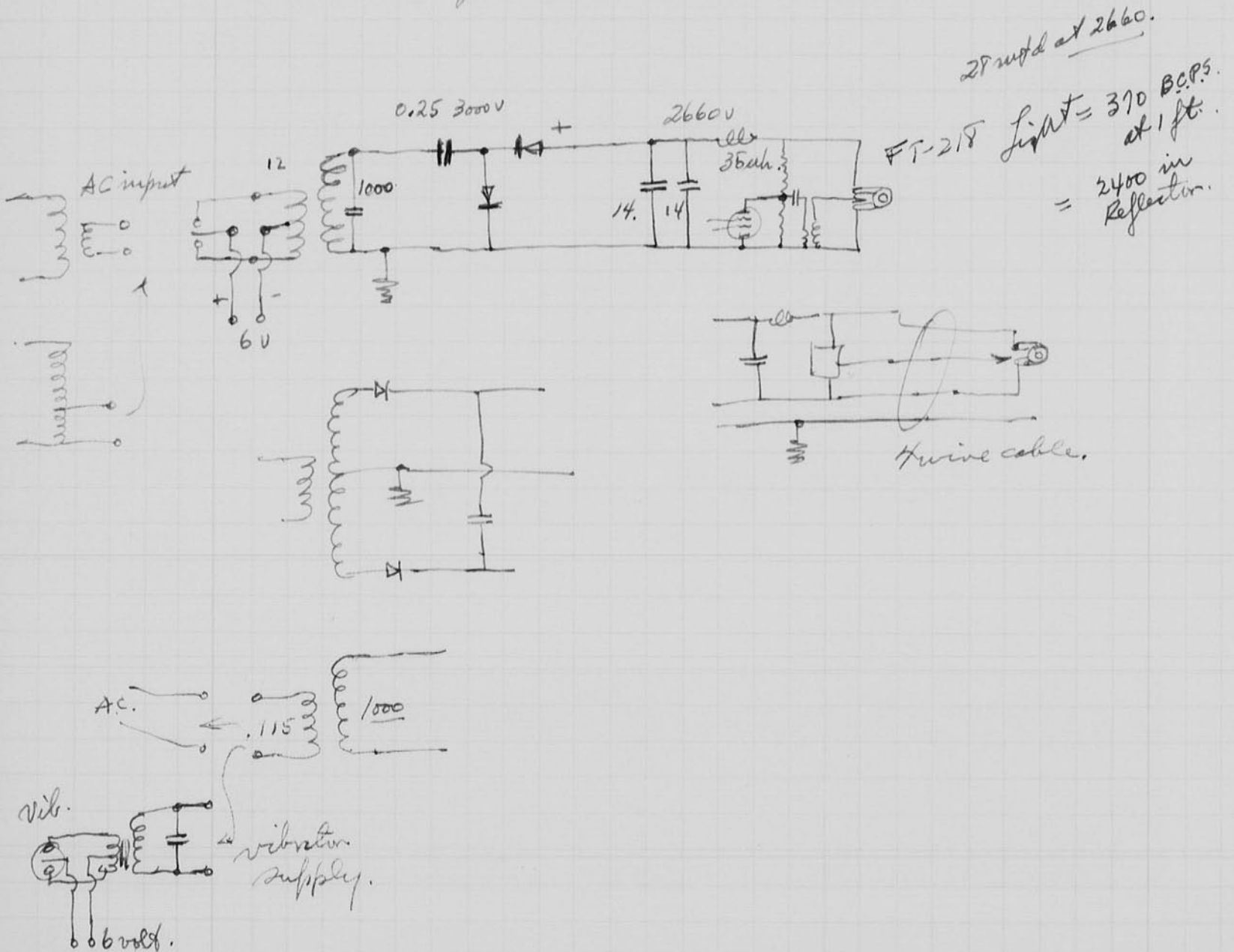
Flash duration 50 μ s or less, will compromise with 70 to 100.

Light about 2000 B.C.P.s at 2 ft., in three lamps.

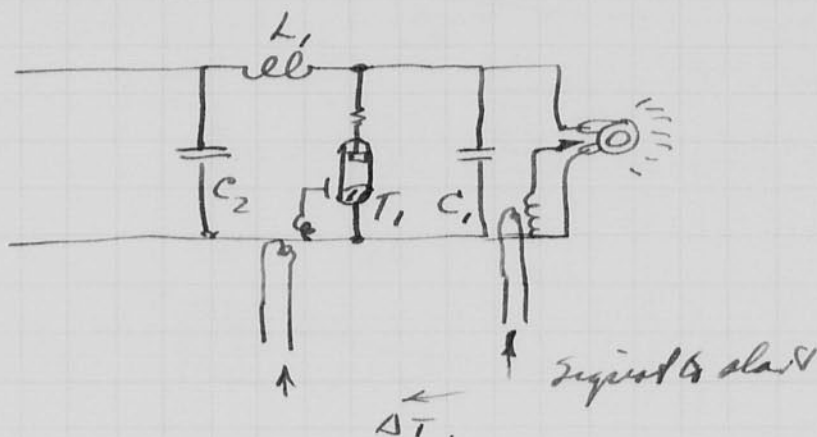
Unit very light weight.

6 volt power acceptable for portable use, auto battery ok.

A.C. for use most of the time.



Flat top light: for use with a drum camera or a matrix type using a sliding plate.



C_1 gives the tube energy for a fast start,

C_2 gives the energy to maintain the light.

T_1 is a low resistance tube to short the capacitor and stop the light

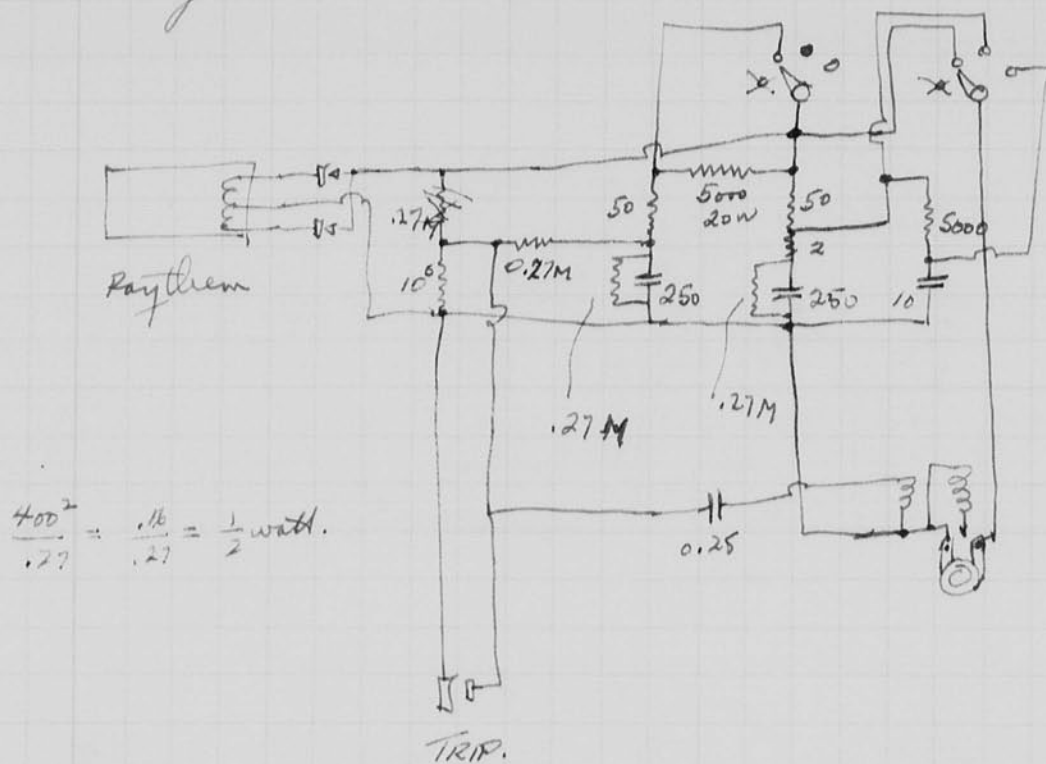
L_1 might be reconnected as well as inductance.



Requirement $\frac{1}{4}$ to 5 millisecc
for a special camera
that Johnson of
Dupont is
making.

Sept 5 1955.

Harold S. Edgerton.



$$\frac{400^2}{.27} = \frac{.16}{.27} = \frac{1}{2} \text{ watt.}$$

| Inputs. | Output | Light. | as read with GR 1501 Light meter x1 Lumens sec / sq foot at film position. |
|---------|--------|--------|---|
| 80 | 108 | | |
| 90 | 110 | | |
| 100 | 114 | | |
| 110 | 113 | | |
| 120 | 112 | | |
| 130 | 111 | | |
| 80 | 111 | | |
| 90 | 112 | | |
| 100 | 113 | | |
| 110 | 115 | | |
| 120 | 113 | | |
| 130 | 114 | | |

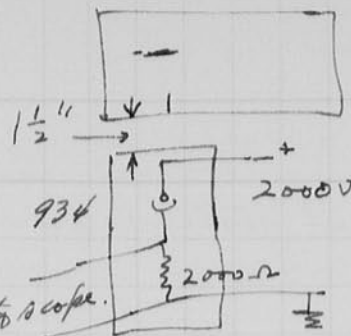
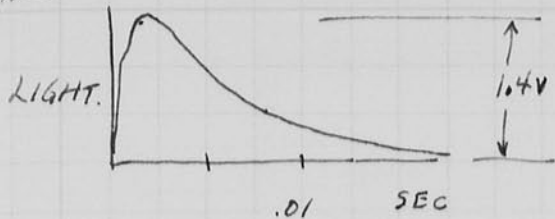
all on 1/100 scale.
2.

| | |
|-----|-----|
| 115 | 115 |
| 115 | 113 |
| 115 | 115 |
| 115 | 112 |
| 115 | 114 |
| 115 | 113 |
| 115 | 113 |

1/100 scale Light.
115V 19.
21

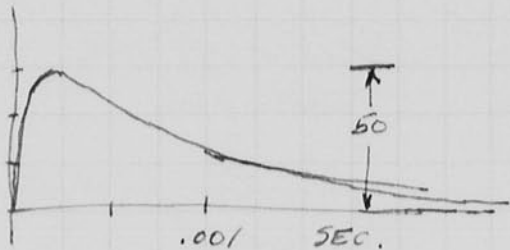
1/10,000 Light
- can suit on the meter.

1/100 Sec

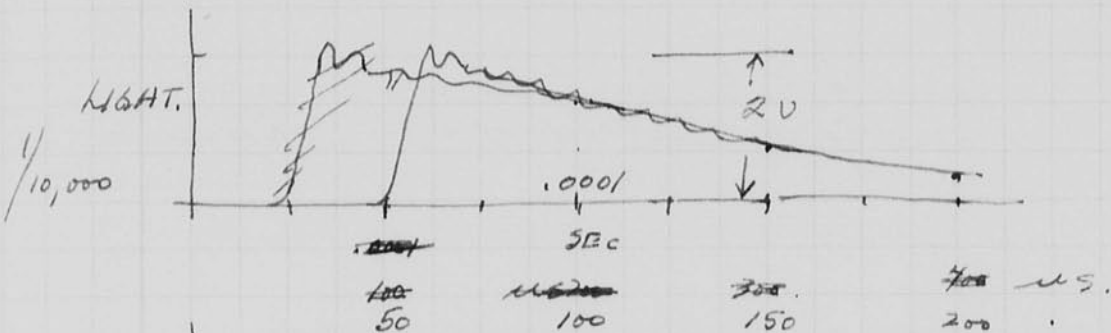


Reads volts and time.

LIGHT
1/1000

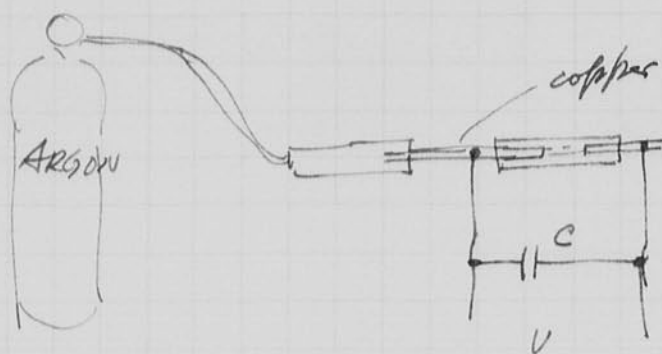


1/10,000



Reports
 20 D 10/2 MIT
 Sept 9 1955.

test yesterday were made with argon
 flash tubes on pressure.

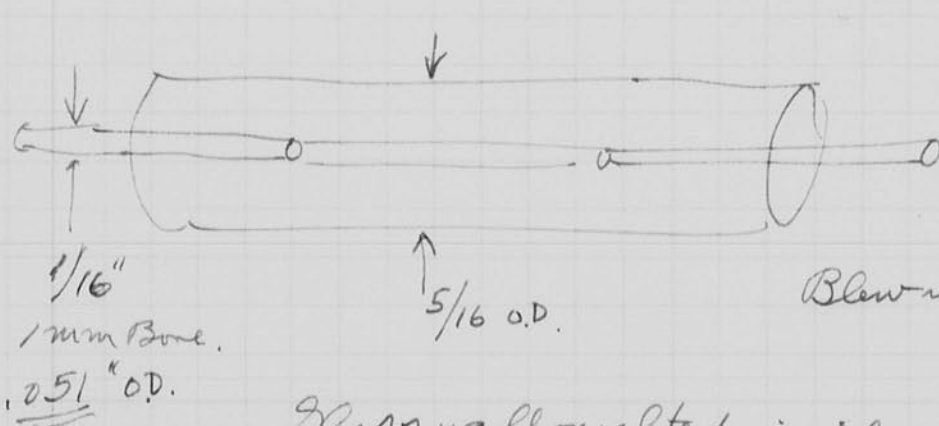


Sealed off one
 1 inch gap.

1500 volts first flash,
 then went up to
 3500 with 1 mfd.

Second tube flashed on pump.
 up to 10 mfd at 4 KV. Copper
 metal splatters on the
 quartz wall.

Sealed off with pinch seal
 ok. after seal.



1 mm Bore.
 .051" O.D.

5/16 O.D.

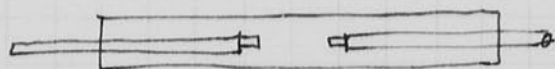
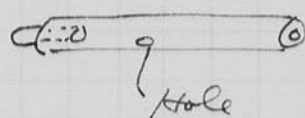
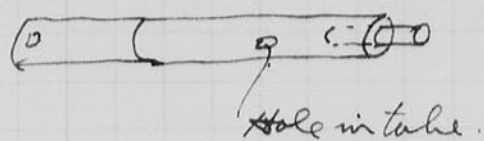
Blew up with 10 mfd
 at ~~3~~ 3 KV.

Glass wall melted inside
 circumferential craze lines.

$$W.S. \frac{9 \times 10}{2} = 45.$$



Tungsten tips were put into the tube.



$\frac{1}{2}$ inch gap.

Starts at 500 to 700 volts.

Flashed at 1, 2, 5 and 10 mfd.
the 10 1500 volts
Shows deep cragging.

Tube above sealed off.

Another tube made.

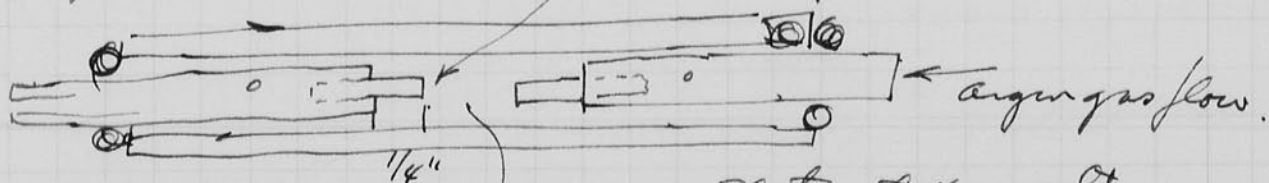
5 mfd at 1000 volts no cragging some metal spots.

10 mfd at 1000 volts. some cragging after 4 flashes.

The above sealed off with pinch seal.

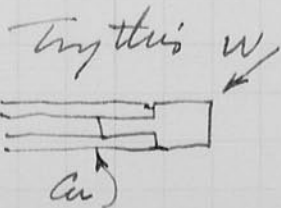
Both the above tubes were leakers. I note that the nichel does not seal when squeezed shut.

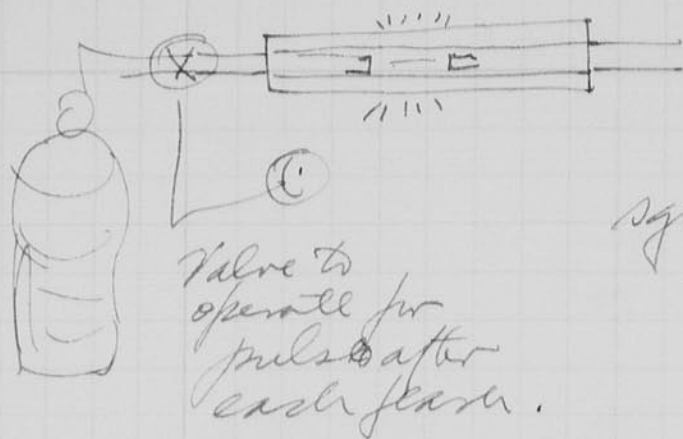
Went back to copper with tungsten tips. 50 mil.



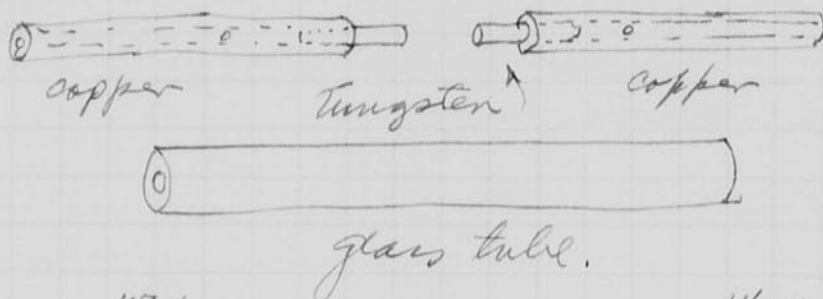
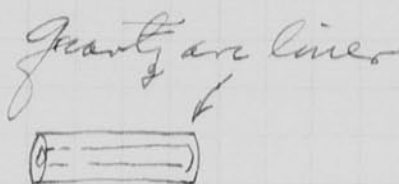
Starts at 400 volts.

Flashed at 30 mfd 1000 v.
Sealed off. Shows copper sputtering due to arc spreading back to copper.





The flow of gas could be used for cooling. After each operation a pulse of gas could be squirted through the tube.



wax joints

wax joints.

cement.

Punched seals after argon gas is introduced.

These designs have a very small exchange chamber for gas to go after a flash. This should cut down the ripples and increase the efficiency.

Possible uses. Microscope tube.
Short flash equipment
Point source for shadow and silhouette photography.

Sept. 10, 1955.

H. Edgerton

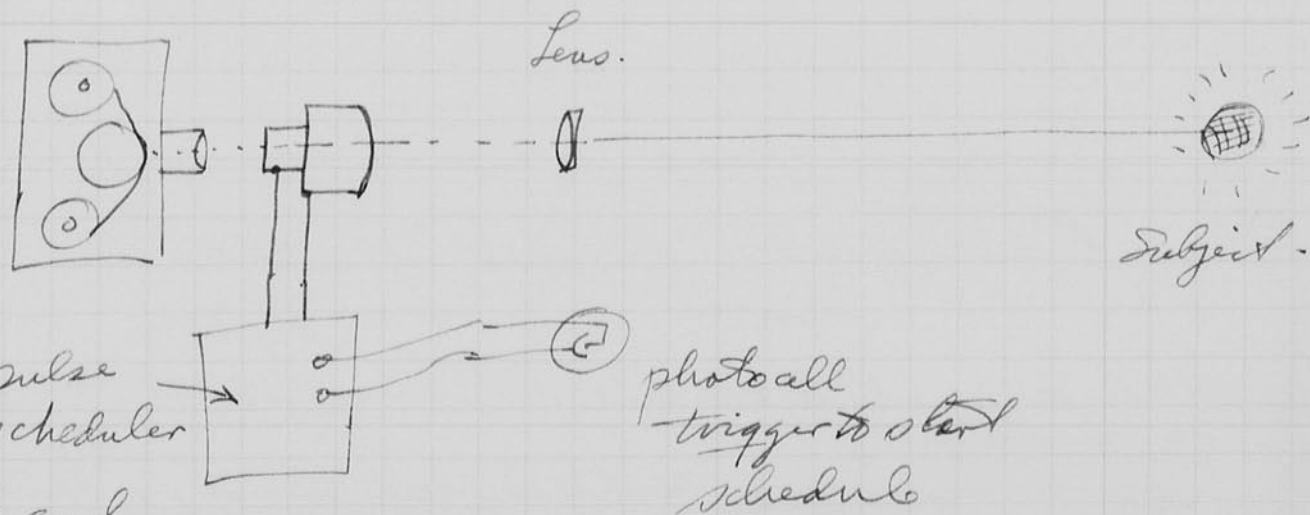
Camera with variable photo time, Exposure time, and effective aperture.

For many technical problems a series of photographs are usually required to study the action. High-speed motion pictures, when used, give a series of constant time spacing from which data can be measured.

I now propose a new system that uses a continuously moving film but with an image converter tube that only puts on photos when they are desired. Further more the exposure of the photograph and the effective aperture, or light amplification, can be varied, either automatically or according to a preset ~~schedule~~ schedule.

A typical problem that requires a camera of the type mentioned above is the study of the radius of the atomic explosion as a function of time. At first the light is tremendous, then the explosion develops in size and as it does so the intensity decreases.

A system is sketched below that might be useful.

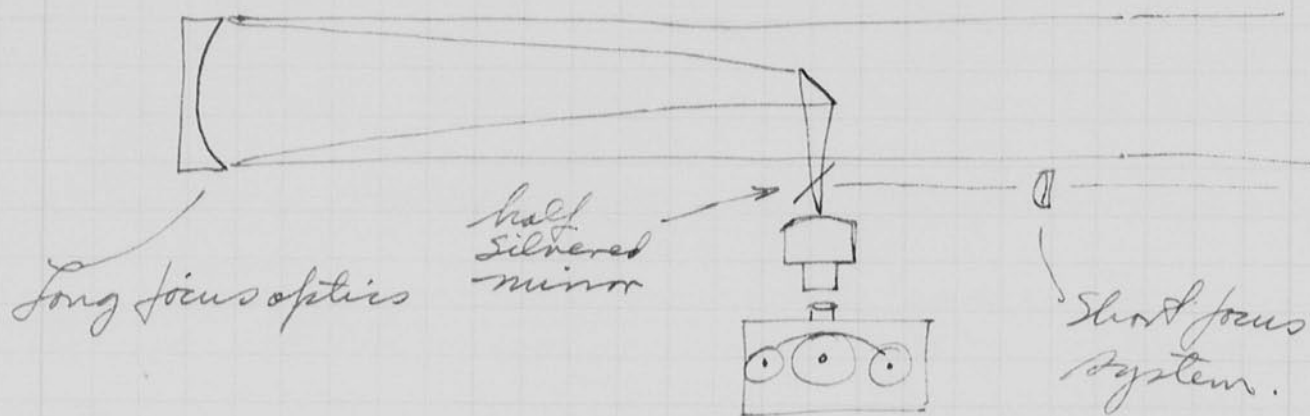


Designed & constructed by me May 8 '56 Miller & Spence

time and amplification and exposure will all be varied for each problem.

The system on the previous page was discussed yesterday with Bob Hartman at 160 Brookline Ave. I made some notes in his lab note book about the method since he will probably carry through a study of the system.

We talked it over with O'Keefe and with Ben Bretler. Ben had several suggestions to offer regarding the times and exposures that are needed for the atomic reaction desired data. There will be several models made if the method works as I think it will.



The above might be useful since it would give an enlarged image for the first part of the record. Then the short focus lens would take over for the later part.

It may be necessary to run up to 10,000 frames a second. To do this on conventional film requires a very high writing speed for full frame 35 mm photos.

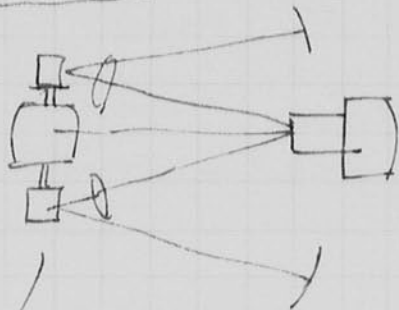
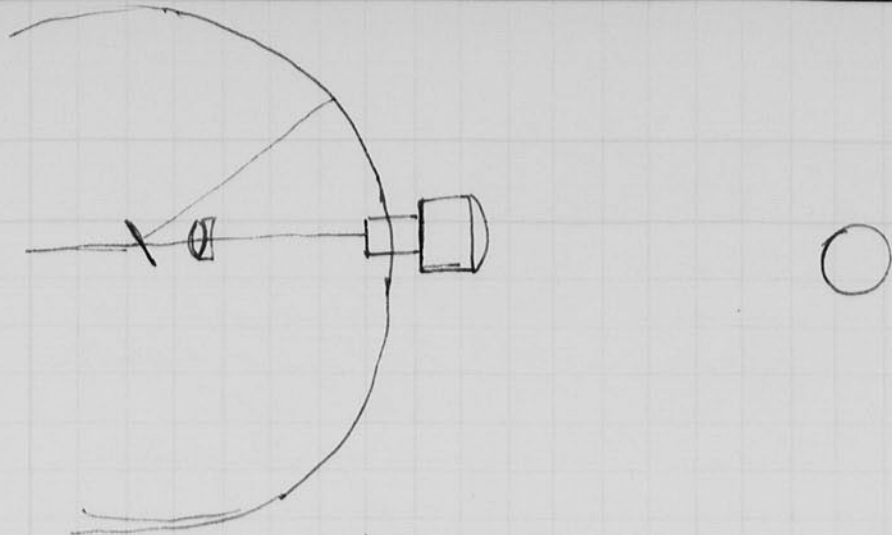
$$\frac{3/4 \text{ inch}}{1/10,000 \text{ sec}} = .75 \times 10^4 = 7500 \text{ inches/sec} \\ \approx 600 \text{ ft/sec.}$$

Difficult to attain on moving film.

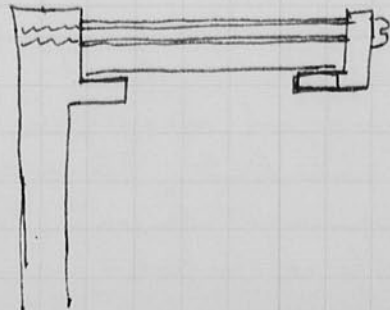
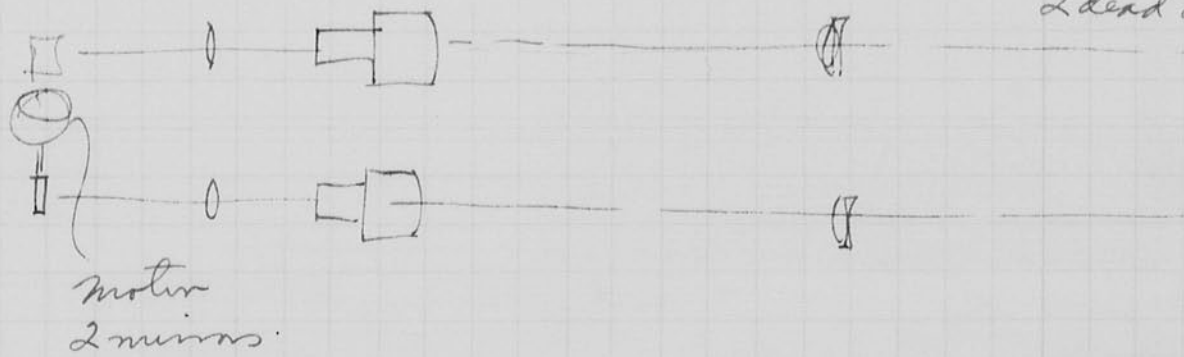
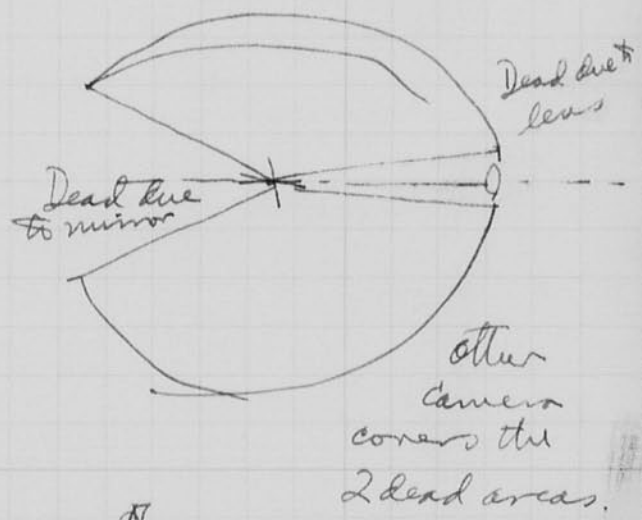
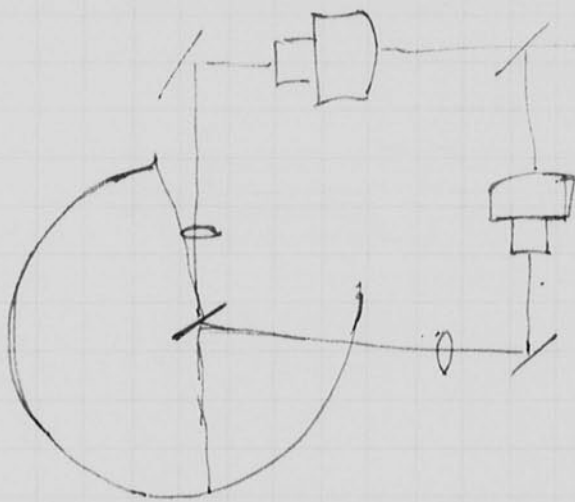
a mirror camera can do this fairly easily. Say a 1 ft radius

$$3 \text{ ft per rev.} \quad \frac{600 \text{ ft/sec}}{3 \text{ ft}} = 200 \text{ rev/sec.} \\ \frac{60}{12} = 5 \text{ r.p.m.}$$

1 ft.



2 mirrors at 90° on axis to give a continuous view.

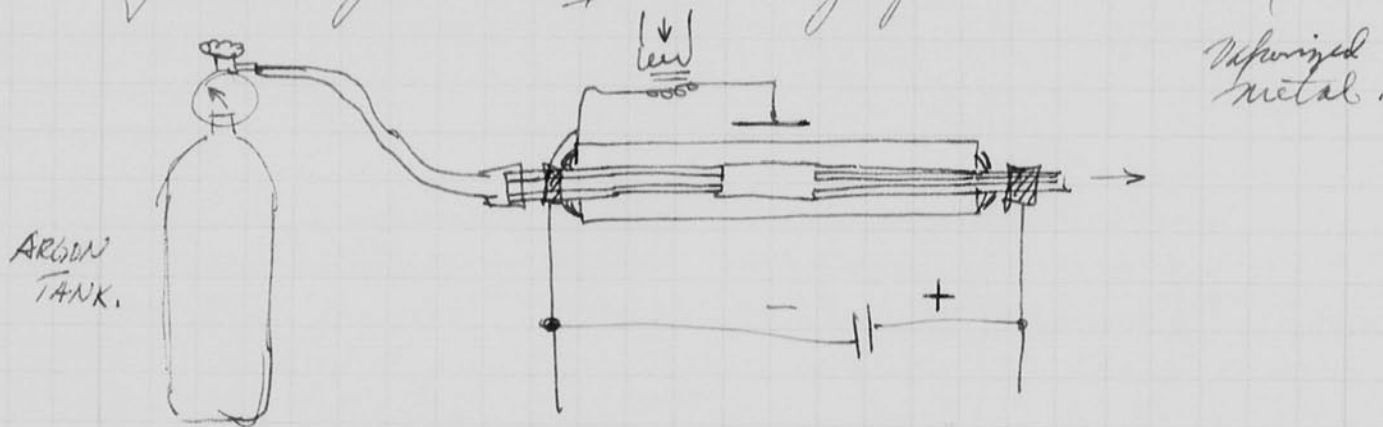


Sept 11 1955
 205 School St
 Belmont, Mass.
 Harold Edgerton.

Flash tube for
 high intensity.

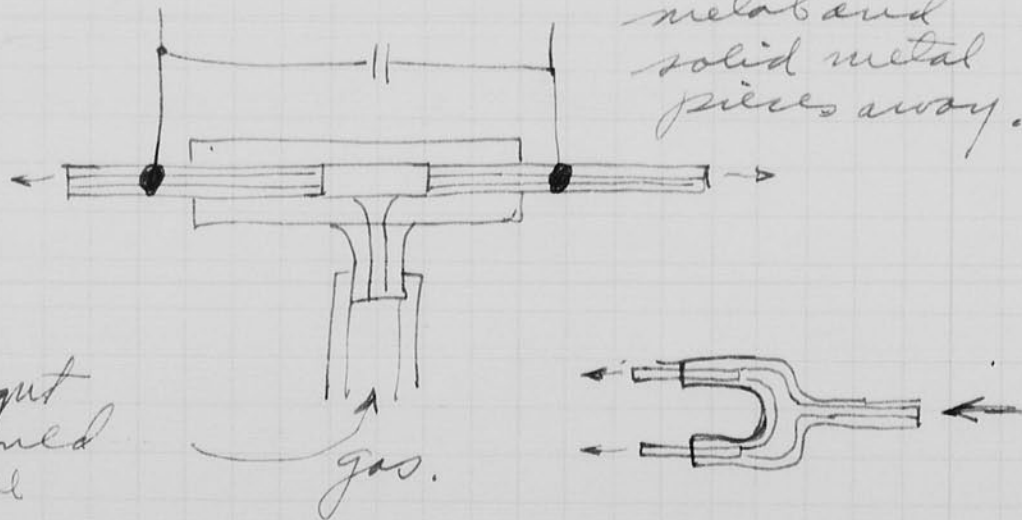
It has been observed that the anode of flash tubes at high intensity melt and splatter metal around in the tubes. The best metal for ~~these~~ anodes is tungsten because of its high melting temperature. It also is well to use tungsten for the cathode since the high current density will evaporate any less easily vaporized metal. When both electrodes are tungsten, the anode sputters the most.

I now propose that a flowing gas through the tube would take away the vaporized metal, thus preventing it from depositing in the gap.



Another way would be to have a flow of gas from the center of the tube into both ends. To take both anode and cathode vaporized metal and solid metal pieces away.

The cooling could be pulsed just before the flash.



A condenser for the vaporized metal might be needed. This could be connected onto the output pipes.

Bobby

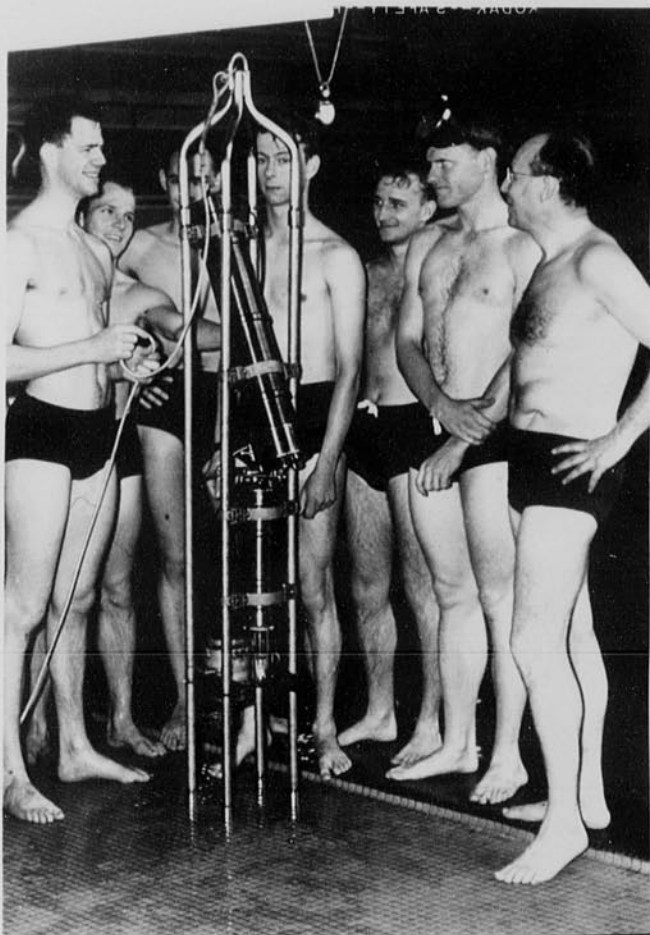


Aubrey

Chief Scout
Coulter
Acker

Bellor

Marcel
Laurin



Bobby

Smith

Hartman

Coulter

Keckell

Edgerton

Deep sea camera

S.M.P.T.E. Journal July 1955.

Sept 17

FT-218

13.5 mfd, 2600 volts

Erectly. Two cases with and without 35 uh.

2. none

3. 35 uh.

4. Two cases, 0 and 17 uh.

17 uh.

none.

6th used later

Sept 19 1952, H. G. G.

Bill Mack, Roberts and Pierre Cathon worked on this problem above today. Bill used a small inductor and which with 6 ft of wire reduced the intensity (peak) to $3/4$ of that without a choke.

A life test showed lots of white material in the tube but no loss of light after several hundred flashes.

Sept 26 1955

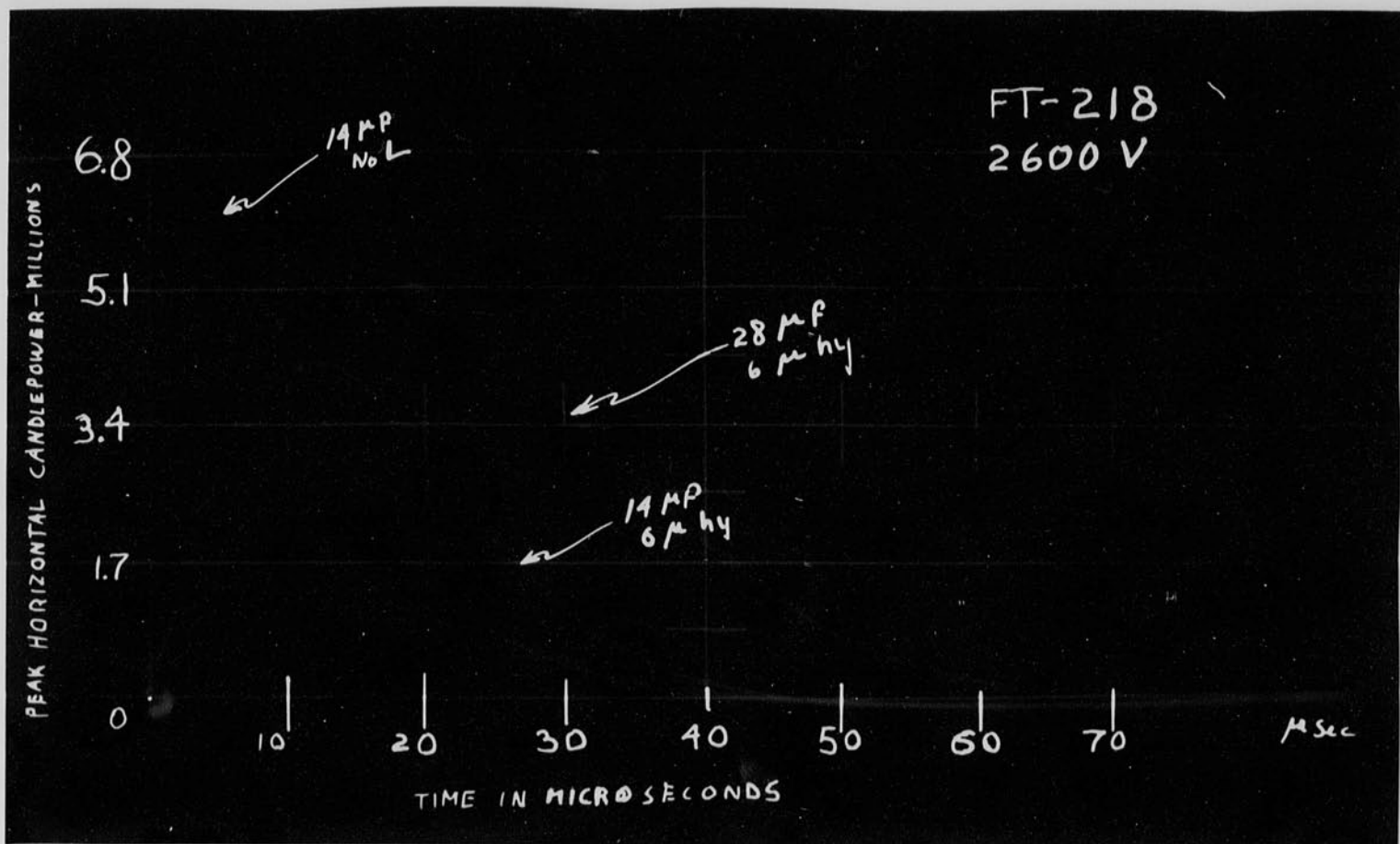
H. G. G.

Last week Bill Mack and I made two tubes with argon / atmosphere in double type quartz lined tubes. The tungsten electrodes were 58 mils. The gaps $1/8$ inch. Copper ends were used and a glass cover. DeKolskini cement on the ends held for a while but eventually leaked due to heat after first blowing a bubble.

A three hour run showed some scoring of the quartz at the arc portion. I had 0.1 mfd at 1800 volts at about 20 flashes / second.

I showed the above tubes to Ropt Pine and gave him a sample.

The 3 hour tube showed a white deposit on the ends due to evaporated quartz. The gap was not very dirty in this time.



Oscillograms taken last week by Pierre Cathou on an FT-214 with 2600 volts with different series inductors and 14 and 28 μ F capacitors.

This is the condition for Greenewalt's flash in Farber's unit.

32 Sept 26, 1955 cont,
H.E.S.

A supply of Wycor was purchased recently with a .1 inch hole and a $\frac{1}{4}$ inch diameter.

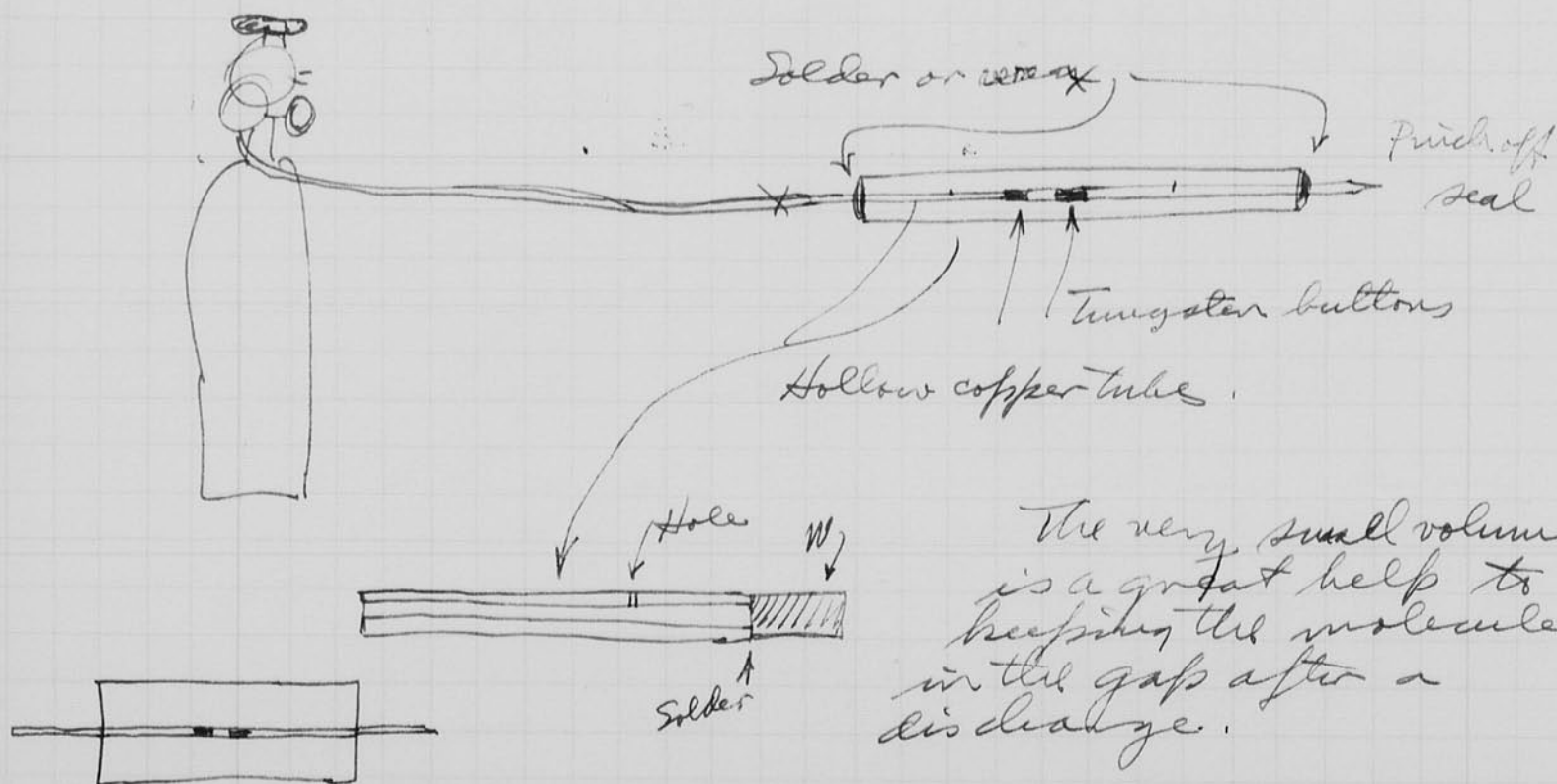
I plan to obtain a .091 inch diam copper tube for ends. The hole is .032."

Tungsten electrodes will be soldered to the copper. Then exhaust holes will be drilled.

Finally the ends will be soldered or waxed into the glass. Sealing will be by pinching.

I have not tried sealing at pressure but believe it can be done without difficulty up to 2000 p.s.i.

There may be trouble with the glass. It may break with the pressure.



The very small volume is a great help to keeping the molecules in the gaps after a discharge.

Oct 5, 1955

33

Harold Edgerton.

One gap tube was tried by my son, Bob, Pierre Cathon and I before I went to Nebraska. The results are in Cathon's book.⁽⁵⁾ They show

1. The efficiency increases with pressure up to 40? #/sq inch.
2. The second bump due to circuit oscillation is reduced when the pressure is high.

The above tests were made on a $\frac{1}{8}$ inch gap in a 25 ~~mm~~ mm diam tube of Vycor with pressures from atmospheric to 40 or 50 p.s.i. See Cathon's book for data.

There was some jitter in the results which I do not understand. Probably it is due to arcs going around the tungsten electrodes.

Oct 8/1955.

Demonstrations of microflash unit at PSA convention last night with Ed Land of Polaroid. We used the microflash to shoot photos of arrows and bullets. Ray Swansen, Pierre Cathon, and Dan Norman helped.

Lined up as per page 17.

32,500 watt bulbs.

3200 K.

Oct. 10, 1955
R. E. Edgerton
Roy Swanson

Bulb #A gain at 8.

Triggered when lamp went on, also
when arc over occurred. Photo
under exposed M.S.

B Again fired prematurely. 115 volts on gap

Good lamp - Gap volts increased to 130
when other gap was used in
M.O. Shutter circuit
no dumpingFlash of stroboscopy to show
growth of filament.

the filament did not show!

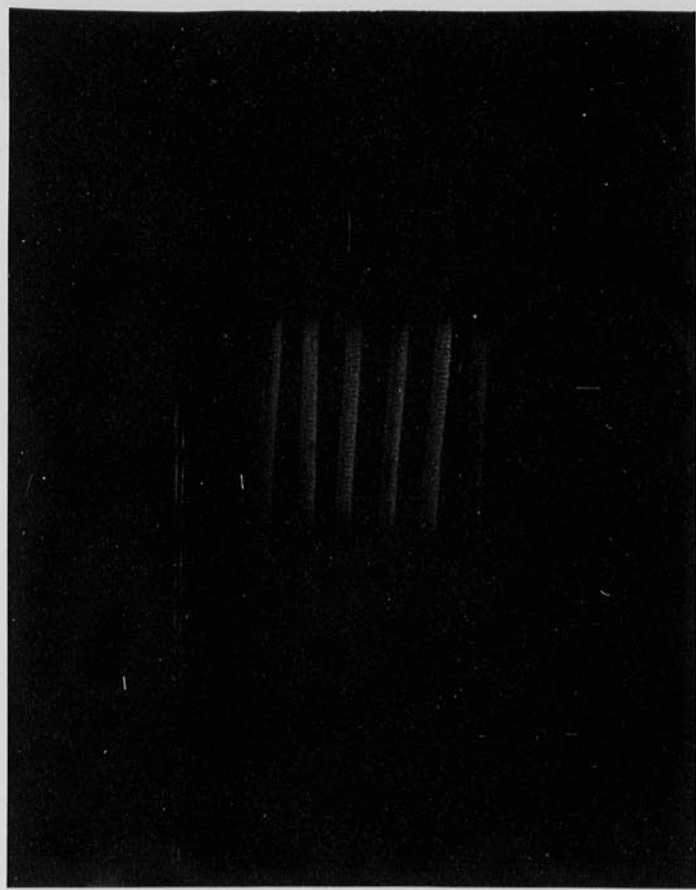
Lamp C. Gap volts 130
Trigger at 7 at 2 ft.
Delay at 6. (zero on ^{scale} scale.)Lamp D. Ditto.
Loud noise in M.O. due to broken wire
in discharge.

Lamp E ok. Ditto time. Blew

Lamp F ok " " Blew

Lamp G ok " " + 10 Blew

Lamp H Shutter blown up.



Shows spot forming
on the filament,

← This was the
only negative
that showed
a spot.

Sent to Nela Park.

Pierre has been testing gap tubes.

$\frac{1}{8}$ $\frac{1}{4}$ and $\frac{1}{2}$ inch gaps

argon 0 to 60 psi. above atmos.

0.1 mfd at 1000 to 3000 volts.

Effy seems to drop off with voltage?

$\frac{1}{2}$ " tube is about 2 times as efficient as $\frac{1}{4}$.

max effy is 0.3 c.p. / watt. Low

Oct. 23, 1955.

Harold E. Edgerton.

I had a session last week with Bill Parkin at the supersonic wind tunnel.

An XP-2 (1/4" gap in a 1 mm tube) was tried for exposure using the big mirrors. The first test was with 0.1 mfd at 2000 volts. Results weak when developed. Another test with 2 mfd at 2000 v gave excellent results. Now to design the equipment with least worry.

Oct. 24, 1955 The XP2 with 0.1 mfd at 2 KV was tried as an Infra red source in the Peat house with Bob Haggel and Johnny Boen. Pierre Cathou etc. The output was the same as a type 309 Sylvania (straight) with .25 watt seconds.

The same tube was also tried with Bob Kriebel in the Sloan laboratory on the interferometer. The capacity was increased to 2 mfd.

Photos were taken with a green and a blue filter to give sharper lines on the photographs.

The effy is about 1 cp./watt with the XP-2 with at 2 mfd at 2KV.

FX-1 conditions.
20 cm pressure
6 inches length
4 mm drain
5 cp./watt
2000 volts.

$$0.1" = 2.54 \text{ mm.}$$

$$\frac{E}{p} = \frac{2000}{6 \times 2.54} = \frac{E}{20} = \frac{131.}{20} = \underline{6.6} \text{ volts/cm/cm.}$$

XP-1 1/2" length
1 atmosphere plus 76 cm.
1/2 inch length.
2 mm I.D.
1 cp./watt. 2000 v.

$$\frac{E}{p} = \frac{2000}{.5 \times 2.54} = \frac{262}{1520} \text{ volts/cm/cm.}$$

$$\frac{E}{p} = \frac{1520}{76.0} = 20 \text{ volts/cm/cm.}$$

or 2. volts/cm/mm.

For comparable performance on the FX-1 the XP-1 should have the same, E/p?

$$\frac{V}{.5 \times 2.54 \times 76} = 6.6 \text{ volts/cm/cm.}$$

$$V = 6.6 \times .5 \times 2.54 \times 76 = 640. \text{ volts.}$$

(if $l = .25$) then $V = 1280$ volts.

another way to reduce E/p is to increase p.
for example if p were increased in the XP-1 to

$$\frac{20}{6.6} 76 = 230. = 3 \text{ atmospheres. (at 2 KV.)}$$

Energy per molecule in FX-1
volume = $\pi r^2 l = V = \pi .26^2 2.54 = 9.6$ cubic cm.

1.4 cm

Gas = $V \times p$ Energy = $\frac{CE^2}{2} = \frac{100 \times (2000)^2}{2} = 200$ wattsec.

FX-1 = $\frac{9.6}{9.6} \times 20 = 38.4$ cubic cm cm $\frac{200}{38.4} = 5.22$ wattsec per cubic cm.

XP-1 $V = \pi r^2 l = \pi .125^2 \times 2.54 = .04$ cubic cm. per.

Input $\frac{CE^2}{2} = \frac{2 \times 2^2}{2} = 4$ wattsec.

$$\frac{4}{.04} = 100 \text{ wattsec/cubic cm. cm.}$$

Data computed by Pierre Cathou

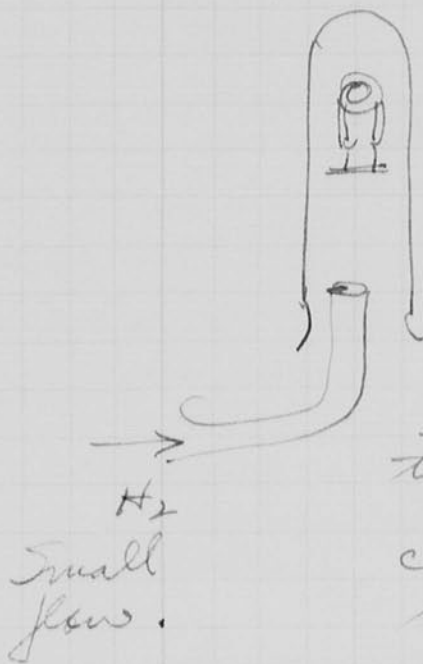
| FX-3 | FX-1 | $d = 0.4 \text{ cm.}$ $l = 6 \text{ inches}$ | XP-1 | $l = 3/8" \quad d = 0.085$ |
|---------------------|----------------|---|-------------------|----------------------------|
| $.13 \times 10^6$ | PHCP | 8×10^6 | 1.8×10^6 | |
| .15 | CPS/watt | 4.8×200 | 4 CPS. | |
| .01 | C | 100 mf. | 2 mfd | |
| 8 KV | V | 2000 | 2000 | |
| 1.2 us. | Dur | 140 us. | 4 us. | |
| .32 WS. | | 200 WS. | 4 WS. | |
| 0.045×10^6 | P.H.C.P./sq cm | 0.41×10^6 | 4.6×10^6 | |
| .05 | C.P.S./sq cm | 50. | 10 | ← |
| 4.5 | WS./cu. cm | 110 | 400 | |
| 2.9 sq cm | Area | 3 sq in | .06 sq in | |
| .07 cu cm | Volume | 0.11 cu inch | .0006 cu inch | |
| .10 cm? | pressure | 20 cm | 76. cm? | |

38 Oct 25, 1955.

Harold E. Egerton

Hydrogen cooled tubes.

I tried hydrogen as a cooling medium last Saturday, helped by Ray Swanson.



a FT-218 was used at 1000 volts with and 5000 ohms charging.

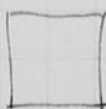
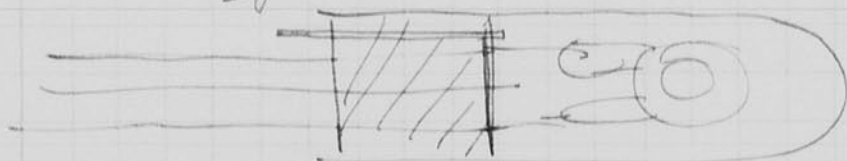
At 60 cycles the tube could be run continuously.

there is other data in Ray Swanson's Book about the tests.

about double the power could be put into the tube before stripping resulted.

It seems to me that a plastic tube might be built for the outer container. In this way, no damage would result in case of explosion. The end could be cemented after the tube installed.

H₂ filling tube



Liquid can also be used for cooling.

Pressure will build up.

Arthur Bosquet recently finished a model of the light meter with a CK 5886 tube in place of the 144.

The instrument now should read 50 lumens/sec. per square foot instead of 200. A 50 μ a meter will be substituted instead of the 200.

One object of this change is to increase the probe sensitivity.

Calc. Prob has 929 or 1P37 photo tube

$$S = 40 \mu\text{a/lumen.}$$

$$\text{area} = 0.5 \text{ sq inches.}$$

$$S = \frac{40 \mu\text{a}}{0.5 \times 12^2} \mu\text{a/lumen/sq. foot.}$$

$$i = S L \quad S = \frac{80}{144} \mu\text{a/lumen/sq ft.}$$

the old 1501 had 2 volts for full scale and an integrating capacitor of C microfarad

$$e = \frac{1}{C} \int_0^{\infty} S L dt \text{ volts.}$$

$$\frac{eC}{S} = \int_0^{\infty} L dt \text{ lumen sec/sq foot.}$$

$$\frac{2v \cdot .05}{\left(\frac{80}{144}\right)} = .2 \text{ lumen sec/sq ft.}$$

C.P.S.

⊙

$$\frac{\text{C.P.S.}}{d^2} = .2 \text{ lumen sec/sq ft.}$$

$$\frac{400^2 C}{2} = .8 \quad \checkmark$$

$$C = \frac{16}{400^2} = 100 \text{ mfd}$$

$$\text{Let } D = 2 \text{ feet C.P.S.} = .2 \times 4 = .8 \text{ candlepower sec.}$$

The new meter should be 4x more sensitive.

FT-214 Sld tube # 634

10 mfd at 2KV.

meter no. fl.

113 1 x 1 37

306 1/2 x 2 43.

#113 .05 m probe
306 .08

Oct 27 1955 Tests continued

4 mfd 1000 volts into FT 214.

113 with prob. at 8 ft

meter $\frac{35}{200}$ lumen sec/100 ft² full scale.

306 8 ft.

meter $\frac{45}{50}$ full scale2-3 lumen sec/ft² at 1 ftC.P.S. = 2.5×10^2

Readings on meter no 306

With Probe

$$\begin{array}{r} .03 \\ 64 \overline{) 2.50} \\ \underline{192} \\ 58 \end{array}$$

Using different tubes at 8 ft

$$\frac{2.5}{82} = \frac{2.5}{64} \approx .04 \text{ lumen sec/ft}^2$$

| Tube | Reading | | | |
|--------|---------|----|----|--|
| 1 1P39 | 52 | 53 | 55 | |
| 2 929 | 34 | 32 | 33 | |
| 3 929 | 32 | 35 | 35 | |
| 4 929 | 30 | 32 | 30 | |
| 5 929 | 37 | 35 | 38 | |

6 1 P 33 47 46 48

Oct. 29, 1955.
Harold Edgerton.

501 ERS equipment tests.

R110 transformer burned out last week. Replaced by Bill MacRoberts.

Observation of light vs time for 0.1 sec showed violent swing of light due to power unit transient.

A resistor was put across the swinging choke to damp out this oscillation.

Then the frequency could be increased to 10,000 cycles per second.

500 ohms was too much.

1500 oh.

2000 oh.

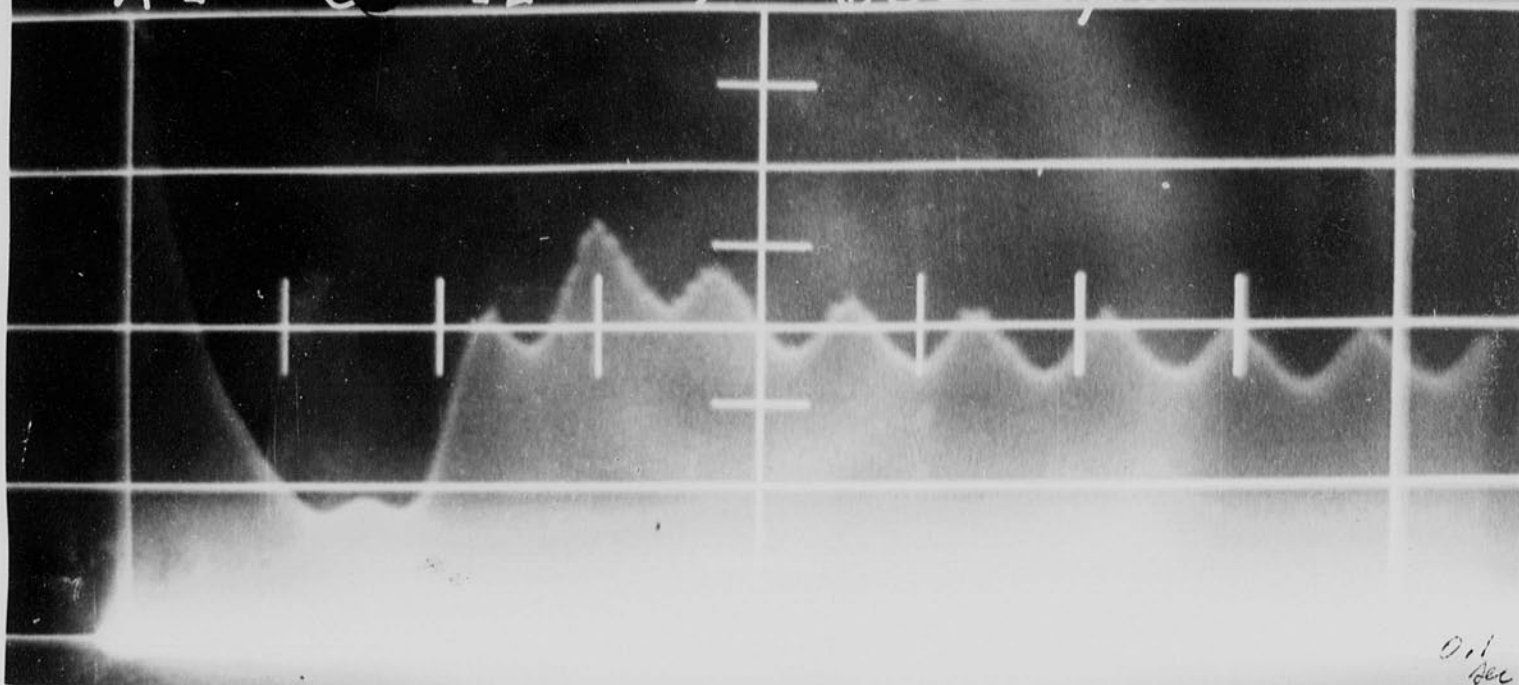
Decided to compromise on 2000 ohms. The lower resistors caused the voltage to drop some what.

Oct 30
Nov 1, 1955.N. Load - 5100 volts with 2000 ohm resistor across inductance instead 3700V.

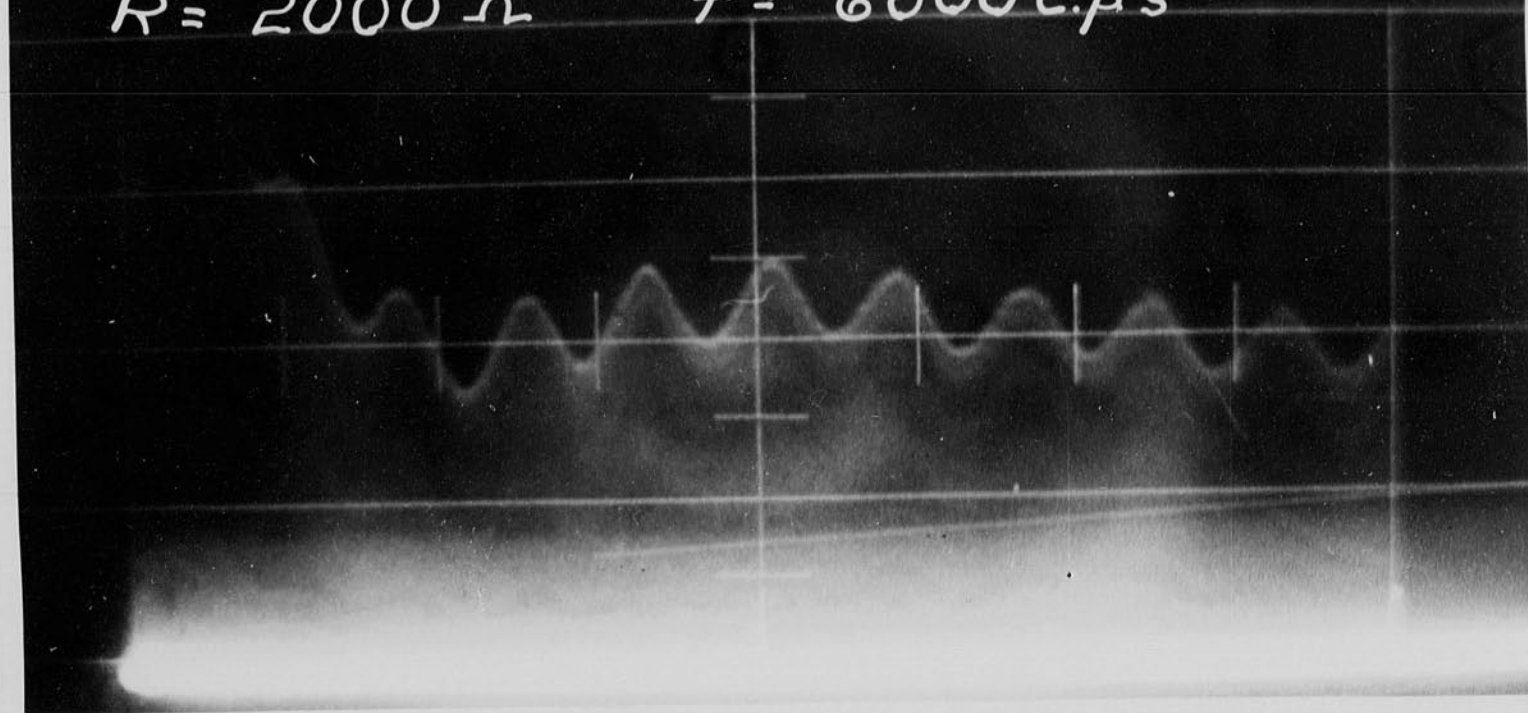
| V_1 | V_2 | | |
|-------|-------|-----|-------------------|
| 5000 | 3080 | 64% | |
| 4600 | 3070 | 67% | R = 2000 & choke. |
| 3600 | 3040 | 84% | as is. |

~~with 2000 ohm resistor and choke 2000 ohms 6000V.~~

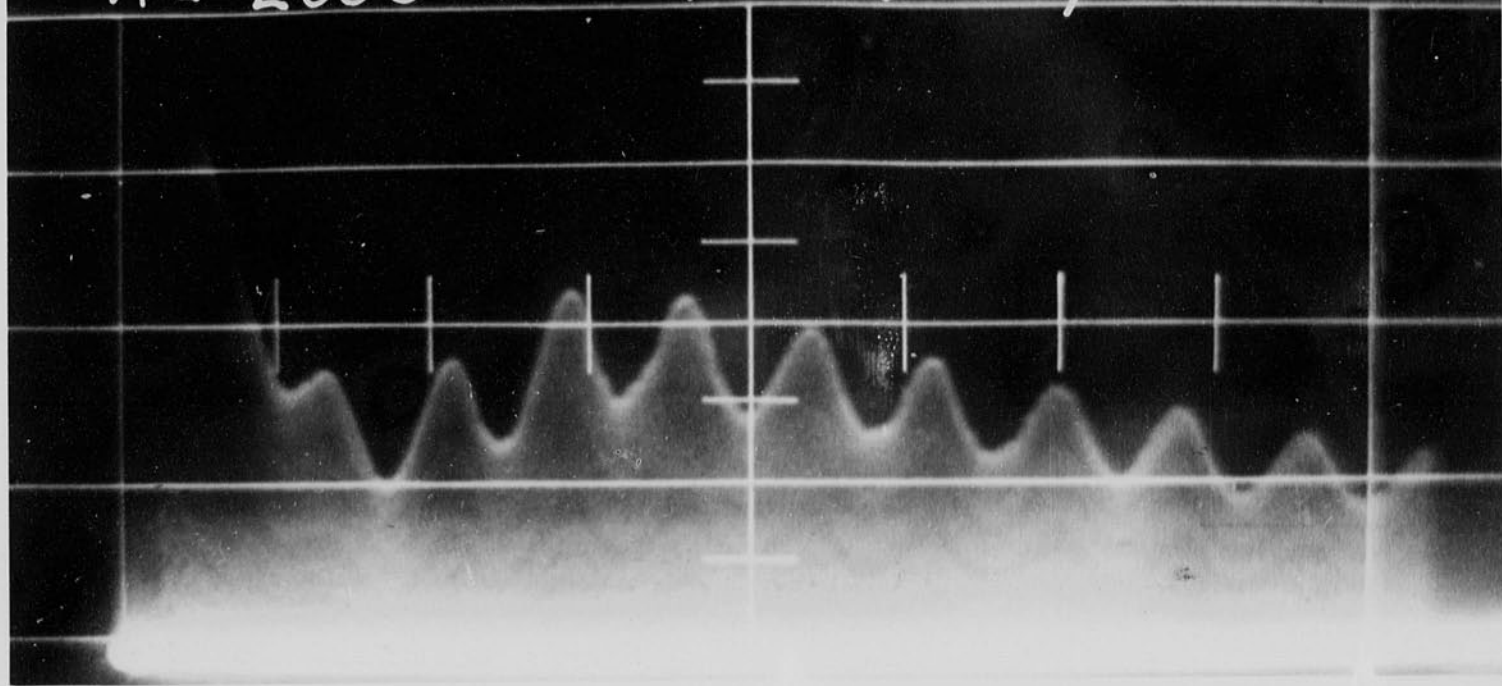
501 Strobe Light Output
Filter Choke Shunted With
 $R = \infty \Omega$ $f = 6000 \text{ cps}$



501 Strobe
Filter Choke Shunted With
 $R = 2000 \Omega$ $f = 6000 \text{ c.p.s}$



501 Strobe Light Output
 Filter Choke Shunted With
 $R = 2000 \Omega$ $f = 10000 \text{ c.p.s}$



Nov. 1, 1955.

the 501 equipment has a violent transient when turned on as evidenced by the light waveform for 0.1 seconds.

a 2000 ohm resistor across the input choke helps greatly — but the initial voltage is now 5000 volts! note also that the voltage is higher when operating.

with the 2000 ohm resistor the flash unit now operates satisfactorily at 10,000 cycles/second, but with same voltage oscillation.

Nov. 1, 1955.

Harold Edgerton.

Our experiments with argon high pressure tubes have been most interesting but not too efficient. It is about time to move to Xenon gas.

With argon - the tank gas was used at high pressure. Now we will freeze the Xenon, to save gas. because of expense. Some ~~\$45~~ per \$35 per liter.

The Fx-1 is most efficient at $\frac{2000}{6 \times 2.54} \frac{V}{cm} = 152. \frac{V}{cm}$ at 20 cm of pressure.

Now consider a $\frac{1}{4}$ " gap at several atmospheres.

$$\frac{1000 \text{ volts}}{\frac{1}{4} \times 2.54} = 1570. \times$$

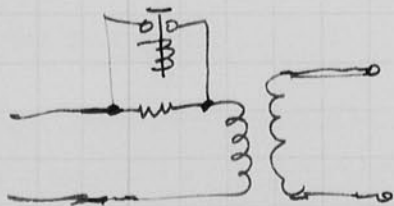
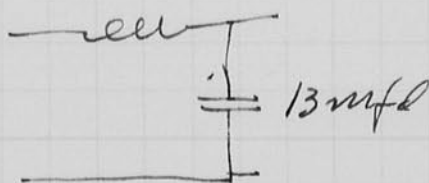
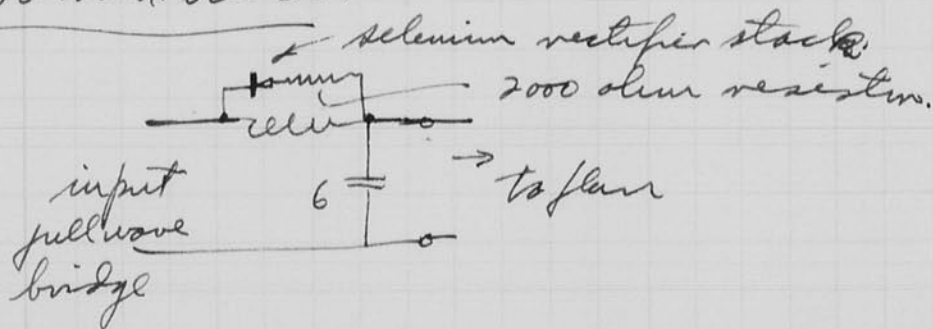
$$\text{now pressure } \frac{1570 \times 20}{P} = 150.$$

$$P = \frac{1570 \times 20}{150} = 210 \text{ cm pressure}$$

$$= \frac{210}{76} = 2.75 \text{ atmospheres.}$$

$$2.75 \times 15 = 41.4 \#/\text{sq inch.}$$

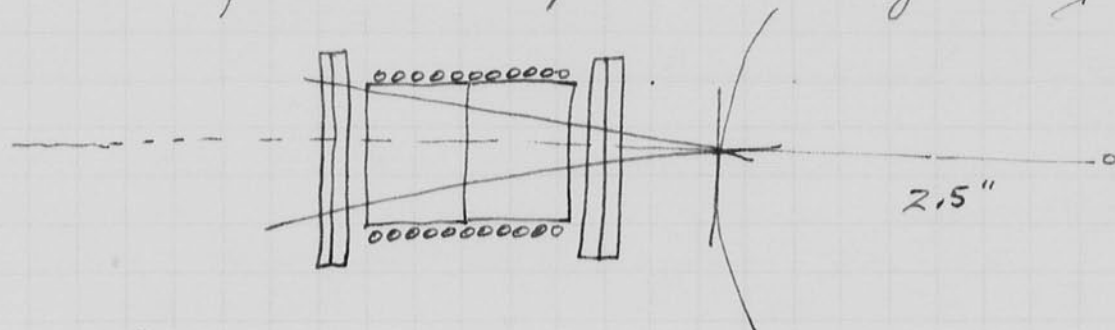
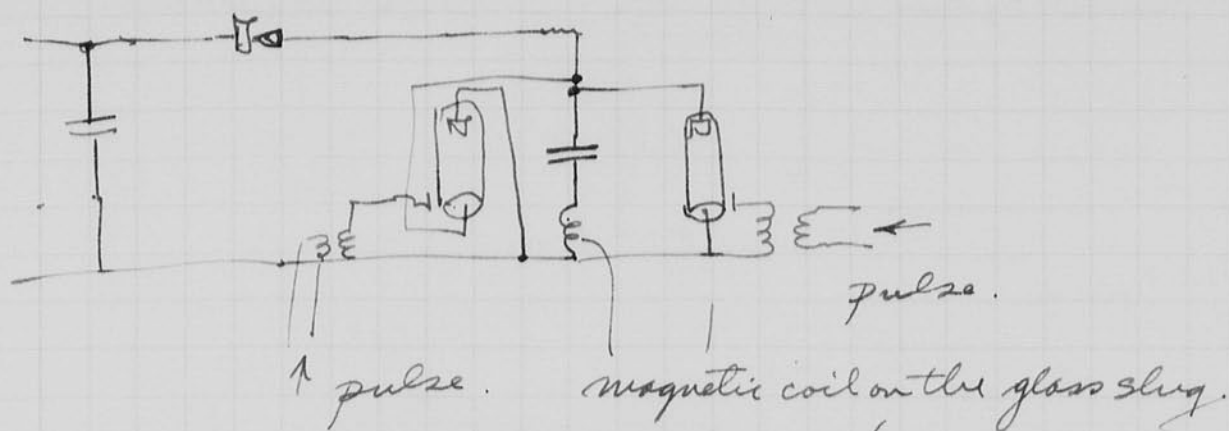
Also tried on 501



Doubling the filter capacitor helped some. Even so the equipment would not run at 10,000 cycles.

Nov. 10, 1955
Harold G. Edgerton.

45



40 inch lens.

Ben. Bretler says the G.L. camera is ok. for film curvature at the focal point.

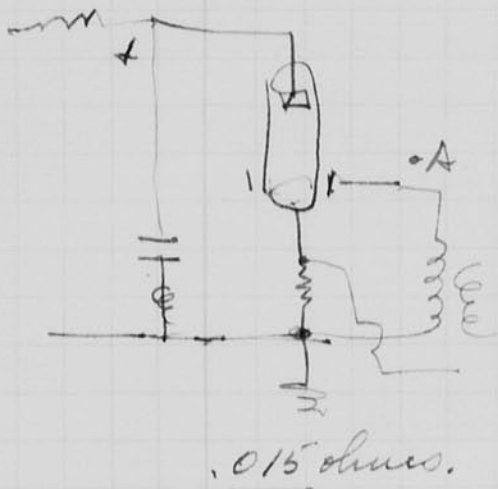
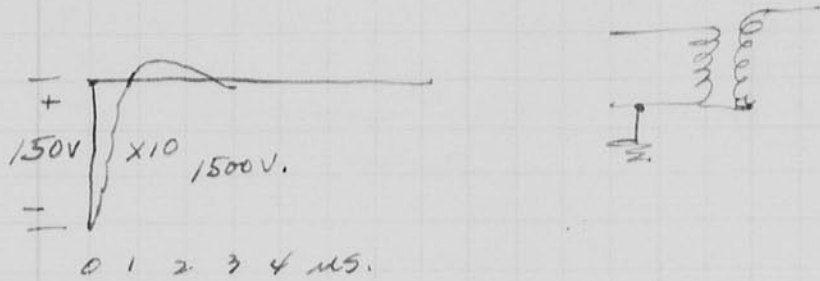
Nov. 11, 1955. Pumped down tube 2 ft diam for the wind tunnel M.I.T. Sealed off with 1 cu of xenum gas. The tube works ok with the Ben Radio 60 cycle unit, 2000 volt \pm , with a series mercury tube for control.

Nov. 12, 1955
 Samuel Edgerton.

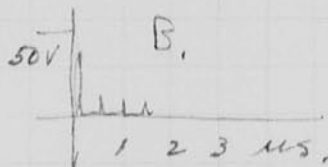
Hg tube circuit

Pulse generator

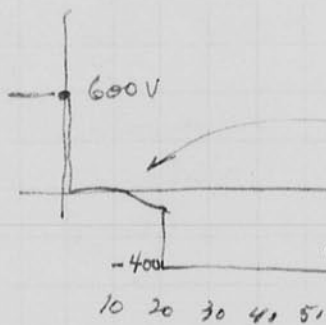
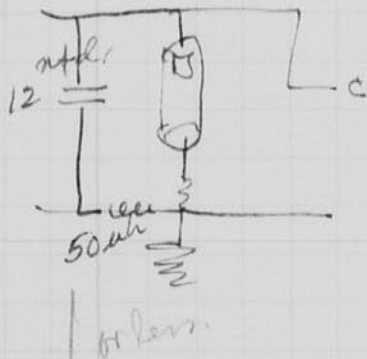
Small Hydrogen thyatron. V11825 transformer. 0.1 mfd?



current spikes.



$i = \frac{50}{0.15} = 3000 \text{ amperes in surges?}$



Hg tube acts as a rectifier here.
 Charge reversed on the capacitor.

also ok at 750

| | | |
|-------------------|------|-------|
| | 800 | |
| Double flash | 900 | 43 μs |
| Hg tube body fire | 900 | 0 |
| | 900 | 43 |
| | 900 | 47 |
| | 1000 | 50 |
| | 1000 | 100+ |
| | 1000 | 42 |
| | 1000 | 36 |
| | 1000 | 100+ |



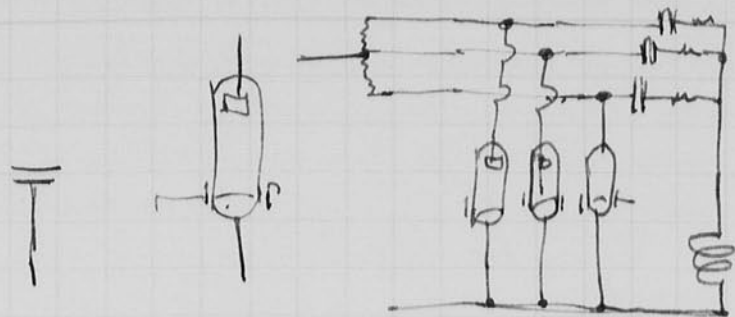
$T = 2\pi\sqrt{LC} = 2 \times 20 \times 10^{-6} \text{ seconds}$

$\sqrt{L} = \frac{2 \times 20 \times 10^{-6}}{6.28 \times 12 \times 10^{-6}} = \frac{2}{4}$

$4\pi LC = 400 \times 10^{-12}$
 $L = 10 \times 10^{-12} / 12 \times 10^{-6} = 10 \times 10^{-6} \text{ henries}$

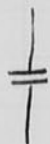
1.2KV 47 μ s.
 1.2 45
 1.2 45
 1.34 48.

Thus the voltage must be below
 600 volts to obtain no back firing
 of the mercury arc tube!



An old Delco (Lange) coil was tried on the
 above. The discharge was very long in
 duration. The second peak came at 50 μ s.

If a spark over is used the voltage
 collapses quite quickly to a small value
 this idea should be useful for the
 fast operation.



Nov. 15, 1955 Conf with Brettker.

40 μ s exposure Double Slug Repetitive 20" lens
 tri X film at 1 m.s. after gives (f16?)
 correct exposure.

The new setup will be
 Single slug.
 110° swing of shutter in Blue

10⁵ watts per meter.

175 lumens/watt.

$$\frac{10^5}{175} = 570 \text{ ~~watts per meter~~ and power/g meter must be cm.}$$

$$= 570$$

Nov 23 1955

Harold Edgerton.

Further experiments were made with small volume flash tubes last Saturday. The data is recorded in Pierre Cathon's book. The tube was a waxed joint one. The experiment was finished when we tried to freeze the vacuum at low pressure temperature and the wax cracked.

Additional tubes are now being built with the soldering technique.

The conclusions from Saturday.

Efficiency seems to be constant about 1 or 2 cm of pressure, with .5 mfd at 300 volts.

Tube self flashed at 500 volts with 1 cm of vacuum.

Tube operates at 240 cycles from .03 (?) mfd. at 500 volts with 10^4 ohms lag.

Anode and cathode were of tungsten. Sputtering from electrodes seems to be nicely confined to the end chambers.

Nov. 26 1955. During past week other tubes were made and tested as per Cathon's note book.

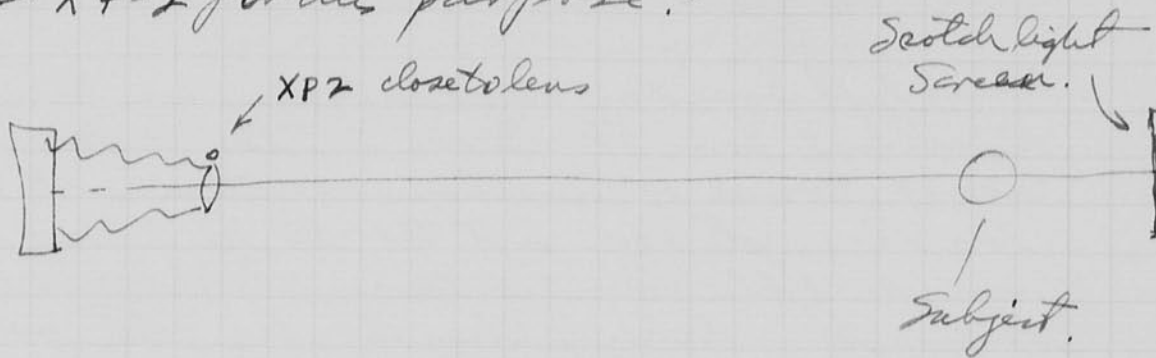
One was sealed off with 10 cm pressure. It would fire at 60 cycles also up to 240 with ~~0.1~~ 0.1 mfd at 900 volts. After 10 hours \pm , there was slipping trouble due to tungsten on the quartz. I popped this off with a discharge from 0.5 mfd at 4 kv. A series gap was necessary to hold off the voltage.

Lunch with Roy today. Discussed after used the rapetronic with mercury arc tube control. 1000 cycle operation on the General Radio camera.

Yesterday I had lunch with my son Bill and Prof Beas at Walker. Discussed the Soldier's school at United Air Craft. Hartford

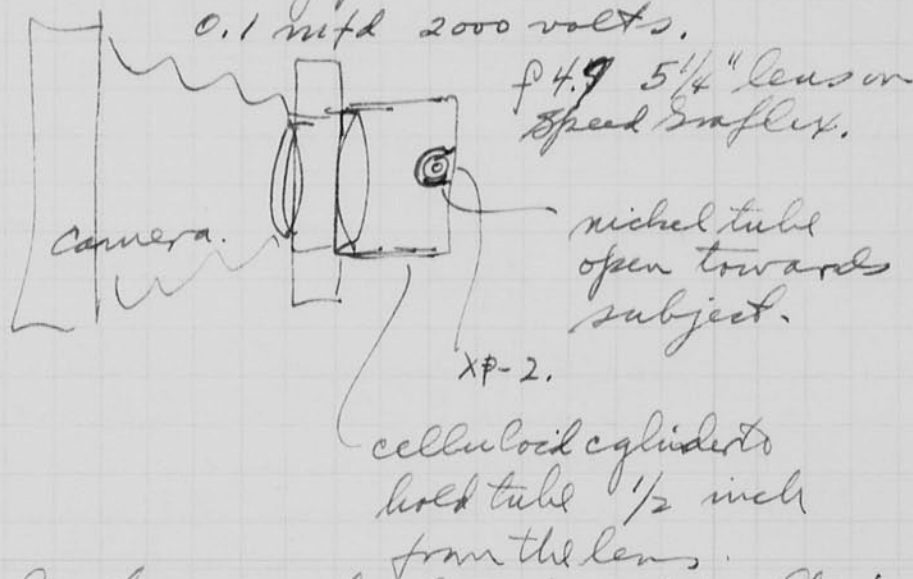
Exposure with Scotchlight background.

Back light might be effective with scotch light for ballistic research using a point light source at the camera. I propose to use the ~~XP~~ XP-2 for this purpose.

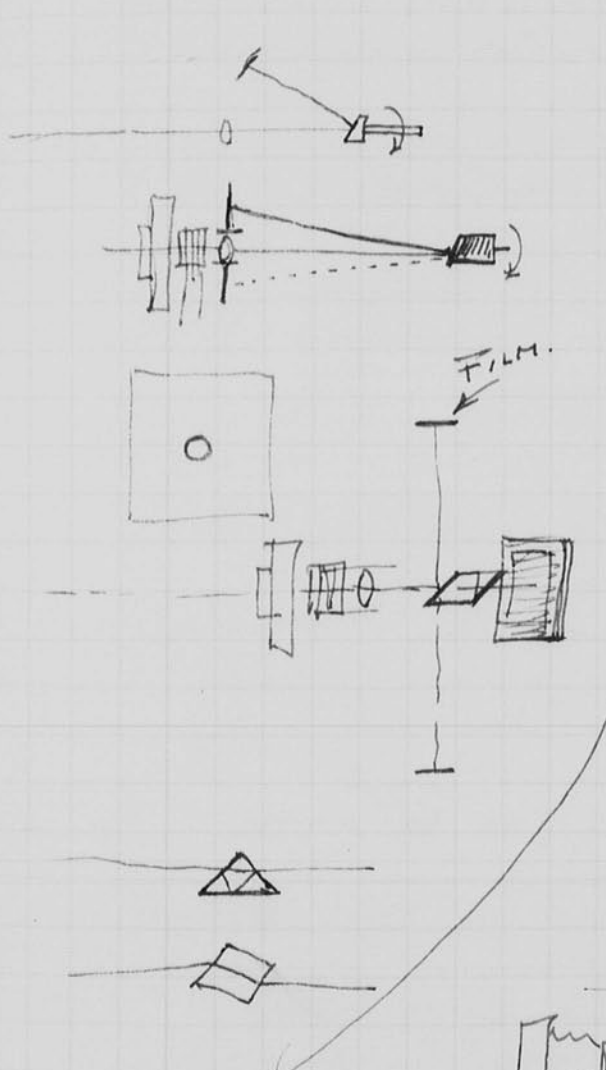


Experiment.

XP-2 gas tube as a source.
0.1 mfd 2000 volts.



In this way the lamp is directly in line with the camera axis.



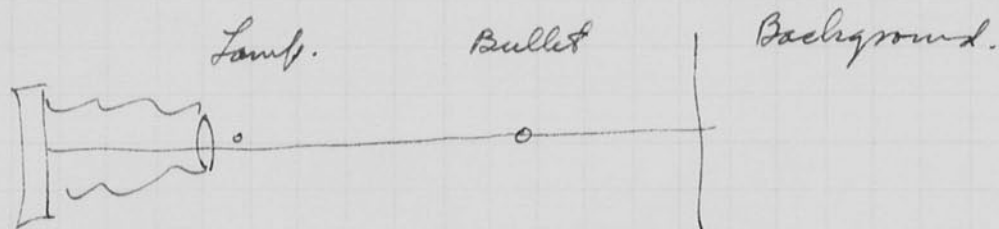
50 Dec 3 1955

Saved E. Elgeton.

Several shadow photos of bullets, 22 long rifle, were taken on Nov. 26 with the Scotch light and the lamp on the lens set up shown on page 49. Roy Swanson shot the gun when he returned from his swim at the pool.

I left Sunday am 27 for Boulder, then to Cleveland Nov. 28, Denver, Los Vegas. Nov 29. Board of Directors meeting at E. S. & S. Los Vegas all day. Left Nov 30 for El Paso, then by car for Holloman Air Base, Alamogordo. I saw Lt. Aven, Chas. Bogley, Ed Marty etc about a contract to study shock waves on the sled. Took 7:05 pm plane to Boston arriving at 8 am.

Shadow with Scotch light background.



If the lamp is at the center of the lens then the shadow of the bullet will be directly under its image. The shock wave shadow will traverse the shadow again, but through a different path. Sensitivity of the system probably will depend upon the spacing of the bullet and the background.

A slight displacement of the lamp from the center of the lens may give an increased sensitivity. The size of the source is also an important factor in the definition of the shadow.

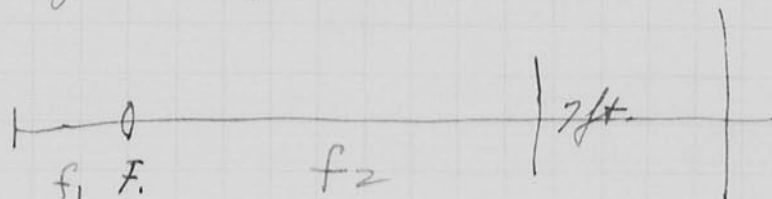
The sled shadow photographs might have more importance on the top of the models. If so, the lamp could be placed slightly below the lens center. A second camera could be used also at a different angle to record any shadows that were lost.

Charles Bogley at the conference in Galoman air base stated that he wished to work in day light. This means

(1) a dark house for the sled to enter at the photo area.

(2) or a magnet optic shutter to sync with the 1 microsecond flash.

Lens system. 7ft subject



4x5 film.

Let 4 inch side = 10 feet

$$\frac{4\frac{1}{2}'' \text{ as } f_1}{10} = \frac{10}{\frac{1}{3}} = 30 = \frac{f_2}{f_1} \text{ reduction on film.}$$

Let $F = 20$ inch lens.

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{F} \quad f_2 = 30 f_1 \quad f_1 = \frac{f_2}{30}$$

$$\frac{1}{f_2} + \frac{30}{f_2} = \frac{1}{F} = \frac{31}{f_2} \quad f_2 = \frac{31 F}{30} = \frac{20'' \times 31}{30} = \frac{12620''}{30} = \underline{\underline{50}} \text{ feet.}$$

Try 12" lens. $12'' \times 31 = 31$ feet.

New gear used, Exposures.

.22 cal. Low. 3ft f8 Pan Royal film. mm

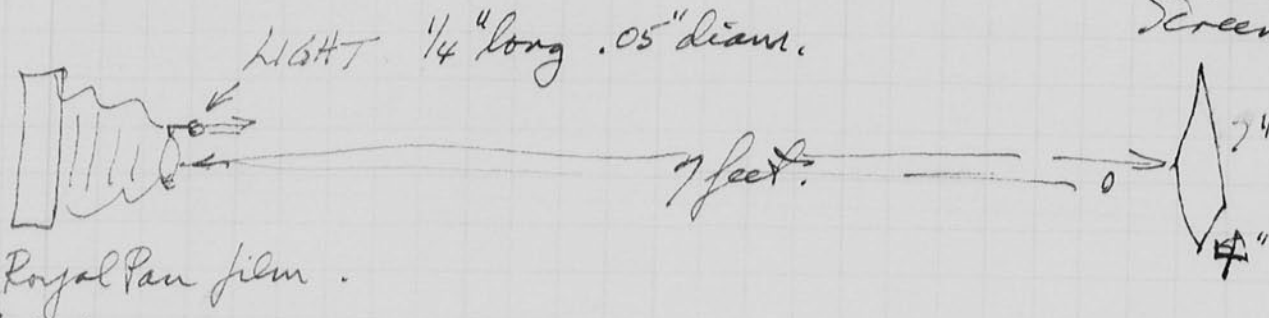
Several dozen photos were taken some showed a good shock wave. I tried quite a few setups. A 6 inch ~~light~~ Bellini screen was the largest. Perhaps a larger space would bring out the shock waves? The above photos were taken with an old style XP-2 table. 1 atmosphere, with black tape over the lamp showing only $\frac{1}{20}$ inch \pm of the 30 mil bore. Exposure was 1/2 with the lamp in the middle at f8.

I now have put in a new XP-2 tube with
3 atmospheres in Xenum, a 50 mil diam I.D. tube,
and a 1/4 inch gap between tungsten electrodes.

about 1/10 inch
of cathodoluminescence
was shown

I wrapped a nickel strip around the lamp to
cut out the rear light. The ends of the
tube were covered with black tape.

Gold light
Screen white

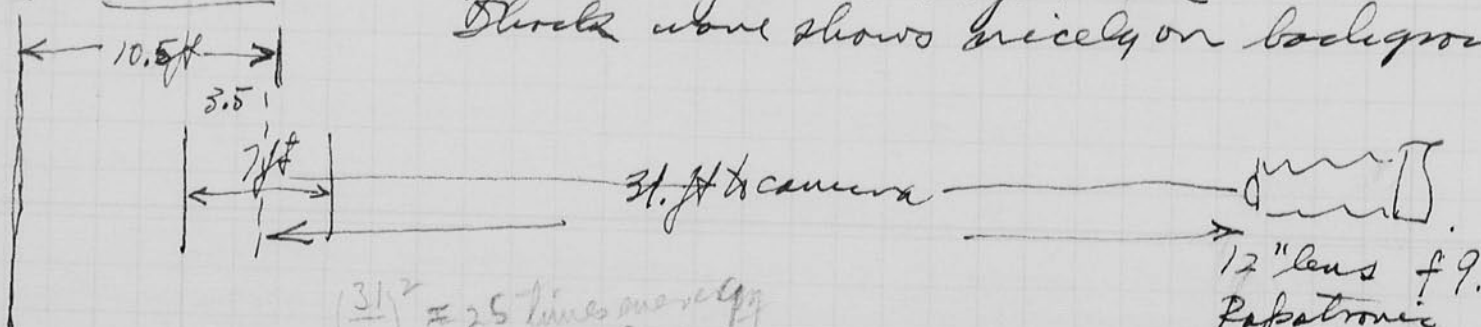


Film #1 f³² Exposure thin. Lamp about 3/4" off axis
0.1 mfd 2000 volts. of camera lens.
Developed 5 min DK19? 70 degrees.

Film #2. f³² and f¹⁶. Same set up as above, the
camera was moved slightly between the
two exposures.

Film #3. f¹⁶ } 22 caliber long rifle bullets.
4 f¹⁶ } 21" Bullet to back screen.
0.1 mfd 2KV. 3 atmos XP-1
Lamp - lens center (3/4" inch spacing.
6 ft + lamp to bullet * about 1/2 inch.
2 ft - Bullet to back screen

for Holbman



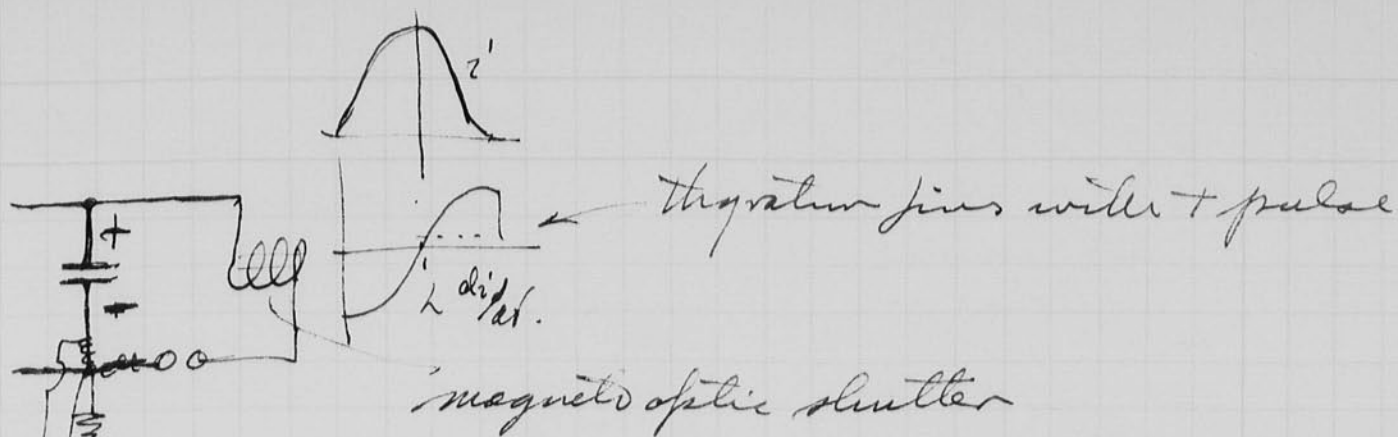
$(\frac{31}{6})^2 \approx 25$ times more exp
required

for extra distance.

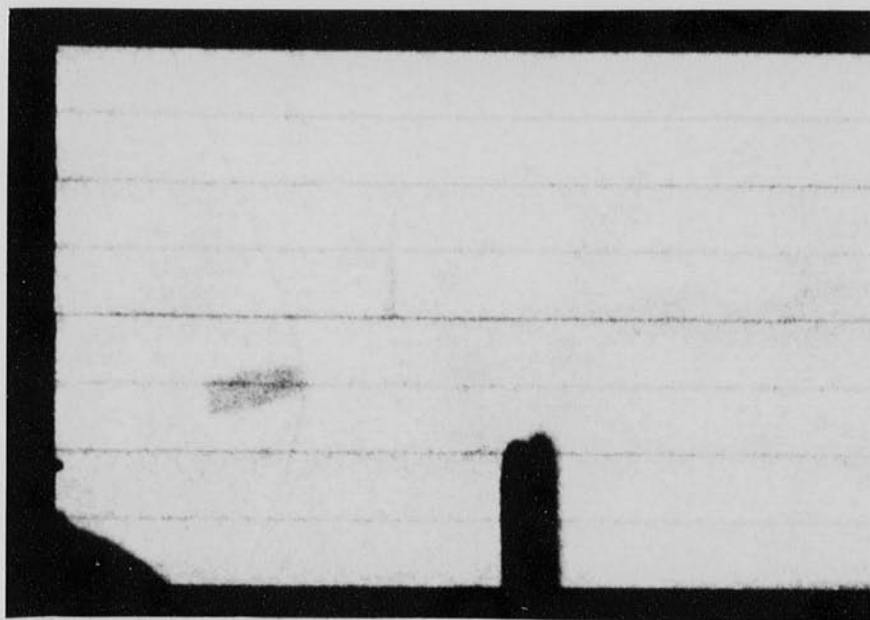
$(\frac{16}{f4}) = 4 =$ will need perhaps more
for magneto optical
shutter.

12" lens f 9.
Papatron
shutter
4 u.s.

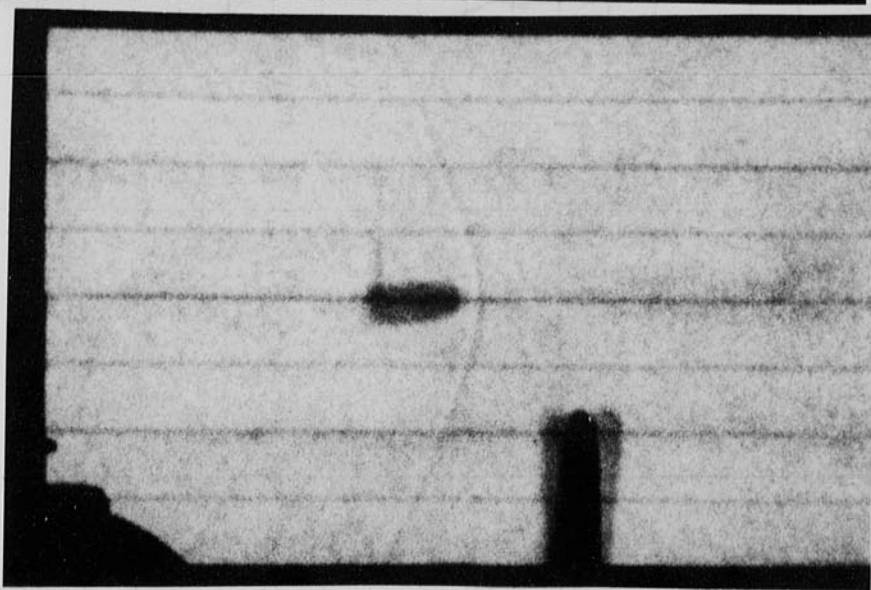
4x5" film = 14 x 17/8
field



Trigger to thyatron in spark circuit;
 circuit to fire shadow spark at the
 exact moment to catch the shutter open.



22 caliber
 Long Rifle.

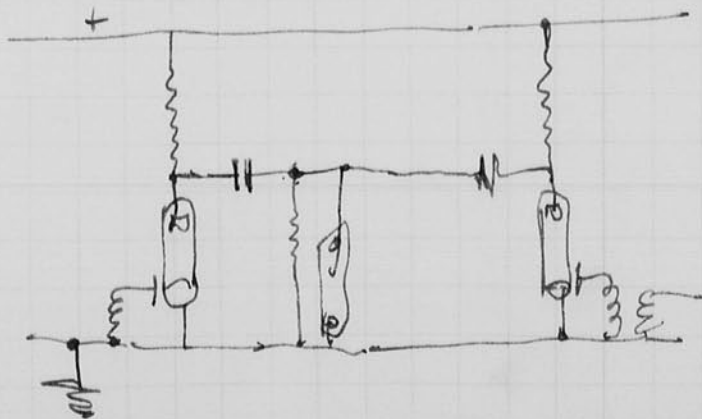
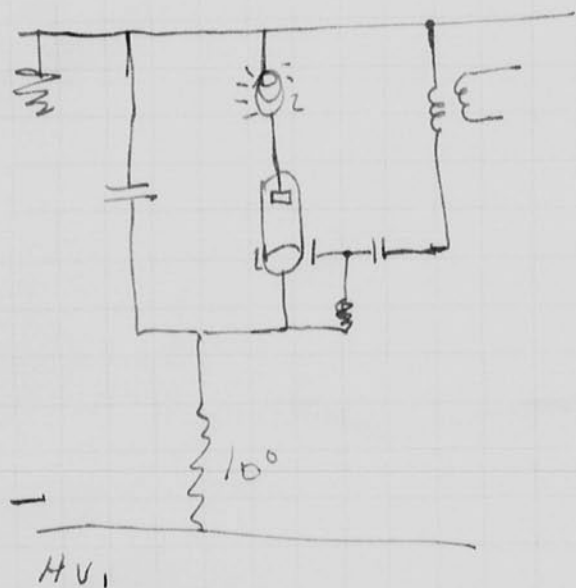


54 Dec. 6, 1955

Harold S. Edgerton

Bill Pavlin and Pierre Cathou made some tests today in the Schlieren in the supersonic wind tunnel.

Photos were obtained with 0.1 mfd at 2000 volts into the XP-2 with 3 atmospheres at $1/4$ " gap with 50 mil diam. The negative was slightly thin on our 810 film. Exposure time 0.75 microseconds.



Dec 10, 1955

multiflash unit test.

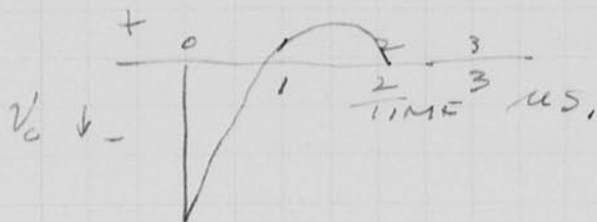
H. E. Edgerton
Bill Brock Roberts

Trigger circuit gate very slow in charging.

33 K changed to 10K. Some help but not enough - 10 sec. seems to be min time to wait.

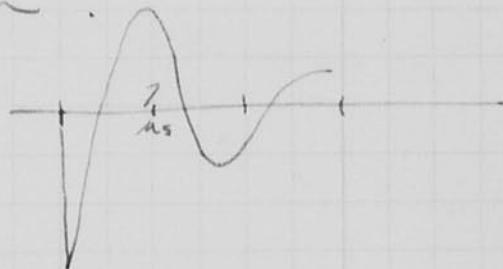
Mercury lamps tested with 15 KV static and installed.

Spark from 0.1 mfd at 300 volts, about 1/8 inch output.



this unit flashed 1/2" lamp ok.
Noise inside once in a while probably a loose connection.

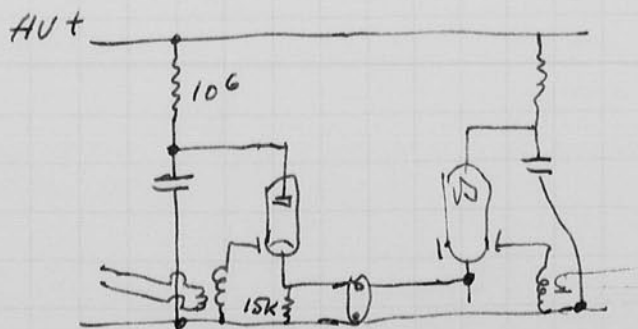
Sound unit #1. Transformer pulse



Chg circuit changed to + high.

— Spark changed to positive first
cap on spark = .35 mfd.

Works well with 5000 ohms in parallel with lamp,
50 volts on Vanac.
also op at 15,000 ohms, 2ft of H.V. cable.



56 Dec, 19, 1955.

Harold E. Edgerton.

Multiflash.

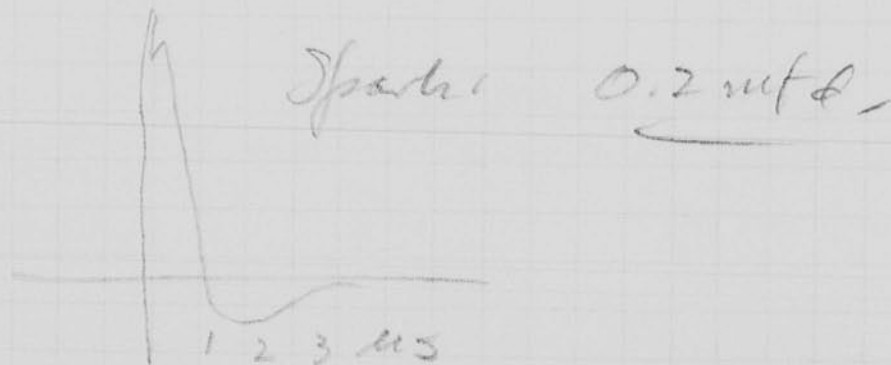
In the past two weeks Bill MacRobert and I have worked on the 20 flash unit that is being made for the government. This flasher is 9 watt sec per flash and is supposed to go at 50 Kc with a 3 μ s flash.

A week ago we had installed three mercury-arc tubes in place of the spark gaps. With those we did get up to 50 Kc, actually about 70 or 80.

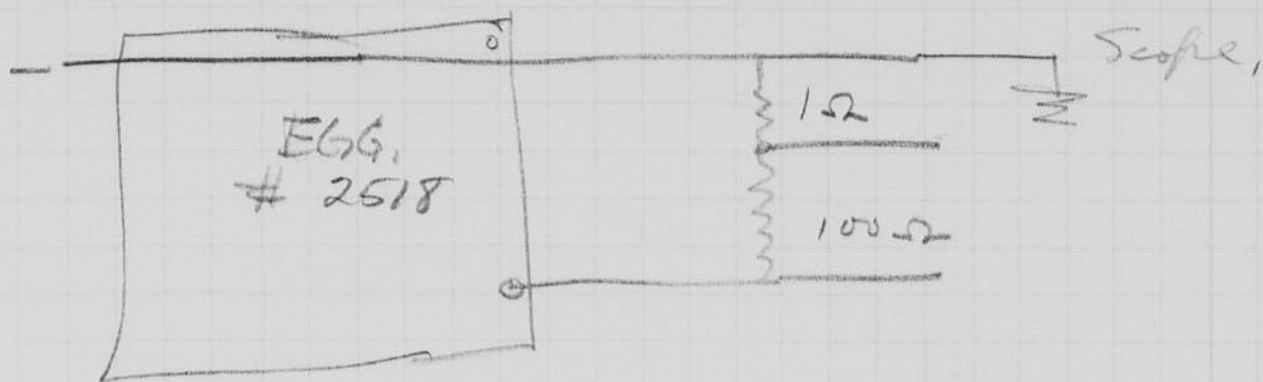
Then we put in 7 more ~~big~~ mercury arc rectifier tubes and have been trying to get good performance. The set works quite well at 10 Kc. There is a drop off at 20 or 25, in the last few light pulses. The action is different for different types of flash tubes. We have

tried the
FX-1
Strobolux
FT-110.
FT-125.

Further tests are contemplated within a week or so.



Load Voltage test

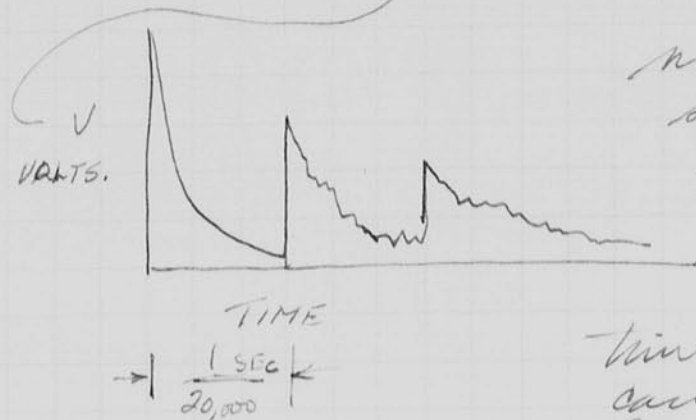
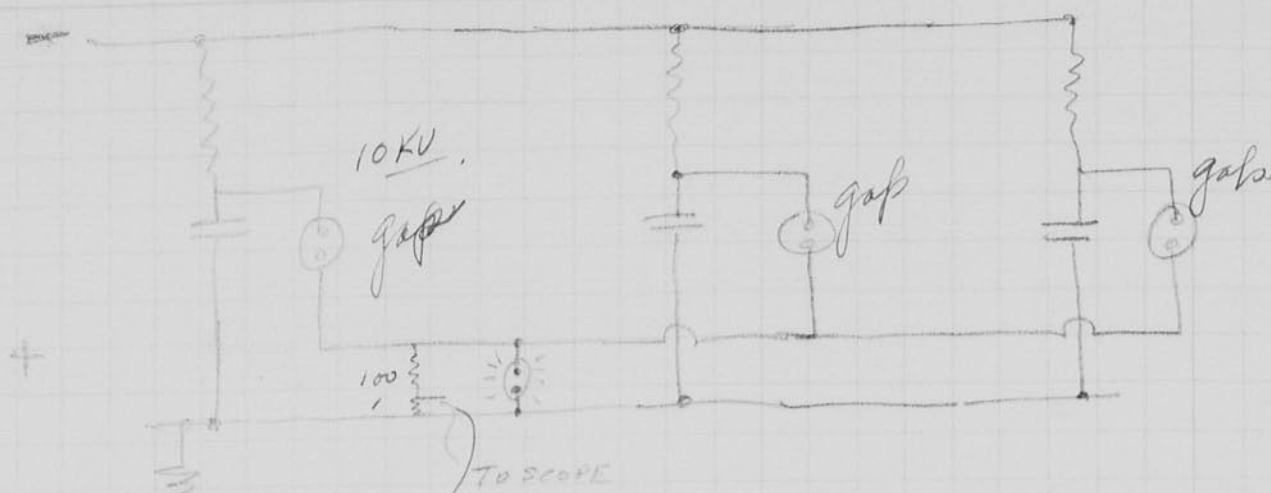


A

| Sec no | Sweeps. | f. | ARC Dups. |
|--------|----------------|----------------|--|
| 1. | Volts | 50 μ s/cm. | 20,000 |
| 2 | " | " | " |
| 3 | " | " | " |
| 4+? | " | " | " |
| 5 | " | " | 20000 with lamp in parallel Strobolux. |
| 6. | " | " | 20000 " " " " " |
| 7. | 10 μ s/cm | 20,000 | " " " " |
| 8 | 300 μ s/cm | 2000 | " " " " |
| 9 | " | " | " " " " |
| 10 | " | " | " " " " |

| | | | | |
|------------|--------|------|---------------|---|
| MERCURY 11 | Volts. | 100. | 20,000 | Wonderful! Plenty reversed Hg # 3 is out of the circuit |
| 12 | Volts. | 100 | 20,000 | with Strobolux lamp. In parallel. |
| 13 | Light | 100 | 20,000 | " |
| 14 | " | 100 | 20,000 | " |
| 15 | " | 200 | 10,000 | " |
| 16. | " | 400 | 5,000 | " |
| 17 | " | 50 | 30,000 | FT-220 |
| 18 | " | " | 50,000 | " |
| 19 | " | " | 40,000 | " |
| 20 21 22 | " | 50 | 30,000 | FX-1 old. |
| 23. | " | 3. | Light output. | Brown tube. |

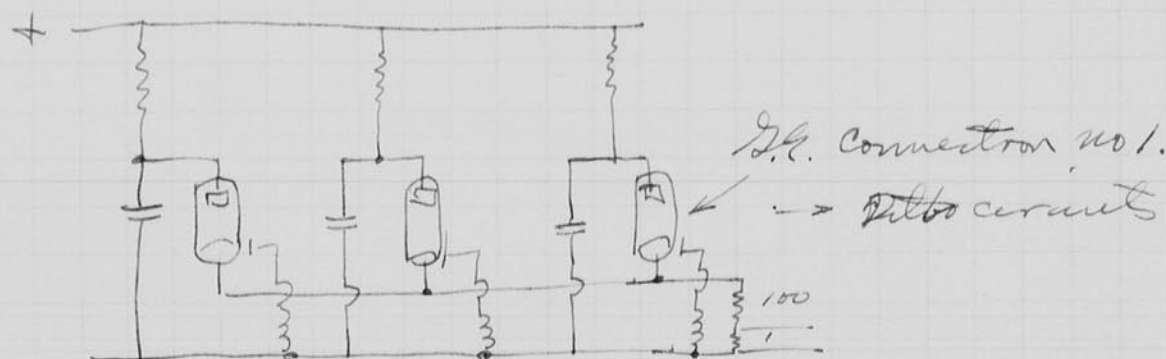
Original Gap circuit which
drops out at 1000 to 5000 cycles.



note the irregular
self firing of the
first and
second gaps.

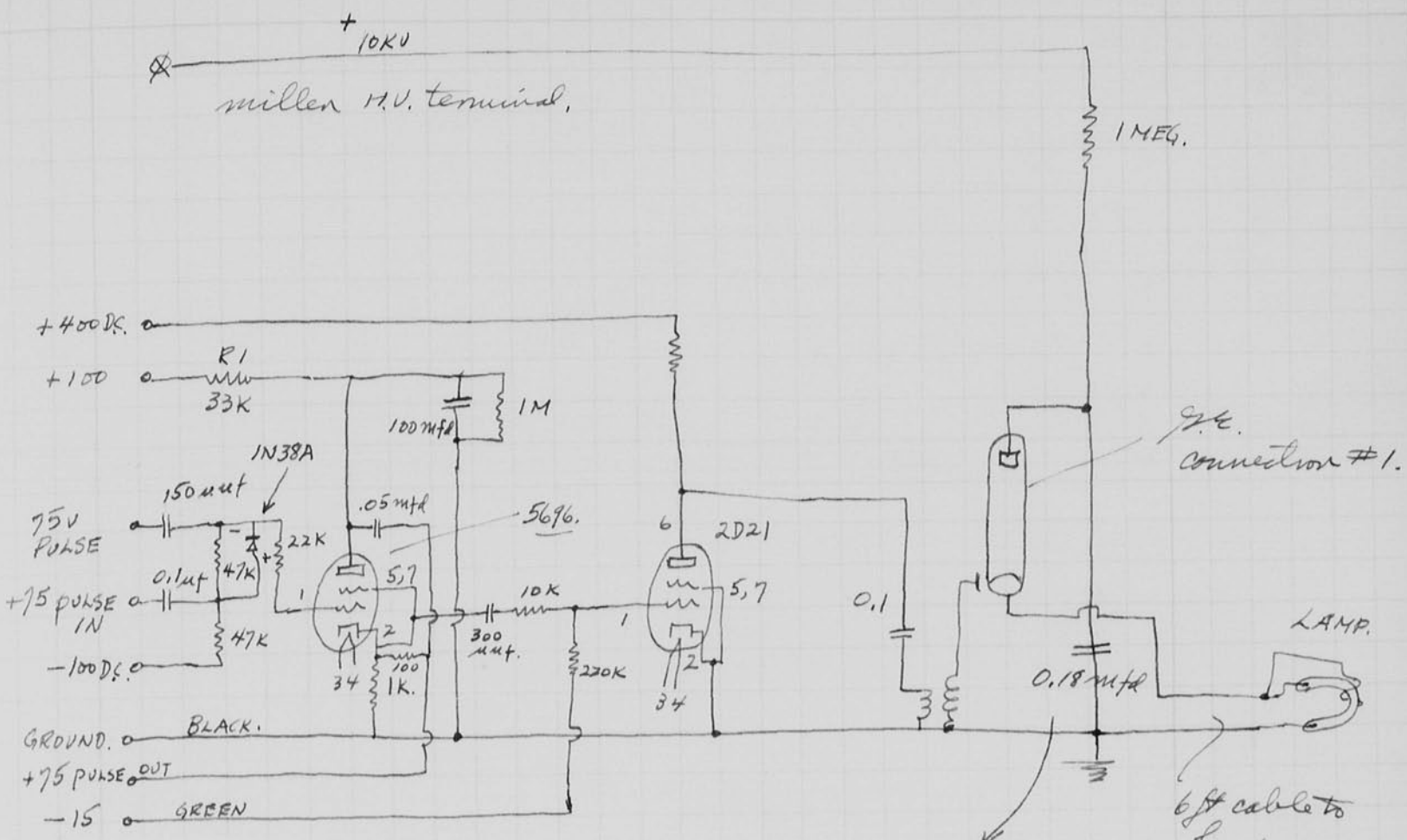
This changes the
time constant and
causes the peaks to be
lower.

the same experiment was made with mercury tubes.



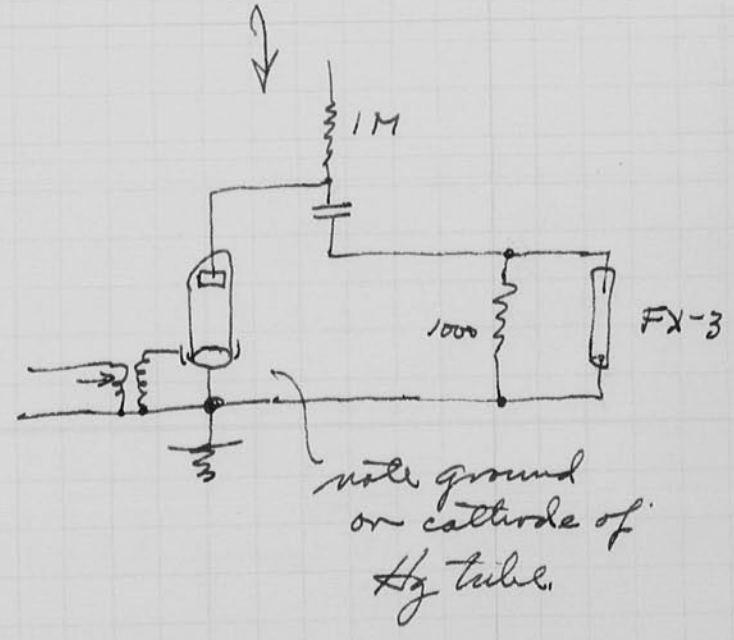
operation ok at 20 RC with 100 ohm load.
operation N.G. with 1 ohm lamp.

Delay panel for 20 flash unit.



Winchester connector.
male.

Mar 10 1956
This circuit was changed
later to the following.

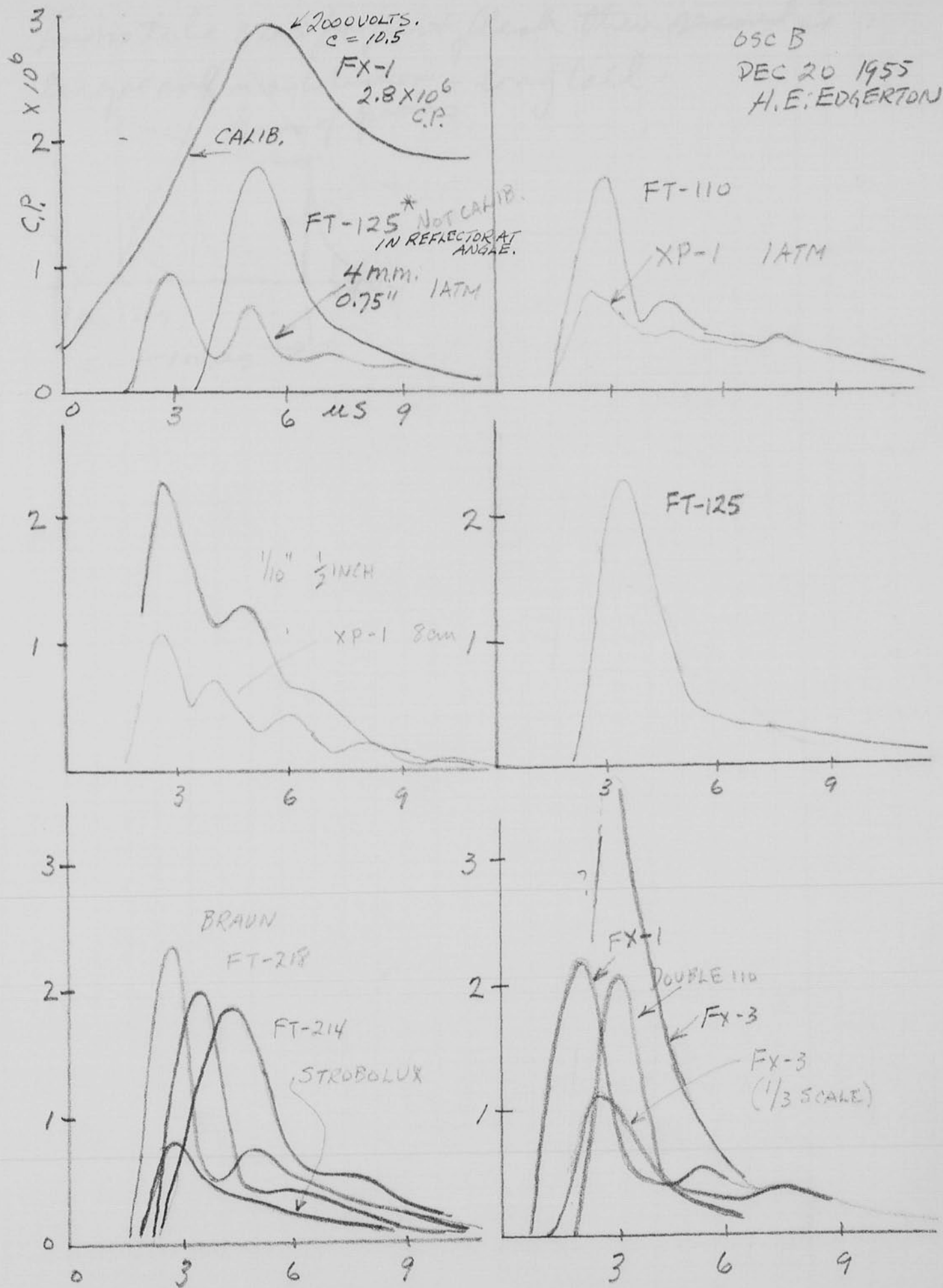


Dec 22 1950

Light output.

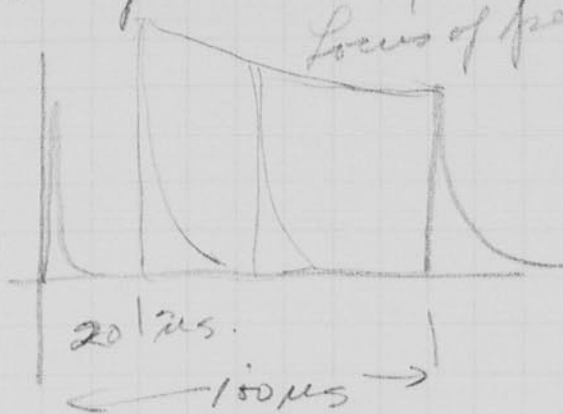
C = .18 mfd
10 KV
1000 ohm parallelArc No. Lamp^s Distance
Switch Cellid.B₀

| | | | | |
|------|-----------------------|---------------------|-------------|----------------------------|
| ✓ 1 | Crown | 3 1/4" 30" | 3cm = 15V | |
| ✓ 2 | " | " " | " | |
| ✓ 3 | FT-218 | " " | " | |
| ✓ 4 | " | " " | " | |
| ✓ 5 | Strobolux | " " | " | |
| ✓ 6 | Strobolux | " " | " | |
| ✓ 7 | FT-214 | " " | " | |
| ✓ 8 | FT 214 | " " | " | |
| ✓ 9 | FT-210 Double | | | |
| ✓ 10 | " | | | |
| ✓ 11 | FX-1 | | | |
| ✓ 12 | FX-1 | | | |
| ✓ 13 | FX-3 | | 3cm = 15 | |
| ✓ 14 | FX-3 | | 3cm = 45 | |
| ✓ 15 | 125-straight | | 3cm = 15 | |
| ✓ 16 | " | | " " | |
| ✓ 17 | 1/10" 1/2" long | geo. only | | |
| ✓ 18 | " | " | | |
| ✓ 19 | .05" 1/4" | " " | " | 8 cm pressure |
| ✓ 20 | " | " " | " | |
| ✓ 21 | geo | | | 1 atm pressure |
| ✓ 22 | .05 1/4" | " | | " |
| ✓ 23 | " | " | | " |
| ✓ 24 | FT-110 | | | |
| ✓ 25 | FT-110 | | | |
| ✓ 26 | 4mm 3/4" 1 atm Xenon. | all same | | |
| ✓ 27 | " | " | | |
| ✓ 28 | 1/2" gap 1 atm Xenon | 1 cm diam | | Exploded! |
| ✓ 29 | geo | | | |
| ✓ 30 | FT-125 in Reflector | at 30° angle. | | |
| ✓ 31 | FX-1 | 10.7 mfd 2000 volts | calibration | } assume 2.8×10^6 |
| ✓ 32 | " | " | " | 9.7 peaks |



one flash operation. a second flash is longer than the first.

Looks to be 3 μ s for first flash then second is longer and maybe higher - long tail.



one flash operation. a second flash is longer than the first.

Dec 23, 1955

Edgeston
Miss Roberts.

Osc. Tube f.

220 10, KC

220

220

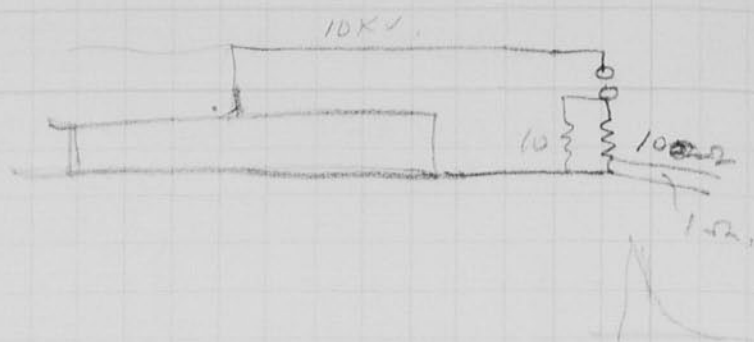
220

#16 F1-3 10 KC.

"

"

"

Operation etc before
N.S. & (100?)Shows green glow with
spark.

Dec 26 1955

Fred Barstow came in about noon ^{Dec 23} for several hours.

The operation of the 20 flash unit looks back. We cannot meet the specifications at present. These specs are.

3-microsecond exposure.

50 Kc flash rate.

9 watt sec. per flash at 1 c.p./watt.

It appears that we must compromise in some way to deliver the unit. I suggested to Barstow that we take this up with the people who ordered the unit, since they are best qualified to decide.

Late on Dec 23 I used a strobolux lamp and reduced the voltage. I was able to meet all the requirements except the 9 watt sec. per flash. Possibly this is the compromise to suggest.

There is trouble with irregular firing time when a low impedance lamp is used. We must find why and how the lamp transient triggers the other stages.

Dec 27 1955
A. S. Edgerton.

20 Flash Unit.

010A

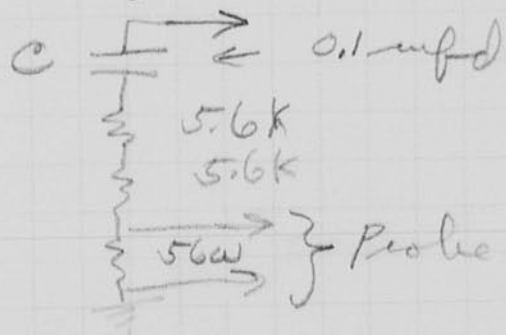


1. Grid signal on 5th stage. trigger from first ϕ .
10-30 volts/cm.
50 μ s/cm. 50 KC
2. Same but with 10 μ s/cm sweeps
3. Spark coil secondary voltage 2nd stage 10 μ s/cm
30-100 volts/cm $\times 10 \times ?$ cap pickup.
- 4.

Dec. 30, 1955
FEB system
U.E. Mac Roberts

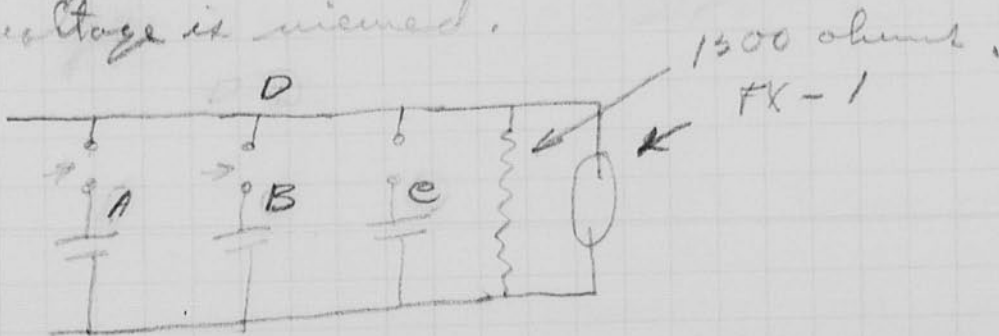
20 Flash Unit

oscillograms using the following divider.



} Probe of Tektronix scope 513D

Capacitor C is used to block DC when main ground voltage is viewed.



Dec. 30 55
 FEB and
 VF Procs
 cont.

1. Voltage at A 7000 volts 1 μ -sec/cm
 other units disconnected. 20,000 V Trig from unit A
 2. Ditto
 3. Voltage at A 11,000 volts 1 μ -sec
 other units disconnected 20,000 Trig from Unit 4
- 2 shots taken one showed oscillations, other did not.

New film

4. 3 units connected 7000 volts 5 μ -sec/cm
 Voltage at A 20,000 V Trig from Unit A.
 Usually second trace does not occur. Second trace triggered by osc. at time B fires.
5. Ditto
 except voltage at B Trig from Unit B
6. Ditto
 except volt at C " " " C
7. 3 units connected 7,000 15 μ sec/div
 Voltage at D 20,000 V Trig from Unit A
8. Ditto except 10,000 V
9. " except 11,000 V 5 μ -sec/cm
10,000 V

Note - other times this occurred at lower voltage & much lower freq, but necessary to increase to these values for consistency.

Dec. 30, cont.

65

10. Same condition as 9. except one taken at Position A
11. Ditto 10. except one, at position B,
12. " 10. except one, at position C,

Jan. 3, '56

E. Mack, J.E.B.

The 20 flasher was set up with the hydrogen gap and 3 air gaps.

It was found that the hydrogen gap conducted in the reverse direction when succeeding gaps were fired. This occurred even when high voltage was not applied to the capacitors of the hydrogen gap system, or when the hydrogen gap had not been triggered previous to the gap in the next position firing.

66 Jan 7, 1956.

multiflash testing

Harold Dyer
Vernon Mac Roberts.

Denys Akhurst moved into Burton Hall on Dana St today

We first sent Greenewalt's flash unit to Wilmington by air to arrive at 5:45 on flight 455. Eastern, 5300 BCPS on 3 lamps. 14 mfd at 2600 volts on each lamp. 30-35 μ s duration.

This multiflash unit has caused a lot of trouble due to deionization of the trigger gaps. I am trying to get the unit out with mercury contact tubes.

We are having trouble with spurious
(1) firing of the circuit and with deionization
and (3) length of flash. m

Removed units 1 to 6. In

(1) Insulated capacitor case from ground and ~~seal~~ other.

(2) Separated capacitors into 1 and 5 groups so that selection could be made at will. .03 mfd at 10 KV = rating.

(3) Put in new capacitors.

4. Soldered charging ground on electrolytic capacitor.

Operation ok 1-5 tubes at 20 KC. Some flashes weak at 50 KC.

$$\begin{aligned} 0.20 \text{ } \mu\text{s cycles} &= 50 \mu\text{s} \text{ detw} \\ 30,000 &= 33 \mu\text{s} \end{aligned}$$

$$1100 \text{ f/sec.} = 12,000 \text{ inch/sec}$$

$$33 \times 12,000 \times 10^6 = d = 50 \times 10^{-2} = 0.5 \text{ inches.}$$

Jan 7, 1956. cont.
H. H. Dutton.

67

Dr. Clark visited me at my home at 205 School St Belmont and showed me his records of light as measured with a photomultiplier tube in the ocean. His previous experiments had been with a photovinic cell. These only extended to 200 meters below the surface.

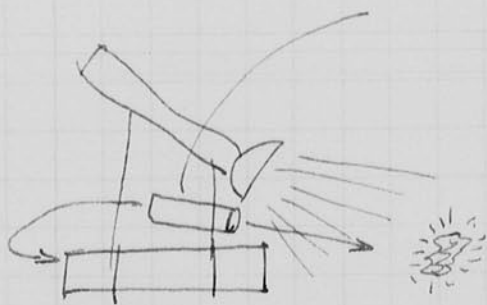
Clark uses a 5819 RCA photomultiplier into a Edin amplifier and a Brush recorder for the transient pulses. The max sensitivity of the system was about 10^{-7} uwatts/sq cm.

Records at daylight showed a log decrease down to ~~200~~ 1200 feet where the energy was 10^{-7} uw/sqcm.

The night time record was most interesting since the light went down to 10^{-6} or 10^{-7} and then showed many flashes. Clark interprets these as being caused by animals etc. Clark also found that the light level goes up with depth since, as he explains it, there is an increase in the animal produced light.

I proposed that the pulses could be used to trigger a camera and thereby photograph the animal that produces the glow. This is a real possibility for a project.

Photomultiplier trigger to flash camera at time when a stroby flash is received.



10^{-6} flash \rightarrow 0.1 μ a.

$$\begin{aligned} & 931A \\ & 10^{-7} \text{ uw/sqcm.} \\ & \text{Cathode area} = \text{1.0 sqcm.} \\ & 10^{-7} \text{ uw received.} \\ & \text{sens} = 8200 \text{ ua/uwatt.} \\ & i = 10^{-7} \text{ uw} \times 8200 \text{ ua/uwatt.} \\ & = 8200 \times 10^{-7} \text{ ua} = 0.008 \text{ ua} \\ & \approx 0.01 \text{ ua.} \end{aligned}$$

Better to use a larger cathode device.

Jan. 8, 1956.

Conductivity of Xenon Gas tube.

Harold Edgerton.

Use FX-1 as example.

When at 2000 volts and 100 ma the current is 1000 amperes.

$$R = 2 \text{ ohms} = \rho \frac{6''}{\text{area}} \quad 6'' = 2.54 \times 6 \text{ cm.}$$


$$\text{area} = \left(\frac{.4}{2}\right)^2 \pi = .08 \pi \text{ sq cm.}$$

$$2 = \rho \frac{6 \times 2.54}{\left(\frac{.4}{2}\right)^2 \pi} = \rho \frac{15}{.25 \cdot 125}$$

$$2 = \rho \cdot 120$$

$$\rho = \frac{1}{60} \frac{\text{ohms}}{\text{cm}} = \underline{\underline{.0166 \text{ ohms/cm}}}$$

$$\sigma = \frac{1}{\rho} = 60 \text{ mho/cm.}$$

 πR^2


R = .2 cm.

$$\text{area} = .04 \pi = .125$$

$$\frac{1}{R} = \sigma \frac{\text{area}}{\text{length}} = .125$$

$$\sigma = \frac{1}{R} \frac{\text{length}}{\text{area}} = \frac{6 \times 2.54}{2 \cdot \frac{.4^2 \pi}{.125}} = \frac{6 \times 2.54}{.2 \times 5} = \underline{\underline{60 \checkmark}}$$

Resistance of 1/4" tube with .05" diam

$$\text{area} = .025^2 \times 2.54^2 \pi \text{ sq cm.}$$

$$= .062^2 \pi = .0122 \text{ sq cm. } \frac{.06}{.0026}$$

$$\text{length} = \frac{1}{4} \times 2.54 = .63 \text{ cm. } \frac{.0026}{.0108}$$

$$R = \frac{1}{60} \frac{.63}{.0122} = .86 \text{ ohms}$$

$$\frac{2000 \text{ V}}{0.86} = 2330 \text{ amperes.}$$

Real Small tube

$$\text{length} = 0.1 \text{ inch} = .254 \text{ cm}$$

$$\text{area, diam} = .010$$

$$\text{area} = .0122 \times \frac{1}{25} =$$

$$R = \frac{1}{60} \frac{.254}{.0122} = 8.5 \text{ ohms.}$$

See Cotton about this
Exp.Experiment shows it much
lower than 8.5 ohms?
 $\frac{2000}{8.8} = 228 \text{ amperes}$
 measured.
 $\frac{400}{8.8} = 45 \text{ amperes}$
 experiment 200 amperes
 2 ohms

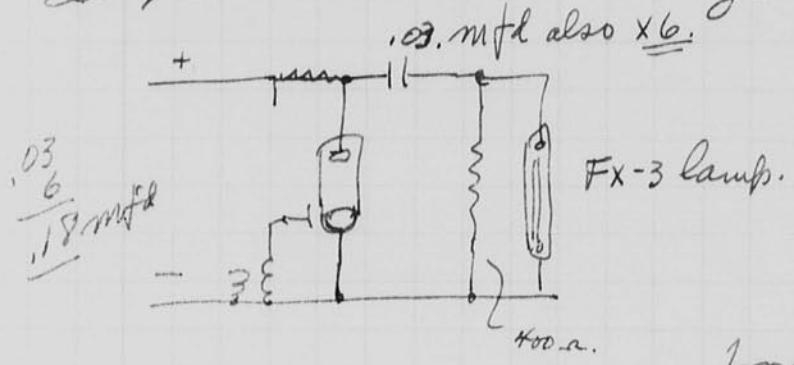
$L = 100.17$ lumen sec / sq ft sk for Ektachrome, ASA 10,
 $L = 100.2$ " " " " an average value to use.

Jan. 15, 1956.

Wed ~~Thursday~~ - conference by Amer Acad of Sciences. Loeb, etc.

Thursday conference at Hascomb field Bedford on
Friday pulsed light etc. Hantz Trisler.

Borstein and Mac Roberts worked Thursday and Fri
(also sat) on the 20 flash unit. They were
working with hydrogen thyristors with cold
cathodes - using them a gap switches.
I hope to continue mercury arc tests next week.



Try this to see if
coupling from flash
into control circuit
is eliminated.

Up to now we are getting trouble
from the main bang into the
control circuit. I have a
suspicion that it comes from
sparking (bad connection) capacitors
or from the coupling into the
spark coil from the cathodes of
the mercury arc tubes.

The above circuit will enable me to see if
the second cause has any effect.

Jan 18 1956.

Harold E. Dyer.

Worked with Roy last night on the layout for the 5 flash unit.

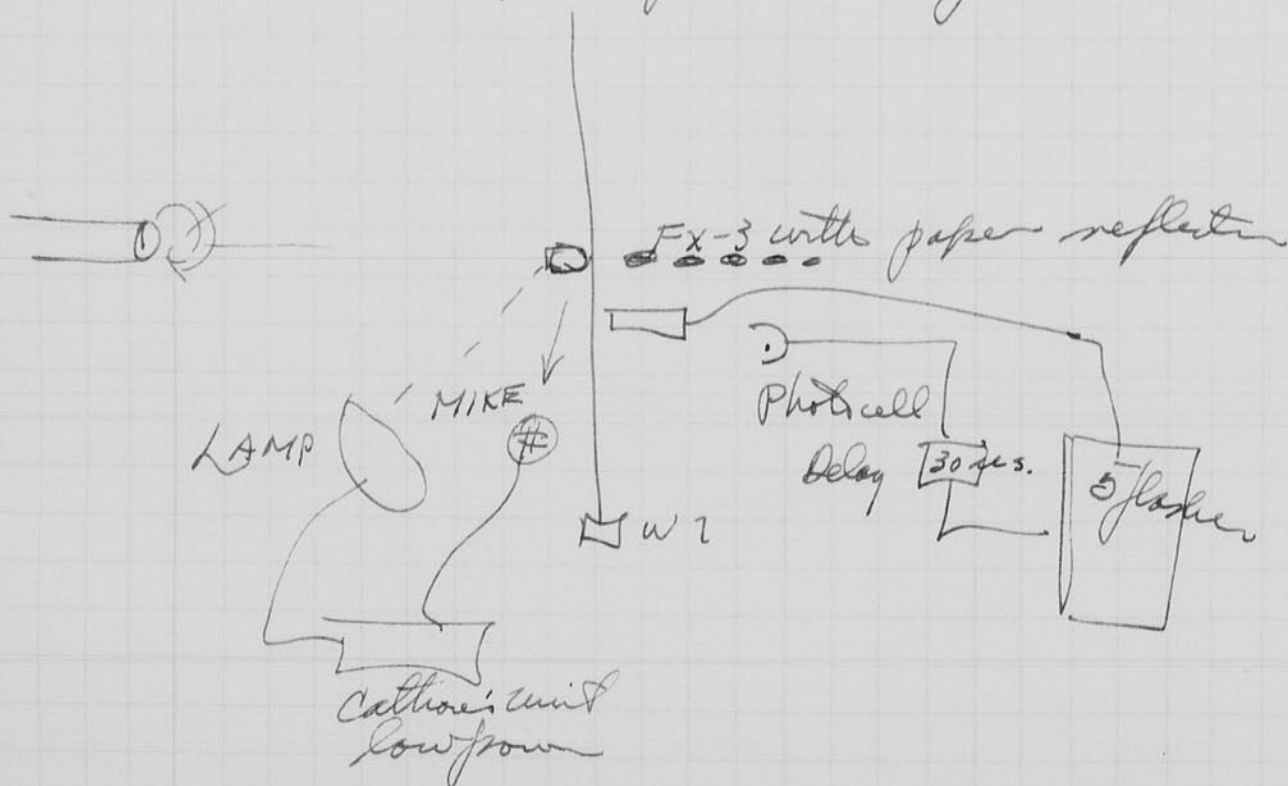
We tested the Explosive Shutter
Power unit # 3180

Also looked at 250 c.p.s. marker # 3122.

Jan 18 56 cont. Bill Mack finished wiring the 5 mercury arc tubes as per page 68. He increased the trigger spark capacitor to 0.1 mfd from .05. to eliminate sparking of the Hg tubes.

He also put in a 15 ohm resistor in the cathode circuit which seems to even out the flashes and also apparently helps out the starting.

I hooked the equipment up as follows first with a 22 caliber a string was put in the field.



The first photo caught the #1 trigger bullet just as it touched the string. The next 5 from the 5 flasher started after 30 us. The rate was 5000 cycles or 20 us between.

I then took some without a string at 100 KC and another at 25 KC since the images overlapped with the 22.

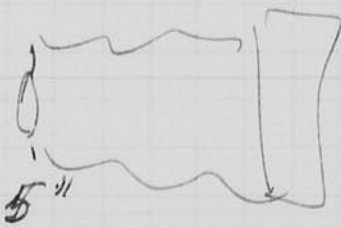
Next I fired a 220 Super Speed Swift

1. The first shot was of a string. The photo showed late. 50 KC
2. Ditto on one without a string.
3. String again also late but shows velocity and motion of fragments.
4. Sens of mike increased - works ok 5 shots - now show tip of bullet. 50 K.C.

Bullet.

©

5"



4x5 Royal Pan

7 min D72 x 2 ±

70° ±?

Fx-3

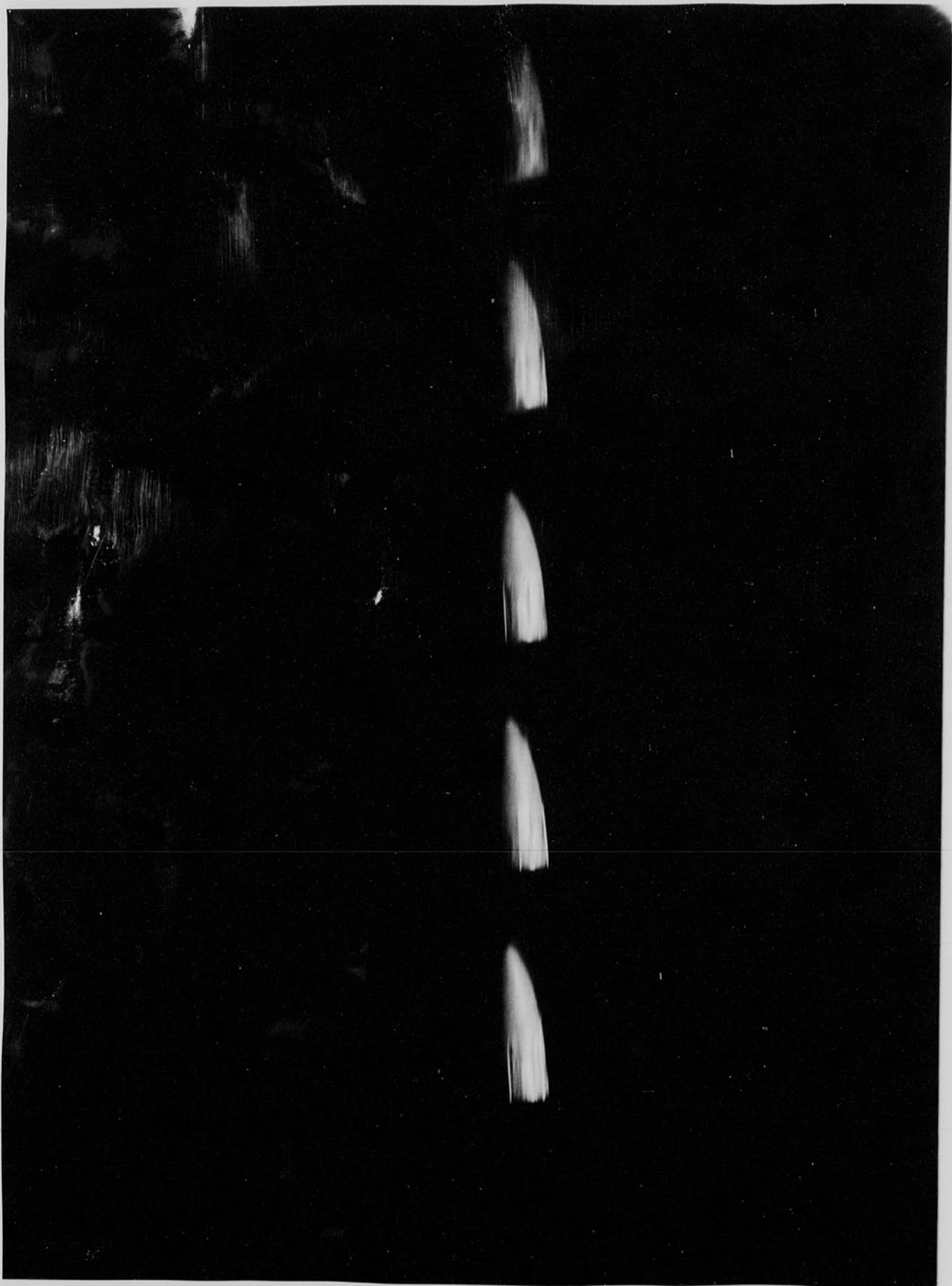


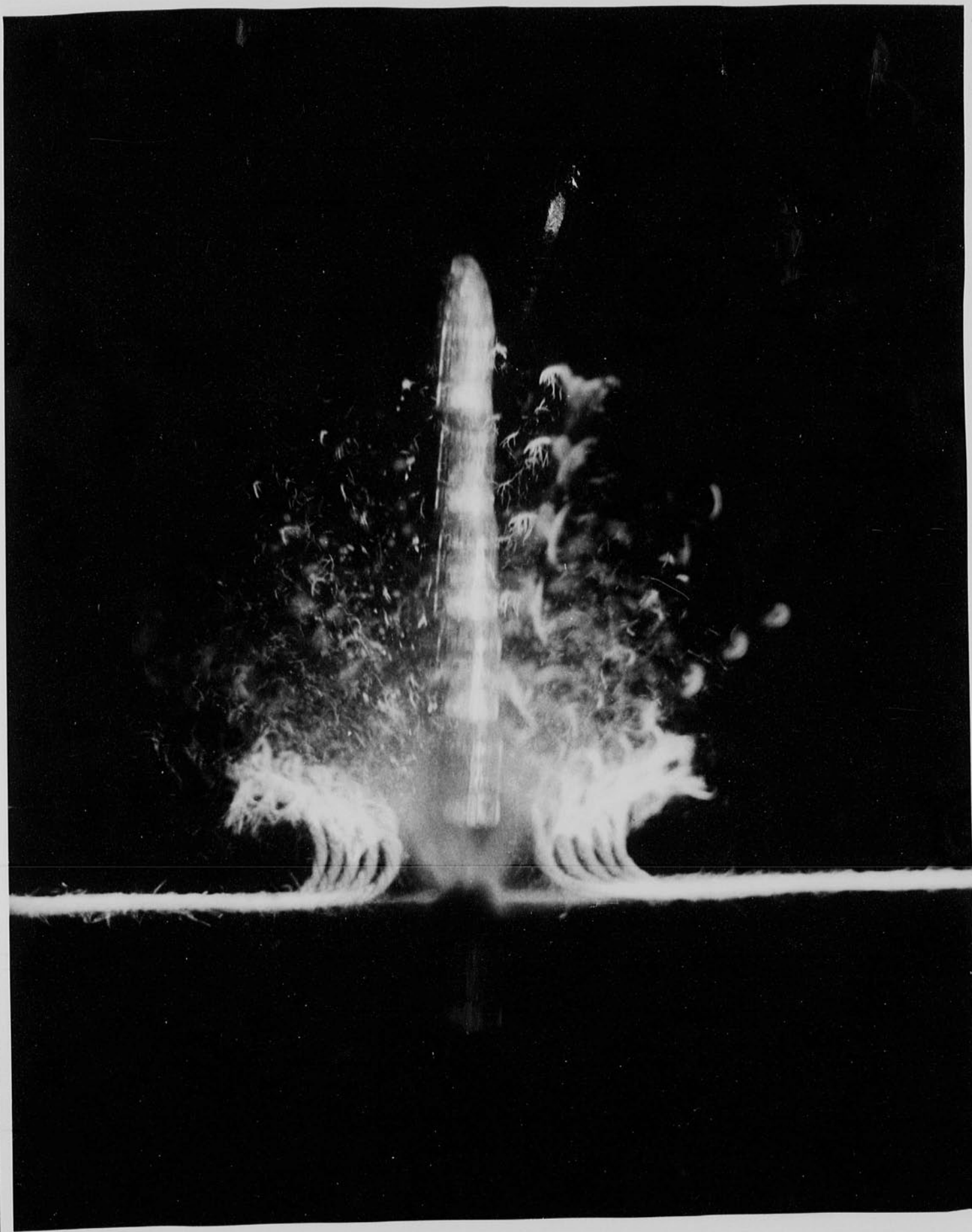
f 8 for shot 4

f 6.3 for 22 cal. shots.

White
cardboard

220 Swift 50 KC LIGHT.





20 CAL. INTO STRING 50 K.C.

74

Jan 20, 1956

Herald E. Edgerton

The results of the multiflash at 50 Kc is on the previous two pages. I also took some shots at 100 Kc. A capacitor of 0.03 mfd was used at 10 KV with a FX-3 lamp. The new circuit uses a grounded cathode ~~and anode~~ which apparently gets away from self starting and back flashing.

Today Bill connected a series of 5 tubes with 0.1 mfd. The peak light was $2\frac{1}{2}$ times and the duration 3 μ s instead of 1.

The equipment ran ok up to 50 Kc - also ok at 100 Kc. This is great.

+
Vosbury
Double play.



Sely Buchsbaum Jan 22, 1956.
H. Edgerton

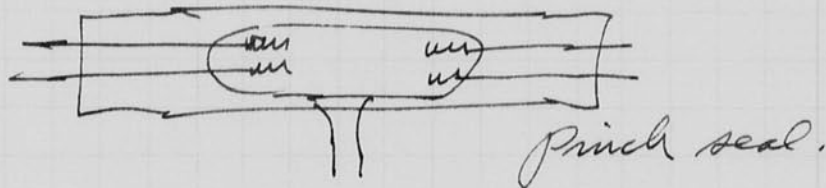
I.D. = 8.6 mm Nonex
length = 8"

Helium gas 10 cm ^{1 mfd} HV for first few tests
Strong yellow green blue lines.

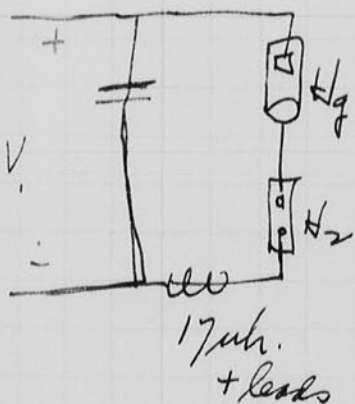
| Press | min | Self flash. | |
|-------|------|-------------|-----------------------------|
| 5 | 3000 | 4200 | Single turn 1/3 from + side |
| 10 | 4800 | 4800+ | |
| 5 | 3000 | 4000 | |
| 3.5 | 2700 | 3800 | |
| 1. | 1800 | 3300 | |
| 3.5 | 2700 | 4500± | |

Jan 24 1956. Tests on Hydrogen tube.

Pumped G.E. Quartz tube.
about normal size 1 1/2".



Heated and exhausted.
Filled with H₂ at 2cm. Ok at 1 mfd 2 KV
then put in 10cm H₂.



Broke when flashed 10 times at 1/2 second
intervals from 7 mfd at 2KV, ±.
the seal broke. This seal is a
ribbon type.

The mercury tube enables
us to fire the Hydrogen tube at
high pressure.

Experiment in tube.

Series of tubes:

20 ~~30~~ cm. in. tube 1" spac 3/4" cap.
2 mm i.d. quartz.

3 Kv with series tube 1 mfd.

Pressure reduced to ¹⁰ 20 cm. (1.53 min star
 starts at 2 Kv. 3 mfd

2 Kv. ---

7 mfd

continuous and very bright spectrum

only for the 7 mfd example.

new gas ¹⁰ 11 cm H₂. min breakdown = 1900. volts.--- 6 cm H₂ " = 1400--- 2.5 " H₂ " = 900.

1000 - Red line alone

1200 - many lines appear.

new gas 11 cm. 2 Kv 1 mfd few lines
 2 Kv. 4 " many lines.

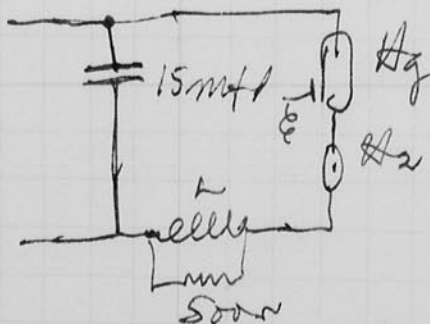
new choke 2.2 mh.

15 mfd. choke 2.2 + 3.5. pressure 7.5 cm.

1800 - Red line.

2000 - other lines come in.

Sealed off at 7.5 cm?



Jan 29 Test on XP-2 tube on Pump. Xenon gas.

1956
Hamed Elgarni
20D-102

Breakdown self - about 750 to 1000 volts.
Spark - 350. with 2 cm of xenon gas.

These results are higher than those of carbon.
I did not heat tube.
Now balsaed.
New gas - about same as above.

Scope 513D tech 6000
P.C. 935 + glass into 1000 ohms 2000 volts.
12" P.C. to tube.

| Pressure cm | V. | C. | D_{max} us. cm. | volts def. V. | |
|----------------|---------------------|-------------------------------|-----------------------------|------------------|---------------------------------|
| 1.9 | 750 | 1 mfd. | 1.3 | 2.2 | 22, 1.02×10^6 C.P. |
| " | 500 | 1 mfd. | " | 1.4 | 14, .65 |
| 3.3 | 500 | | | 1.7 | 17, .78 |
| " | 750 | | | 3.5 | 35, 1.62 |
| " | 1000 | Self flashes after first Pop. | | | |
| 4.7 | 500 | | | 1.8 | 18, .835 |
| | 1000 750 | | 1.4 x 3 | 39.43 | 2.0 |
| 6.3 | 1000 750 | | 1.5 x 3 | 45 | 2.1 |
| | 500 | | 1.8 | 18 | → ← 1 us. Long rise? .835, .835 |
| 8.1 | 500 | | 1.8 | 18 | |
| 8.1 | 4000 750 | | 1.5 x 3 | 45 | 2.1 |
| 8.1 | 1000 | | 2.7 x 3 | 81 | 3.76 |
| 8.1 | 1000 .75 mfd | 2 x 3 | | 60 | 2.8 |
| | 1500 | Self breakdown. ± | | | |
| | 1000 | 0.1 mfd | 1.5 to 1.9 x 1/3 | 5 | 5 jittery .232 |

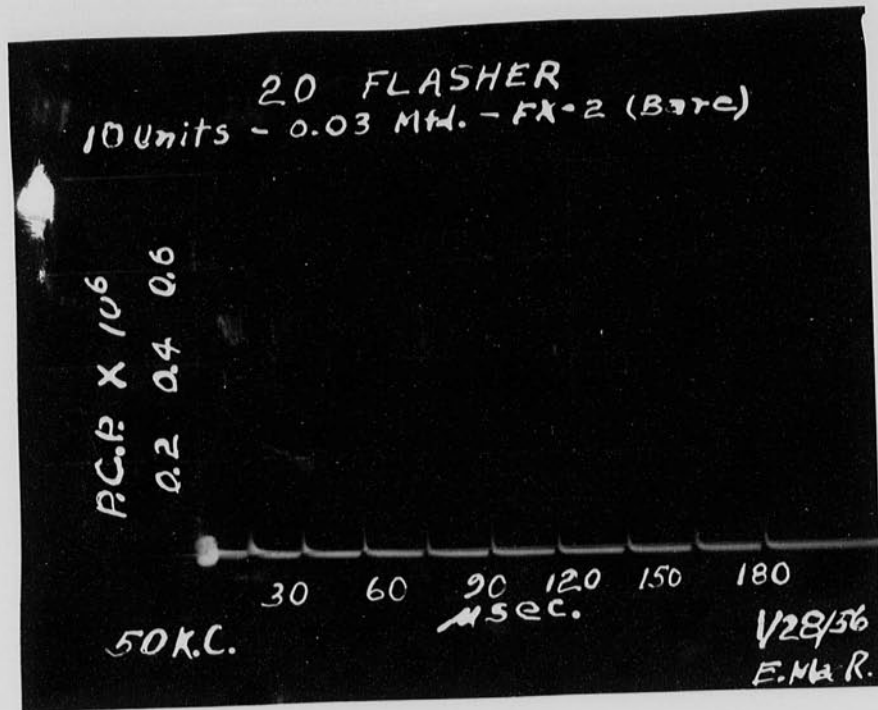
Sealed off at 8 it cm.

FT 218
Calibration 2000 100 mfd. 2 cm x 3 60.
629 C.P.S.
Peak. 2.6×10^6 C.P.S. at 3 ft.

$60 \text{ volts} = 2.6 \times 10^6 \text{ C.P.} / 3^2$
 $1 \text{ volt} = .43 \times 10^6 \text{ C.P.} / 3^2$
 $1 = .047 \times 10^6 \text{ lumens} / \text{sq ft}$
at 3 ft.
above at 1 foot 1 volt = $.43 \times 10^6$ C.P.

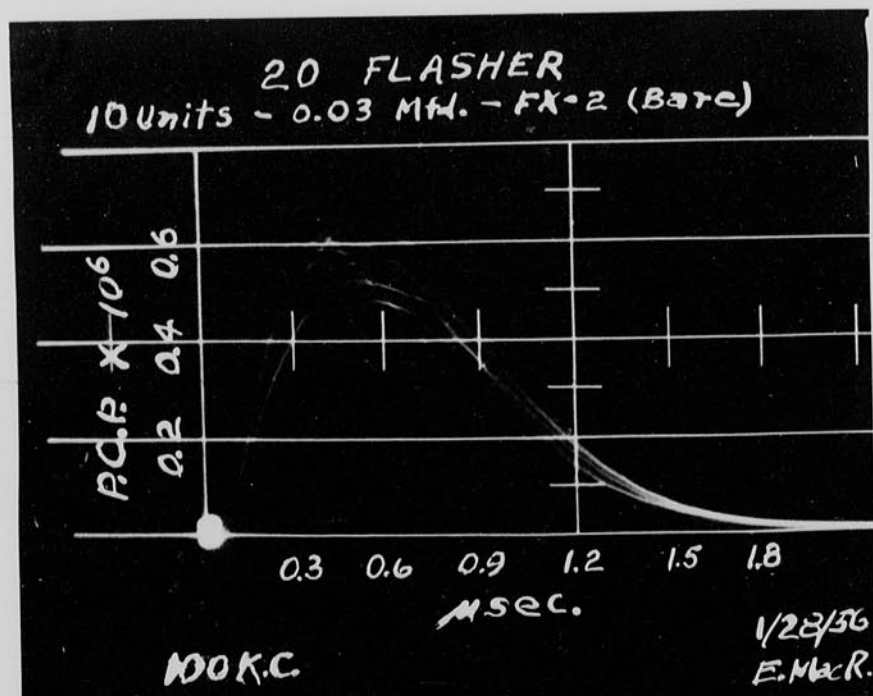
Oscilloscope 0.5 us per cm.
 1.5×10^6 C.P./cm. .015 ohms.
50 V = .7 cm calib for current.

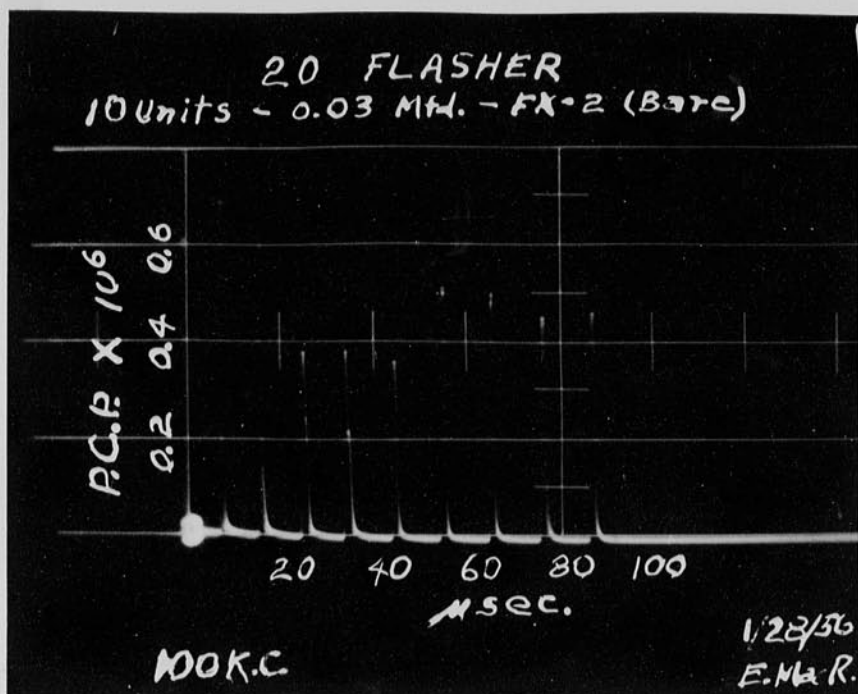
47
9 41
36
70
70



50 Kc operation 20 us between flashes

Duration shot 10 superimposed sweeps





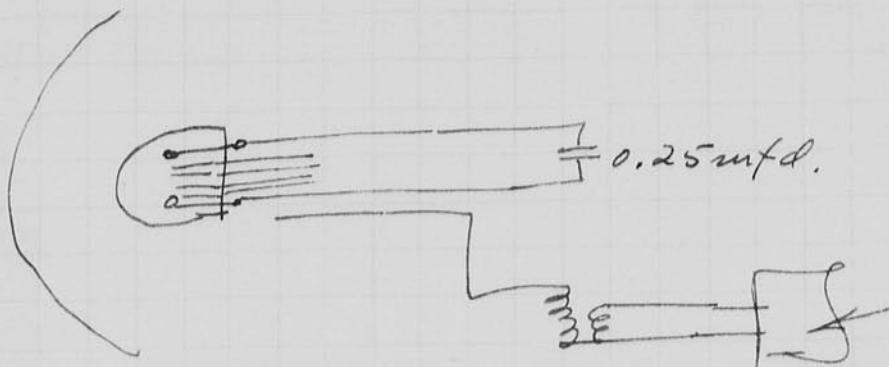
100KC 10 μ s between shots.

This equipment was operated on Sat at 100 KC for bullet photos of string and 22 caliber bullets. Mr. Grossman was here on Monday for a conference and demonstration. He oked changes in the contract for 100KC with 1 μ s exposure and 1.5 watt/sec.

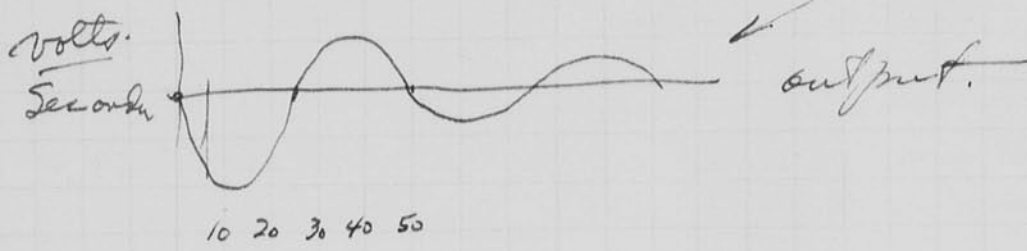
Jan 30 1956.

Harold Egerton.

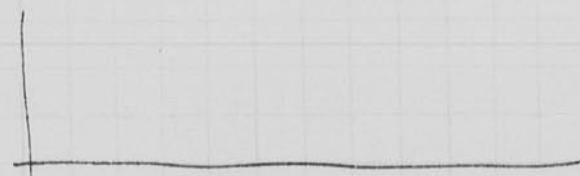
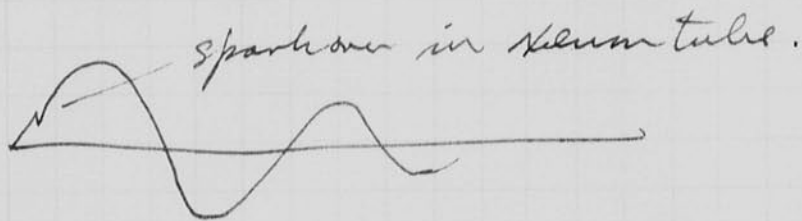
Tests of Gensehausen
Xenon gap tube.



Modestric coil. Strobotac.



coil terminal reversed



Arc has some jitter.

Feb 11 1956. This tube
 was demonstrated with
 Gensehausen to
 this star and within
 of 5K. last week.

I put in an XP-2 tube which has about 8.2 cm of X-ray. 81

Starting voltage to glow - about 400 - or 450.

Remook with $\frac{1}{4}$ mfd at 600 over 10 to 60 cycles with 0.25 mfd. Efficiency seems higher than the gap tube. ? 2000 ohm charging resistance.

$$\frac{CE^2}{2} = \frac{600^2}{2} \times \frac{1}{4} = \frac{.36}{8} = .045 \text{ watt sec.}$$

$$\frac{.045}{60} = 2700 \text{ watts for 60 cycles.}$$

at 800 volts $\frac{1}{4}$ mfd operation ok up to 240 cycles on strobo-tachiner with reduced spark on coil. About $\frac{1}{8}$ " ~~gap~~ spark. Tube red hot on the inside.

San X-ray.

Plots all output

.05" Capillary. 2000 Ω

2 μ sec duration

2.5 volts

3 ft from photocell

Germ tube

1.5 μ sec

5.5 volts

With 8 Ω 11.5 volts = 3×10^6 PHCP

.05" Capillary $\frac{8 \Omega}{2000} \times \frac{2.5}{11.5} \times 3 \times 10^6 = \text{PHCP} = 2.68 \times 10^4 \text{ PHCP}$

$$EH = \frac{(2.68 \times 10^4) (2 \times 10^{-6})}{.25 \left(\frac{1}{2}\right) (800)^2} = 0.66$$

Notebook # 23

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 80 and 81.

Item(s) now housed in accompanying folder.

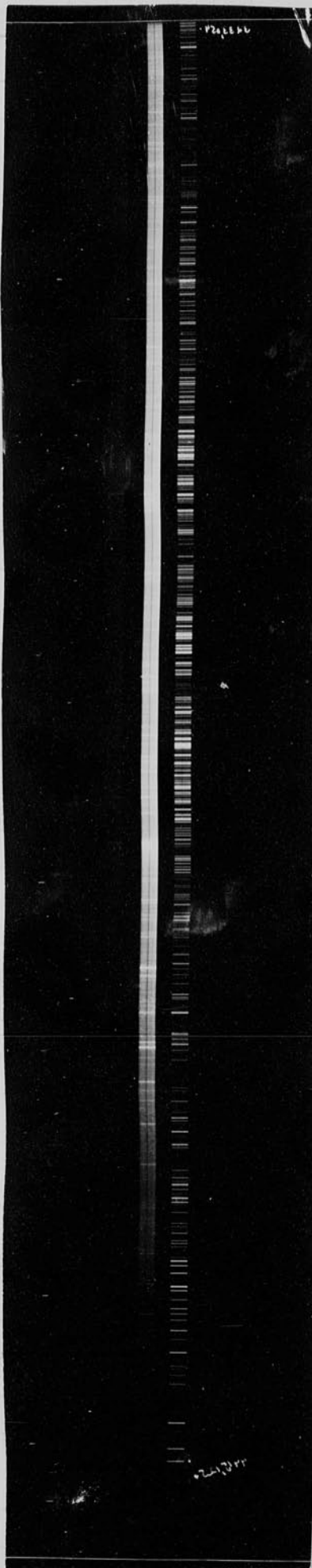
6 us per division.

3 prop. operation

Strobolux lamps.

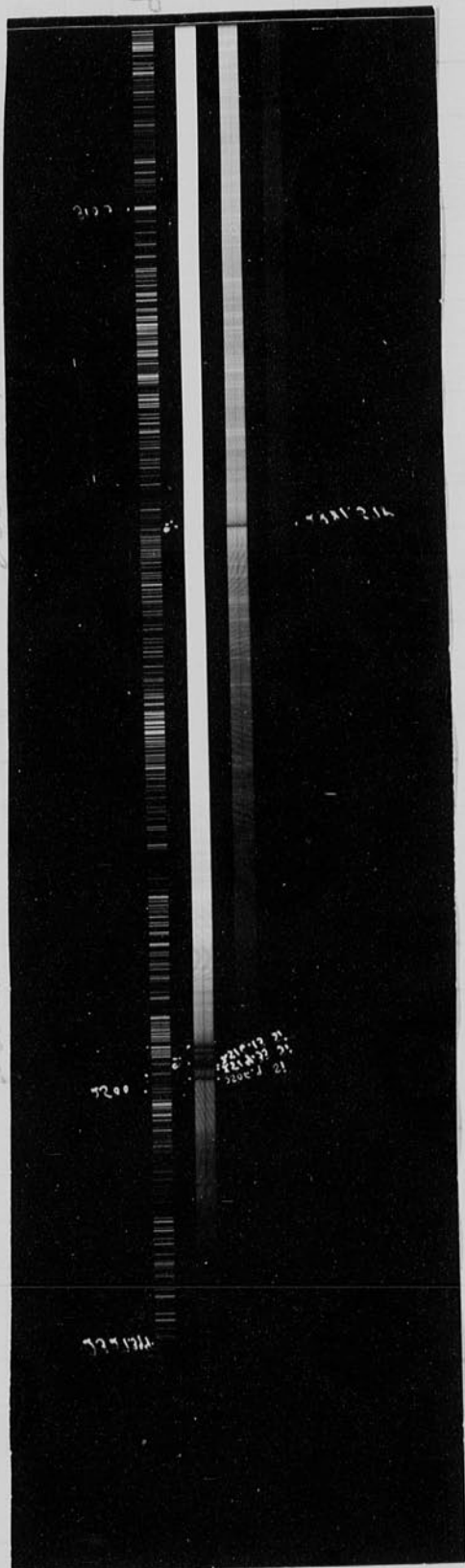
50 Kc.

Blue → U.V.



Silicon

Silicon



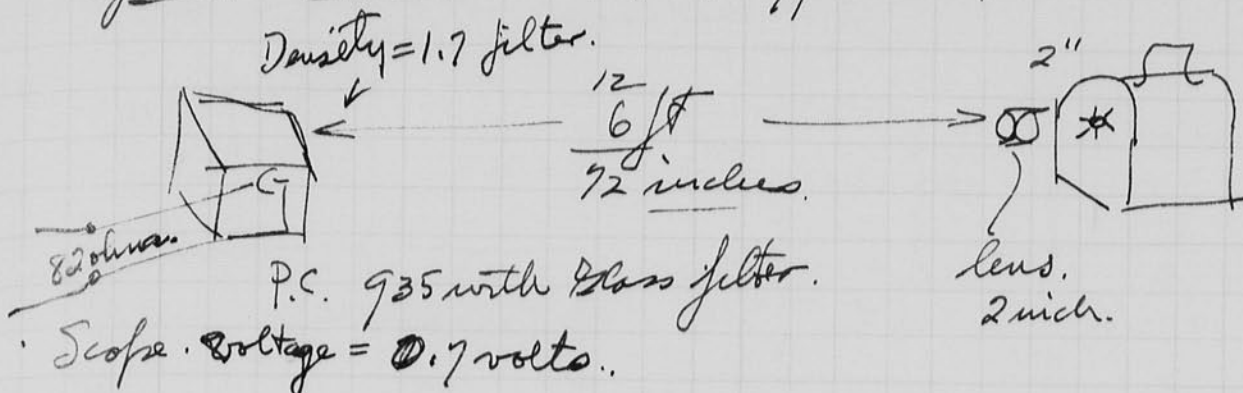
U.V.

Spectrum of the XP-2 flash tube
with 0.5 ml of 2K.V. (600,000V)
taken at Jernell-ash in Jan 1956

An Iron spectrum is used as a
standard.

Intensity of the Source measurements.

Spark source. E.G. & G. type 2314.



3 osc. 0.5 μ s/cm 82 ohm. 0.7 volts per cm def. 2314 flash unit. $D=1.7$

Same experimental setups but with FX-1 100 mfd 2KV.

2 osc. 50 μ s/cm 1000 ohm. $\frac{5V}{2}$ per cm def. 5 1/2 feet to p.c. $D=1.7$

XP-2 1 mfd at 3KV blew up on second flash. Shows dirt on tube walls. BaCO₃ particles.

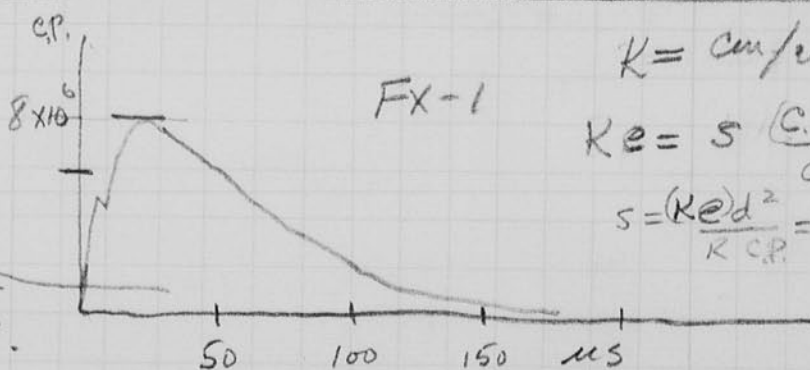
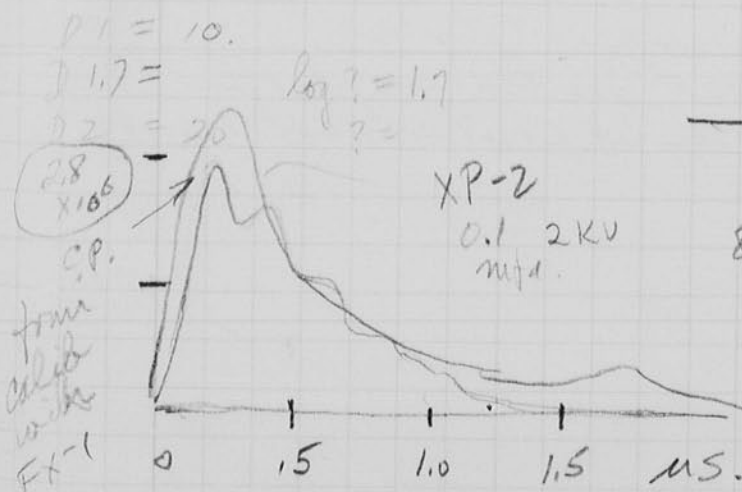
300C 0.5 μ s/cm 82 ohm. $\frac{7.3}{2}$ V per cm def. NO FILTER 5 1/2 feet to p.c. XP-2 - 1 mfd 2KV

(shows with 1000 ohms about 3 μ s!)

Assume FX-1 has peak of 0.41×10^6 cp/cm then spark gap has

air gap: $\frac{.41}{82} \left(\frac{10000}{82} \right) \times \left(\frac{5}{.7} \right) = 35.6 \text{ cp/cm}^2$

XP-2 $.41 \left(\frac{10000}{82} \right) \times \frac{5}{7.3} \times \frac{1}{70} = 4.9$



$K = \text{cm/volt}$

$Ke = 5 \left(\frac{\text{C.P.}}{d^2} \right) R$

$s = \frac{(Ke)d^2}{K \text{ C.P.}}$

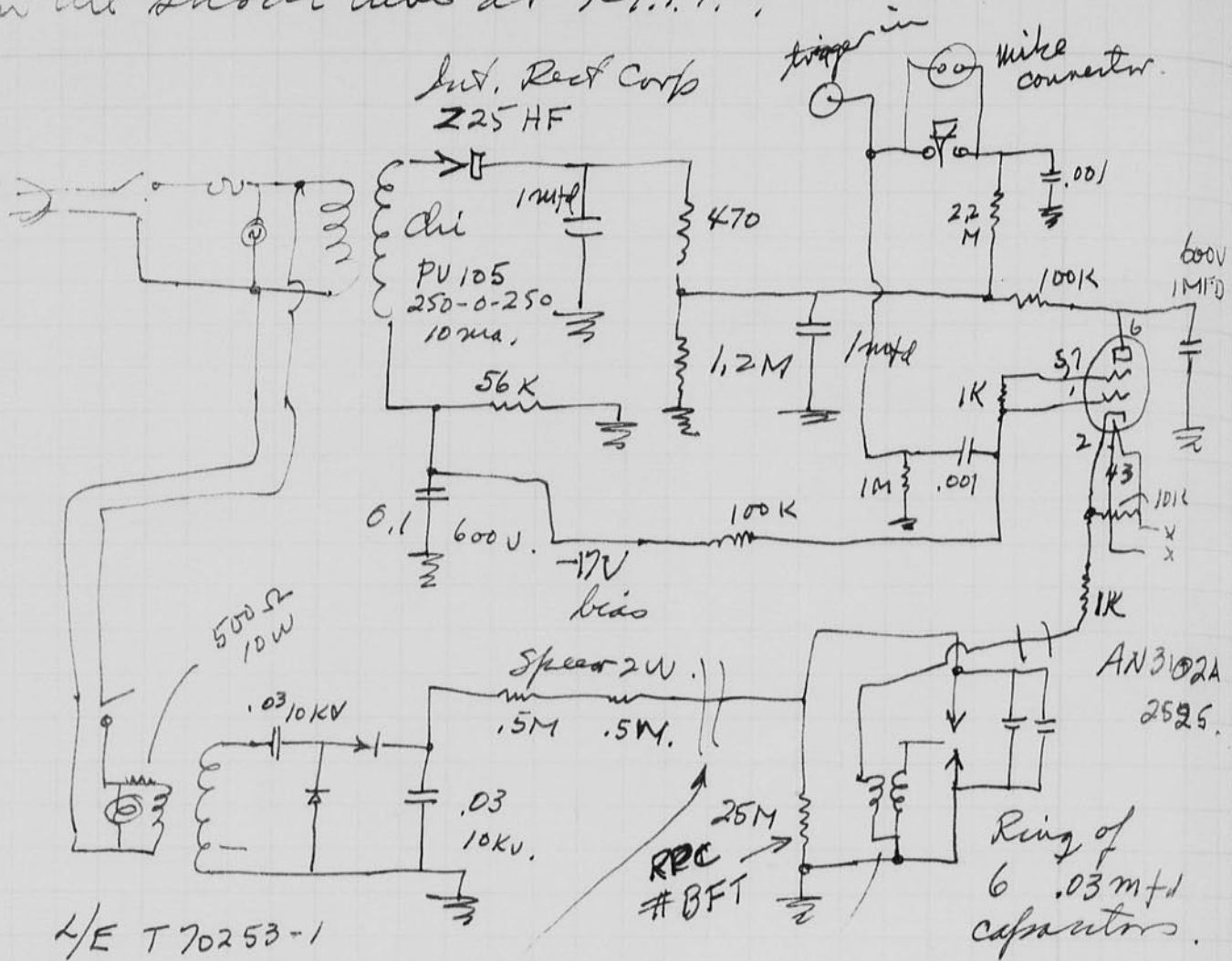
$\left(\frac{8 \times 10^6}{1.3 \text{ cm}} \right)$

d

Point light Source. 2314 B2 type as used in the shock tube at M.I.T.

H.S. Edg.
Feb. 2, 1956.

Ray Rectifier



L/E T 70253-1
6KV, sec.

Scintilla.

3163 B1
Pulse trans
3511
.03
6
.18 mfd.

This equipment was borrowed from the shock tube lab today for measurement of light. It is used in the Schlieren and interferometer at the shock tube on Vassar Street. The shock tube is about 1/10 the cost of a wind tunnel. The M.I.T. total cost about \$100,000.

See page 83 for circuit.
Intensity tests of flash tubes.

Tube

| | C | E | R | Filtes | V _{peak} | Dist. | CP/cm ² |
|---|-----|------|----|--------|-------------------|-------|--------------------|
| XP-2 | 0.1 | 2KV | 82 | 0.3 | 2.5V | 74. | |
| XP-2 | 0.5 | 2KV. | 82 | 0.3 | 11.5V | 74. | |
| Air 2314 | .18 | 10? | 82 | .3 | 11.5± | 74 | |
| Spot diam at p.c. = $\left(\begin{matrix} 3.75'' \\ \downarrow 7.1 \end{matrix} \right)$ at spark diam = $3.75 \times \frac{2}{74} = 0.1$ inches | | | | | | | |
| Air 2314 | .18 | ? | 82 | .3 | 32 | 74. | |
| 3070, 0.15 ns/cm. 32V/cm calibration. | | | | | | | |
| FX-1 | 100 | 2KV | 82 | .3 | 1.1 | 74. | |

NOW WITHOUT LENS

| | C | E | R | Filtes | V _{peak} | Dist. | Area. | HCP. | HCP/Area | E |
|-------------|-----|------|----|--------|-------------------|-------|----------------------|------------------------|-------------------------|------|
| FX-1 | 100 | 2KV | 82 | 0.3 | 2.2V | 76" | 1905 cm ² | 8 x 10 ⁶ | 0.41 x 10 ⁶ | |
| " | " | " | " | " | 2.4 | " | | | | |
| XP-2 | 0.1 | 2KV. | 82 | .3 | .042V | 76" | 0.25 cm ² | .153 x 10 ⁶ | 0.614 x 10 ⁶ | |
| XP-2 | .5 | 2KV | 82 | .3 | .275V | 76" | 0.25 | 1.00 x 10 ⁶ | 4.00 x 10 ⁶ | |
| Airgap 2314 | .18 | ? | 82 | .3 | .562V | 76" | 0.1 cm ² | 2.04 | 20.4 x 10 ⁶ | 0.22 |

(10,000?)

$$\frac{CP^2}{2} = \frac{.18 \times 10^6}{2} = 9.0 \text{ watt sec.}$$

$$\frac{CP}{\text{Watt}} = \frac{2}{9} = 1.115 \times 2 \times 10^6 \text{ HCP} = 2 \text{ HCP5.}$$

Feb. 3, 1956. Phone call from H.M. Peek too damn late today. He wants a bright x-ray source for spectroscopic work. Suggests 240×10^6 lumens/sq. cm. with a 1 ms duration. This is a bright source. We could do it with the XP-1 and the movie unit giving the lamp a burst of light. I am sending all the info to Peek today.

Peek suggests ~~and~~ ^{an} end on view of a x-ray flash lamp such as the FX-1. I told him the intensity might not be much greater than the side view.

Many photos were taken in the evening of a Winchester 220 swift bullet with the multiflash unit. Bill Paulson of the Supersonic wind tunnel helped.

We used 100 KC bullets overlapping
50 KC,
and some at 5 KC.

Strings, wires, etc were hit by the bullets. The unit was set for 10 lights. It worked very well.

Feb 4 '56. Last night's photos were taken with the specular reflector and was FX-2 flash tube, about 3 ft from the subject.

Today I used an FX-3 about 12" from the subject with a white card above the bullets about 8 inches. Royal Pan # X5 film at f8. freq 100 KC.

Feb 6. Schluter came over today with P to discuss inductors and capacitors.

He wants 10,000 mfd to discharge into a coil to create a magnetic field of 300,000 gauss to deflect particles created in the explosion. synchrotron.

10,000 gauss 40 joules/cubic cm needs 50 cc.



SPECIFICATIONS and BALLISTICS

WINCHESTER Rim Fire Rifle Cartridges

| SYMBOL | PRIMER No. | CARTRIDGE | BULLET Wt. Grs. | Type | VELOCITY Ft. Per Sec. | | ENERGY Ft. Lbs. | | MID-RANGE Trajectory | | |
|---------|------------|---|-----------------|-----------------|-----------------------|----------|-----------------|----------|----------------------|----------|----------|
| | | | | | Muzzle | 100 yds. | Muzzle | 100 yds. | 100 yds. | 200 yds. | 300 yds. |
| SS22S | ... | 22 Short, Super Speed† | 29 | Kopperklad | 1125 | 920 | ... | 81 | ... | 4.3 | ... |
| SS22SH | ... | 22 Short H.P., Super Speed† | 27 | Kopperklad | 1155 | 920 | ... | 80 | ... | 4.2 | ... |
| SS22L | ... | 22 Long, Super Speed† | 29 | Kopperklad | 1240 | 965 | ... | 99 | ... | 3.8 | ... |
| SS22LR | ... | 22 Long Rifle, Super Speed† | 40 | Kopperklad | 1335 | 1045 | ... | 158 | ... | 3.3 | ... |
| SS22LRH | ... | 22 Long Rifle H.P., Super Speed† | 37 | Kopperklad | 1365 | 1040 | ... | 149 | ... | 3.3 | ... |
| SS22LRS | ... | 22 Long Rifle Shot, Super Speed | | No. 12 Shot | ... | ... | ... | ... | ... | ... | ... |
| SS22WRF | ... | 22 W.R.F. (22 Rem. Spl.) Super Speed, Inside Lubricated | 45 | Kopperklad | 1450 | 1110 | ... | 210 | ... | 2.7 | ... |
| LD22S | ... | 22 Short, Leader | 29 | Lead† | 965 | 810 | ... | 60 | ... | 5.6 | ... |
| LD22LR | ... | 22 Long Rifle, Leader | 40 | Lead† | 1145 | 975 | ... | 116 | ... | 4.0 | ... |
| K2236R | ... | 22 Long Rifle Smokeless EZXS | 40 | Lead† | 1145 | 975 | ... | 116 | ... | 4.0 | ... |
| EZ22LR | ... | 22 Long Rifle Improved (Low Velocity) EZXS | 40 | Lead† | ... | ... | ... | ... | ... | ... | ... |
| W22BB | ... | B.B. Cap | 18 | Lead | 780 | 570 | ... | 24 | ... | ... | ... |
| W22BL | ... | 22 Short Blank (Black Powder) No Bullet | | | ... | ... | ... | ... | ... | ... | ... |
| SP22S | ... | 22 Short, Spatterpruf, (Gallery Pack) | 29 | Disintegrating† | 970 | ... | ... | ... | ... | ... | ... |
| WA22 | ... | 22 Winchester Automatic, Inside Lubricated | 45 | Kopperklad | 955 | 80 | ... | 111 | ... | 4.6 | ... |
| *25ST | ... | 25 Stevens, Inside Lubricated | 65 | Lubaloy | ... | 985 | ... | 184 | ... | 3.8 | ... |
| *32S | ... | 32 Short | 80 | Lubaloy† | ... | 840 | ... | 158 | ... | 5.3 | ... |
| W32L | ... | 32 Long | 89 | Lead† | ... | 850 | ... | 179 | ... | 5.3 | ... |
| W9LS | ... | 9 m/m Long Shot | | No. 9 Shot | ... | ... | ... | ... | ... | ... | ... |

All Cartridges other than 22 Short Blank loaded with smokeless powder.

* Furnished in Western Brand Only.
 † Wax Coated.
 ‡ Lubricated.



SPECIFICATIONS and BALLISTICS

WINCHESTER Center Fire Rifle Cartridges

| SYMBOL | PRIMER No. | CARTRIDGE | BULLET Wt. Grs. | Type | VELOCITY Ft. Per Sec. | | ENERGY Ft. Lbs. | | MID-RANGE Trajectory | | | | |
|--------|------------|--|-----------------|--------|-----------------------|----------|-----------------|----------|----------------------|----------|----------|----------|------|
| | | | | | Muzzle | 100 yds. | Muzzle | 100 yds. | 100 yds. | 200 yds. | 300 yds. | 300 yds. | |
| W218B | 116 | 218 Bee Super Speed | 46 | H.P. | 2860 | 2160 | 1200 | 835 | 475 | 265 | 145 | 3.8 | 11.5 |
| W219Z | 120 | 219 Zipper Super Speed | 56 | H.P. | 3110 | 2440 | 1940 | 1200 | 740 | 465 | 300 | 0.6 | 2.9 |
| W22HI | 116 | 22 Hornet Super Speed | 45 | S.P. | 2690 | 2030 | 1510 | 720 | 410 | 230 | 130 | 0.8 | 4.3 |
| W22H2 | 116 | 22 Hornet Super Speed | 46 | H.P. | 2690 | 2030 | 1510 | 740 | 420 | 235 | 135 | 0.8 | 4.3 |
| W220S | 120 | 220 Swift Super Speed | 48 | P.S.P. | 4110 | 3490 | 2930 | 2440 | 1800 | 915 | 635 | 0.3 | 1.4 |
| W222R | 120 | 222 Remington Super Speed | 50 | S.P. | 3200 | 2660 | 2170 | 1750 | 1140 | 785 | 520 | 0.5 | 2.5 |
| W225 | 120 | 22 Savage Super Speed | 70 | P.S.P. | 2800 | 2440 | 2110 | 1840 | 1220 | 925 | 690 | 0.6 | 2.9 |
| W25203 | 116 | 25-20 Winchester High Velocity Super Speed | 60 | H.P. | 2250 | 1660 | 1240 | 1030 | 675 | 365 | 205 | 1.2 | 6.3 |
| W25201 | 116 | 25-20 Winchester† | 86 | Lead | 1460 | 1180 | 1030 | 940 | 405 | 265 | 170 | 2.6 | 12.5 |



Hg 5 seconds no watt lamp cold;

- Xe 1 flash
- 4 flashes
- 16 flashes
- 32 flashes with Jarand 450 15-25 filter
- 16 " " " "
- Hg. " " " "

10 6907.5
 6234.35
 6123.47
 6072.63

5790.60
 5769.60
 5675.8
 5460.3

4960.3
 4916.0
 44.3

558.7
 10.8 4358.84
 10.8 4347.50

4339.23

4077.8

10 4046.56

3983.99

3906.4

3663.27

3662.87

3654.83

10 3650.15

3341.48

3131.84

3131.56

3125.6

3021.50

Jarand filter 450 15-25

↑

3

↓

1.5

2.0

2.2

$\frac{100}{30} = 3.33$
 $3.33 \times 0.55 = 1.83$

$392.0 = 1.0$

$2119.45 = 5.4$

3950.15

$5769.60 = 5.4$

$\frac{969.6}{5000} = 196$

5769.60

311.78

396.4

392
 $\frac{349.85}{9650.15} = .89$

3650.15 = 0

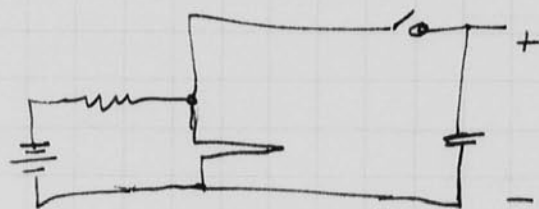
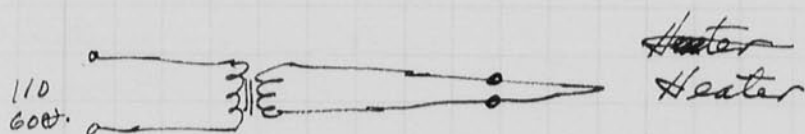
Feb. 9, 1956.

New Stroboscope.

6 watt @ 600
600 v. 89
 $\frac{1}{10} = \frac{600}{2}$
 $\frac{1}{10} = \frac{1}{5} \cdot .26 = 1.04$

A gap tube was given me last week by Fred Conley of E.G.F.S. It has a series of internal starting coils to direct the arc. More tests are to be made tomorrow when Geneshevson visits the lab.

I called Arthur Miller (Sanborn) about the possibility of pulsing his recorder heater. This would be used to record the bottom to various depths in the deep sea equipment. He says that 10 watts are used with a 1/10 sec heating time. Thus the energy is 1 watt second.



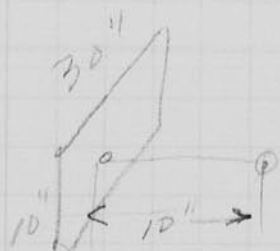
See page 52

Screen for silhouette photos of bullets.

10 ft x 30 ft wide.

model
10" x 30 inches.

1/12 scale factor.



30"



$\frac{600}{2} = .36 = .16$ watt sec.
 $\frac{600}{2} = .6 = .1$

Harvard Edgerton.

The lab. was cleaned out today for a demonstration for a group of students from Lexington (High School) and a group of Harvard students from the Graduate Business School.

Reference: Über die elektrische Entladung ~~bei~~ bei stromstärkeren Funken.

D. Glaser. D. Sautter.

Zeitschrift für Physik Bd 143 544-76 1955.

$$j = n_e b_e e E$$

n_e = electron density.

b_e = mobility.

e = charge

E = field. = U_f/d

U_f = voltage d = electrode spacing

$$i_f = \frac{\pi r^2 n_e b_e e U_f}{d}$$

$$\text{and } R_f = \frac{d}{\pi r^2 n_e b_e e}$$

$$\text{but } n_e = \frac{x}{1+x} \cdot \frac{P}{kT}$$

$n_e b_e e$ = conductivity
= 90 mho/cm
vacuum.

Peak current in ~~XP-2~~ XP-2 flash tube 2000 volts
0.086 ohms resistance in shunt 0.1 mfd.
peak = 120 volts.

$$\frac{120}{.086} = \text{amps.} = 1400 \text{ amps peak.}$$

See page 92

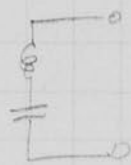
etc. 1. 0.5 ns/cm. 0.87 V/cm. Light

etc 2.

" 3-7 0.5 ns/cm 88 V/cm. Current

$$G = \frac{1}{R_f} = \frac{\pi r^2 (n_e b_e e)}{d}$$

Magnetron Optics Shutter.

Tests by Roy Swanson

0.1 mfd

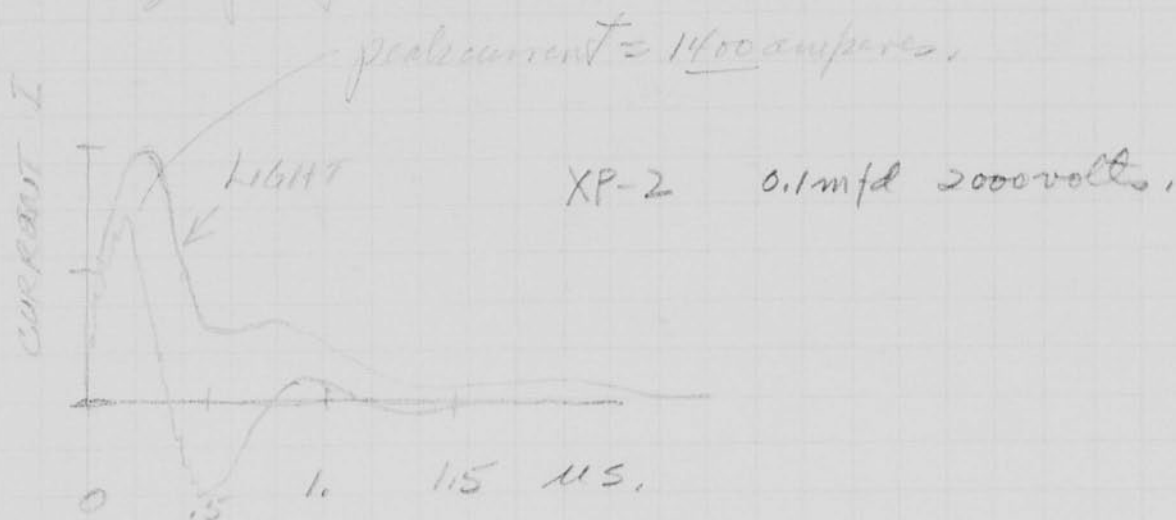
| | |
|------------|---|
| 6 turns | } |
| 0.1 mf | |
| 24 KV. | |
| 1 μ s. | |

This will give 90 degree rotation.
in Blue light!

Red requires more watt sec

Feb 10, 1956.
H. E. Egan

See page 90 bottom
for data.



$$\text{frequency of discharge} = \frac{1}{T} = \frac{1}{.75 \times 10^{-6}} = 1.33 \times 10^6 \text{ cycles/sec}$$

$$C = 0.1$$

$$T = 2\pi \sqrt{LC}$$

$$f = \frac{1}{T}$$

$$\frac{1}{f} = 2\pi \sqrt{CR^2C}$$

$$\frac{1}{f} = 2\pi \frac{CR}{2}$$

$$f = \frac{1}{\pi CR}$$

$$R = \frac{1}{\pi C f}$$

$$L \frac{d^2 i}{dt^2} + R i' + \frac{1}{C} \int i dt = e$$

$$= \frac{1}{3.14 \cdot 0.1 \times 10^{-6} \cdot 1.3 \times 10^6}$$

$$= \underline{\underline{245 \text{ ohms}}}$$

Lamp resistance = 1/4 ohms for 1/4" tube.

$$R = \frac{l}{\text{area}} = \frac{6 \times 10^{-3}}{1.2^2 \times 10^{-6} \pi 6000} = .222 \text{ ohms}$$

$$v = 6000 \text{ mph/meter}$$

Lamp length for crit damping = $\frac{1}{4} \times 10 = \underline{\underline{2.5 \text{ inches}}}$.

Feb. 18 1956

San flash Power unit.

Howard Edgerton

Present
AVCO.

To charge the San flash fast I propose a separate auxiliary power supply to give more current into the capacitors on the beginning of the charge cycle. A slight delay is required to prevent holdover

$$\begin{array}{r} 36 \\ 36 \\ \hline 216 \\ 108 \\ \hline 1296 \end{array}$$

1300 mfd.

$$i = C \frac{de}{dt}$$

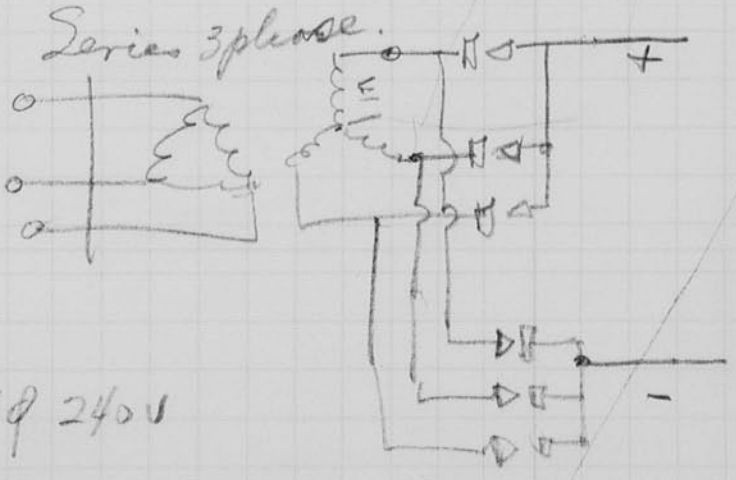
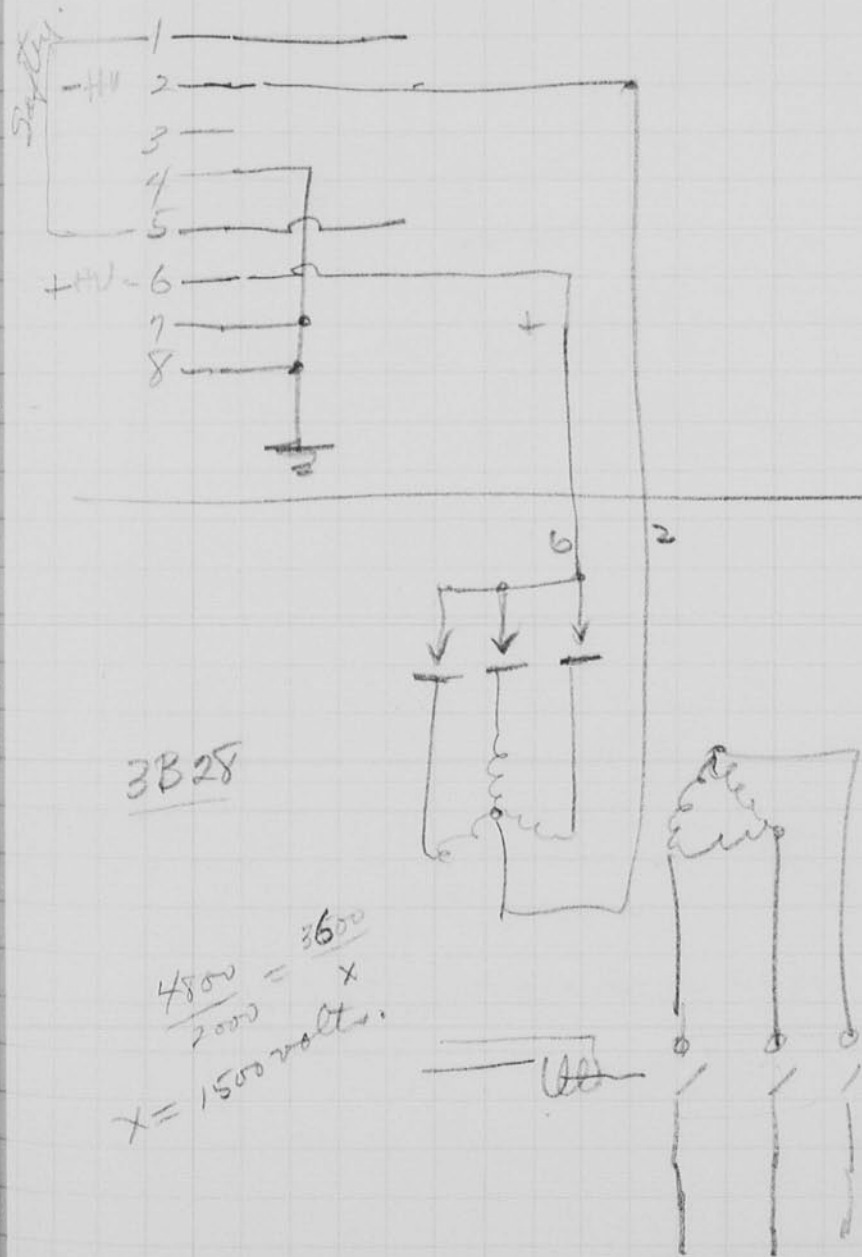
$$= 1300 \times 10^{-6} \frac{3600}{5 \text{ sec.}}$$

$$i = 0.8 \text{ amp.}$$

for 3B-28

(arg. 1/4 amp 10,000 microsec)

Use 6 tubes in
Parallel 3 phase
1.5 amp out per
4KV. = 6kw.



3B28

$$\frac{4800}{2000} = \frac{3600}{x}$$

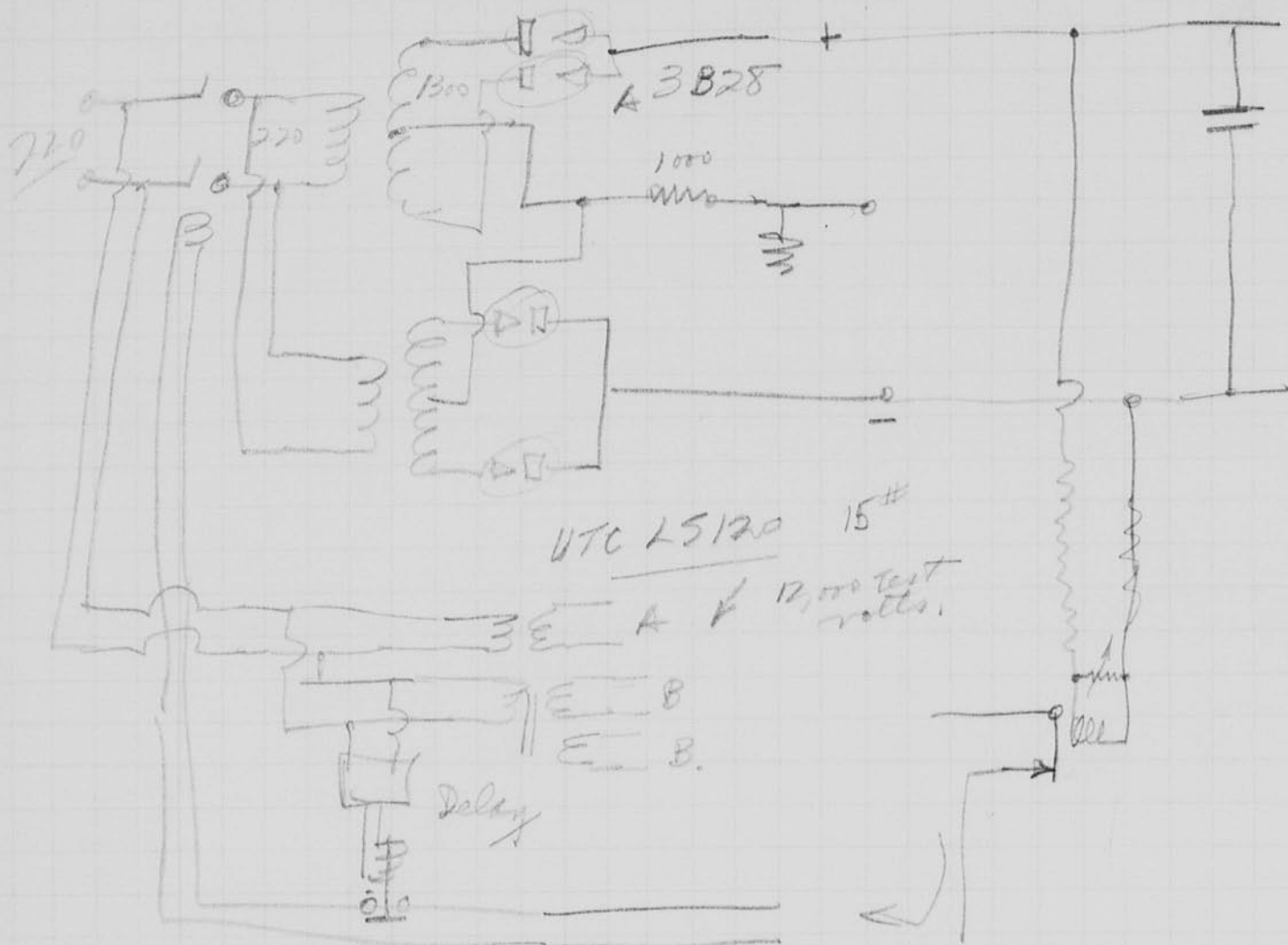
x = 1500 volts.

30 240V

E = 1500 V
E = 2600 V
line to line.

Chicago P1240 150 D.C. mils

~~1150~~ 1425. 26# 360 VA cost \$39.50



another way.

Phototube and timer to activate the high voltage circuit.

~~UTC 1500 - 0 - 1500~~

UTC CG303 300 ma. 22# 1500-1235-0-1235-1500

Power Supply Capacitor

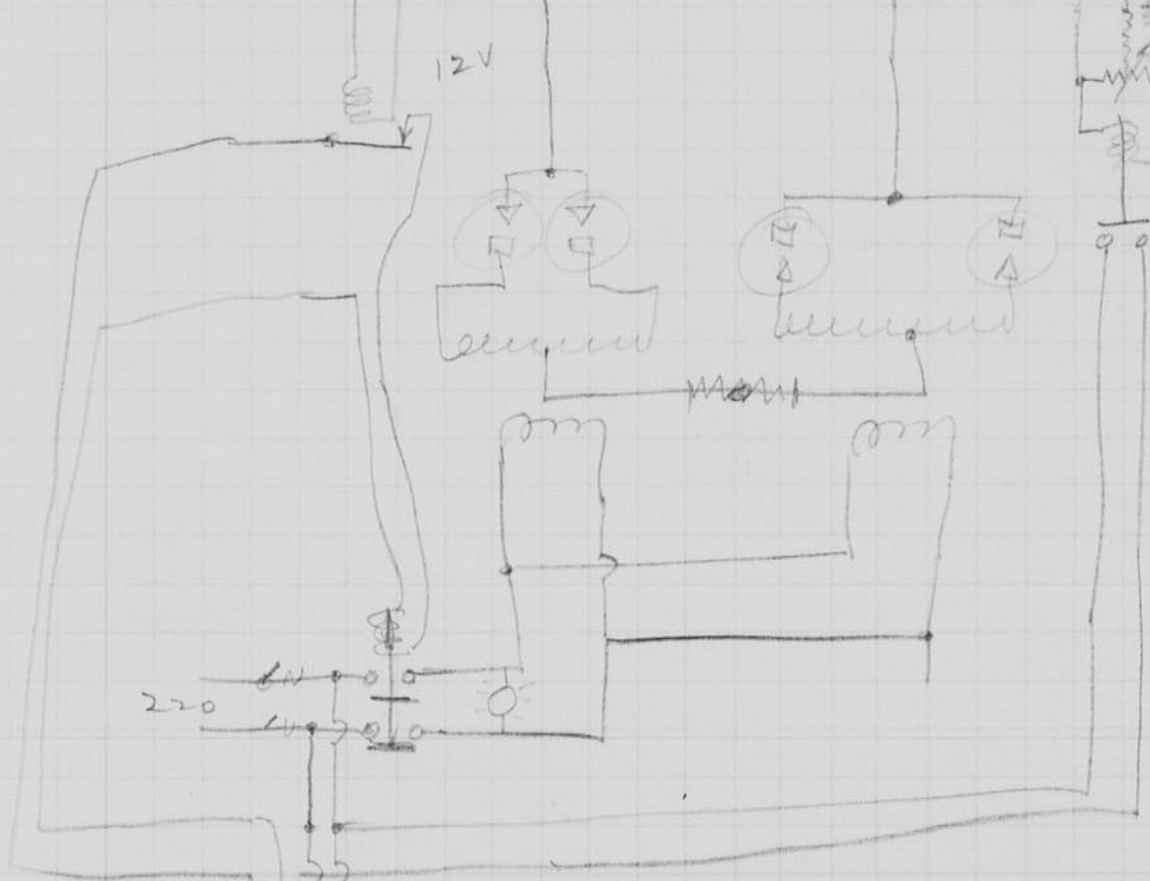
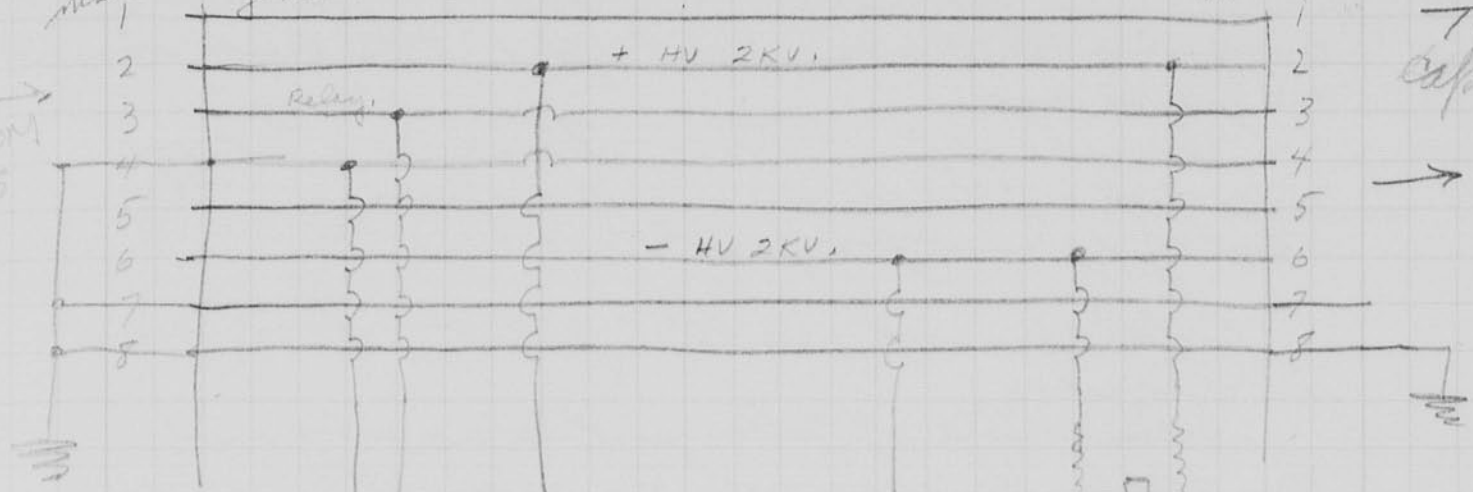
FROM P.S.

male
1
2
3
4
5
6
7
8

female

male female

TO Capacitor



220
140

FIL CRT.

TIME DELAY

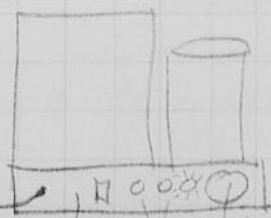
Ok if no holder
Should holdover come
put in break circuit.

F

220

SW. Fuse

Capacitor.



96 Feb. 21, 1956.

Propeller.

David S. Edgerton.

John Light called by phone tonight with further information on the 14 foot Bronze propeller that was lost off a tanker about 14 years ago.

This weights 18 tons. There is a \$28,000 reward by the insurance company. The cost of a new prop is \$51,000.

Capt Howard was the pilot. He is now in Florida.

John White of Cohasset was aboard the ship. He was not too cooperative with data.

The prop. was lost 500 yards from buoy # 1.

Light and I plan a cooperative venture to find the prop. He and his organization with the ship will take 2/3 of the reward. I get 1/3 for furnishing the detecting equipment.

We plan a camera survey first of the bottom, using a chart to accurately determine our position. The work will be done at night. Bob Hartman will help.

Drinner tonight with group at Harvard Business School

✓ Nick Reinhardt K17 4120

✓ Mike Sanyour PR 6 9174

Bob March UN 4 7159

✓ John Ersian

Elliot Novak

Len Stevens

✓ Edward Thayer

Jacques Boward.

General Doriot in charge of the course.

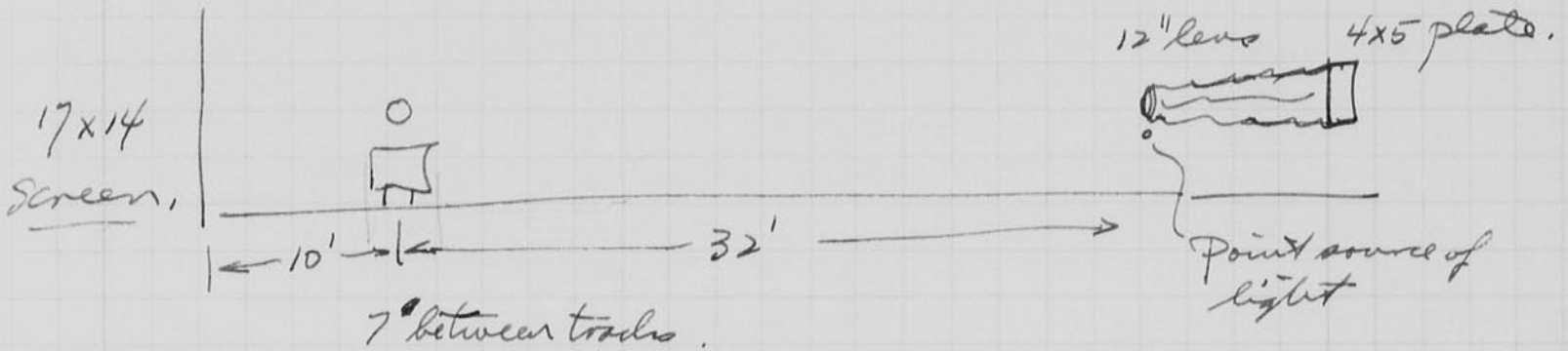
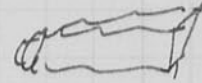
We then went to Balar to see a strok demonstration. It was very well done. From E.D.B. - Bretler, Johnson, Henley, Cadwolder, and I. —

Silhouette method of Photography.
for Holoman air base. See page 52.

Feb 22 1956. 97
Howard Edgerton



Scotch light
Screen.



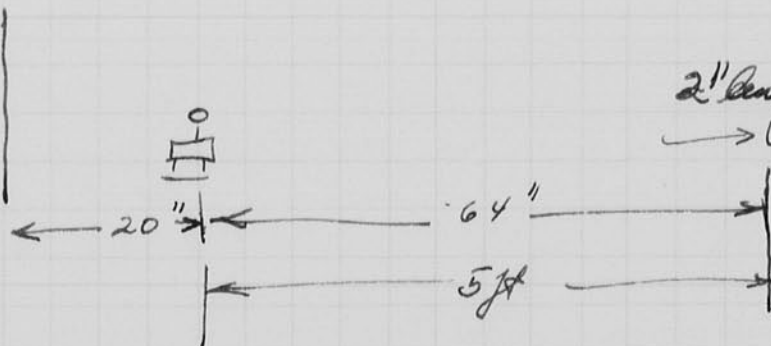
Model for test. - use 2" lens instead of 12"
Scale factor is 6.

$$\frac{17' \times 12}{6} = 34'' \quad \left. \vphantom{\frac{17' \times 12}{6}} \right\} \text{screen size.}$$

$$\frac{14' \times 12}{6} = 28''$$

$$\frac{10' \times 12}{6} = 2$$

34"
x 28"



$$\frac{32' \times 12}{6} = 64''$$

Notebook # 23

Filming and Separation Record

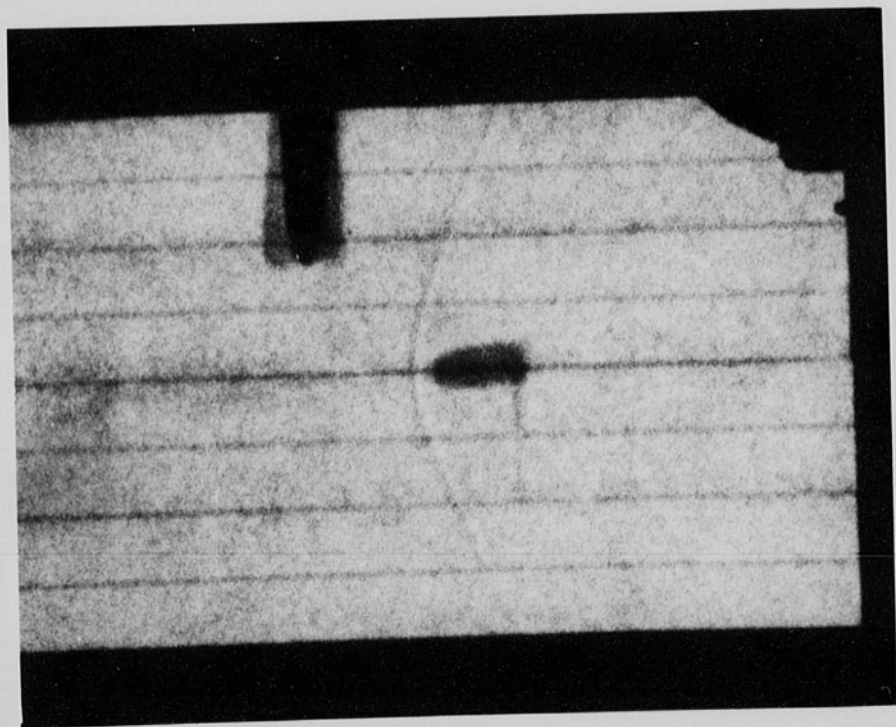
1 unmounted photograph(s)

 negative strip(s)

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

was/were filmed where originally located between page 96 and 97.

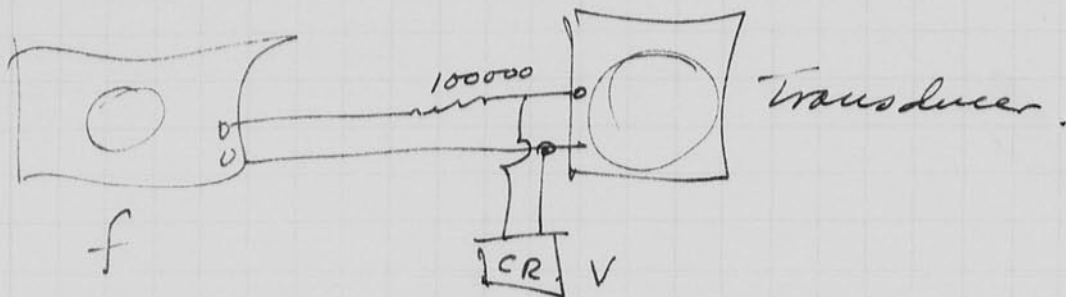
Item(s) now housed in accompanying folder.



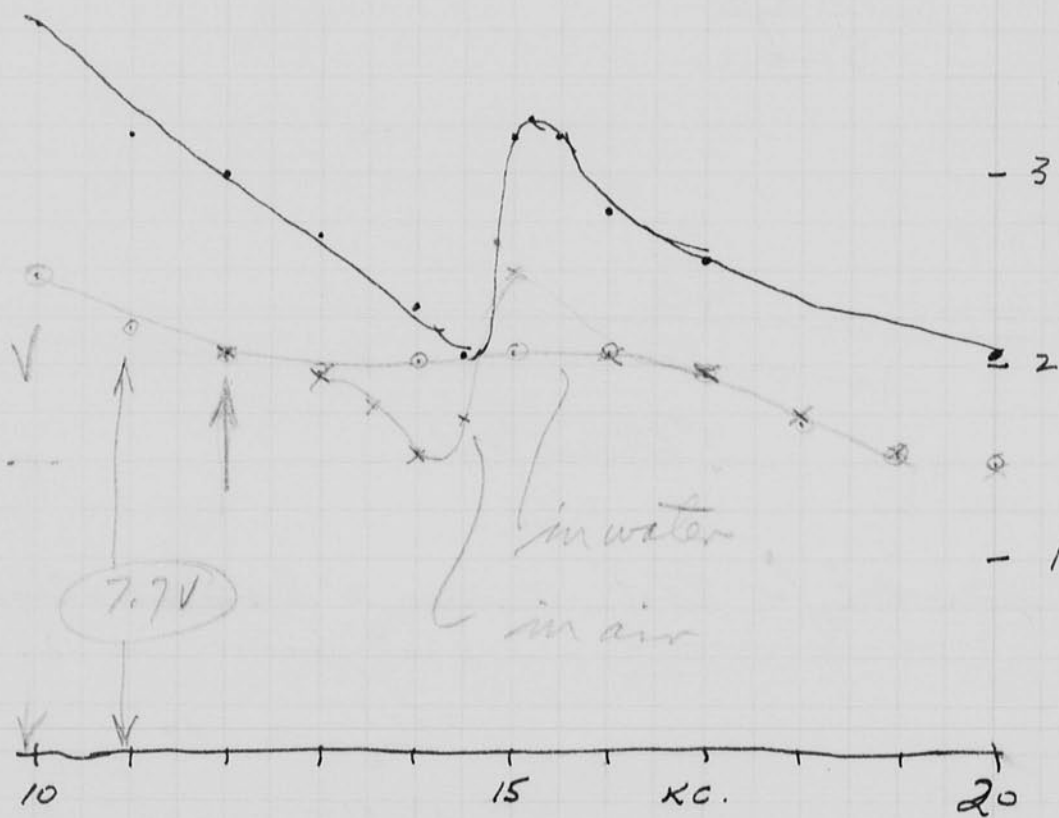
Edo

X20100 Special transducer

R of order 3.8 megohms.



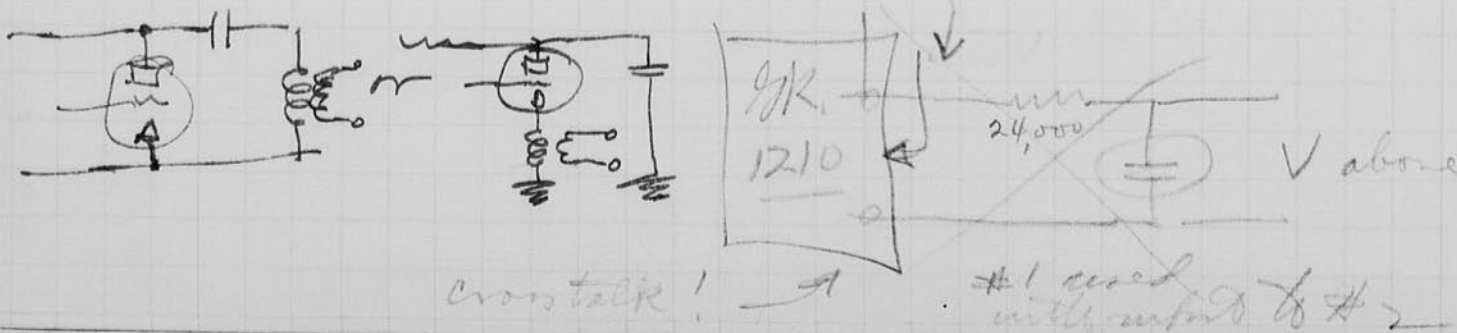
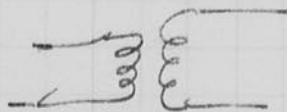
| f. cyc/sec. | V. Rel |
|-------------|--------|
| 20 | 2.1 |
| 17 | 2.6 |
| 16 | 2.8 |
| 15.5 | 3.2 |
| 15.0 | 3.2 |
| 15.2 | 3.3 |
| 14.5 | 2.1 |
| 14 | 2.3 |
| 13 | 2.7 |
| 12 | 3.0 |
| 11 | 3.2 |
| 10 | 3.6 |
| 9 | 3.9 |



1.4 μ m = 50V
 2.6 μ m = 60V
 50 x $\frac{2.6}{1.4}$

Partial curves made Apr 14 1956, on transducer using P.R. etc.

① Water
 ② air



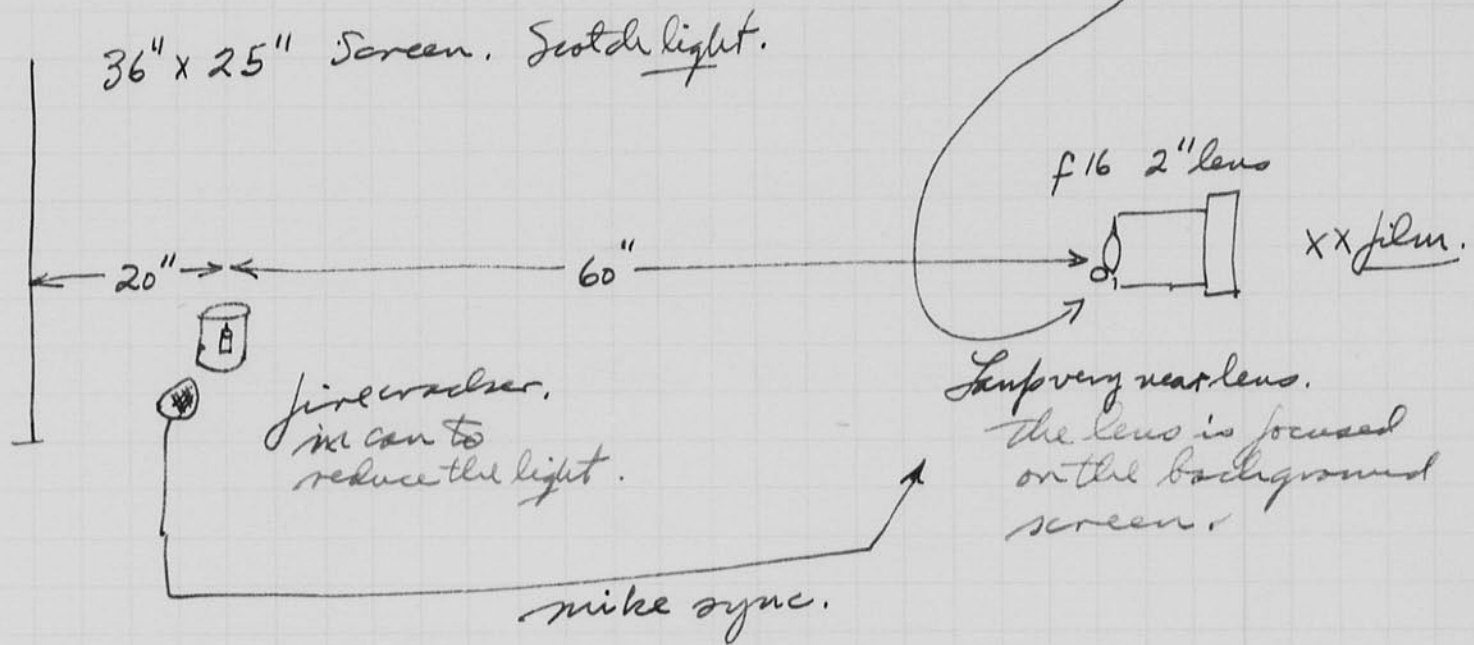
Tests

Date Feb 25 1956 99

James Edgerton

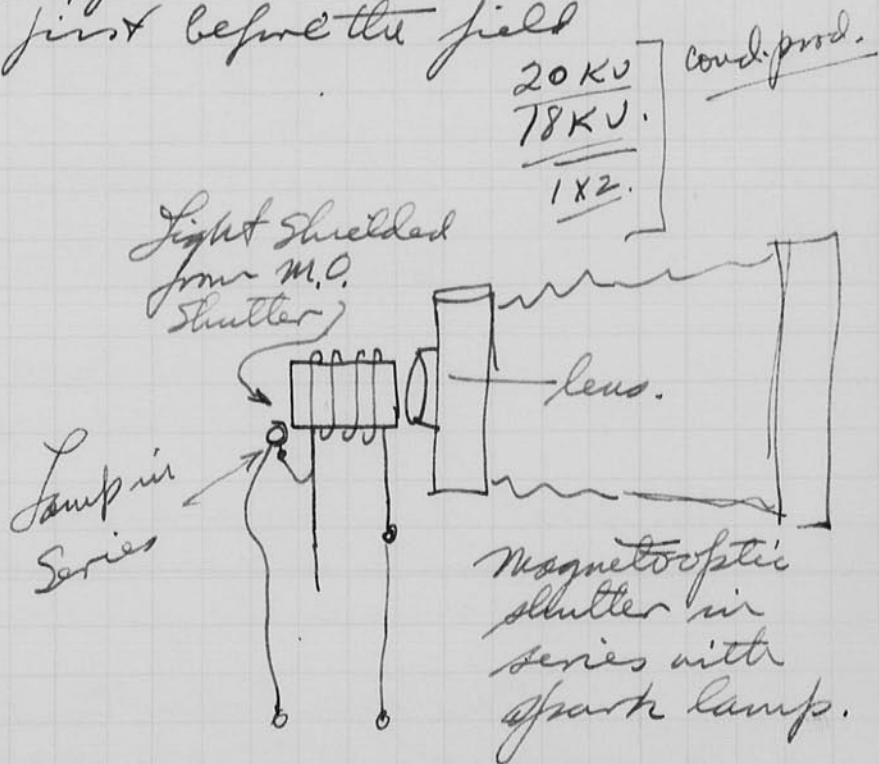
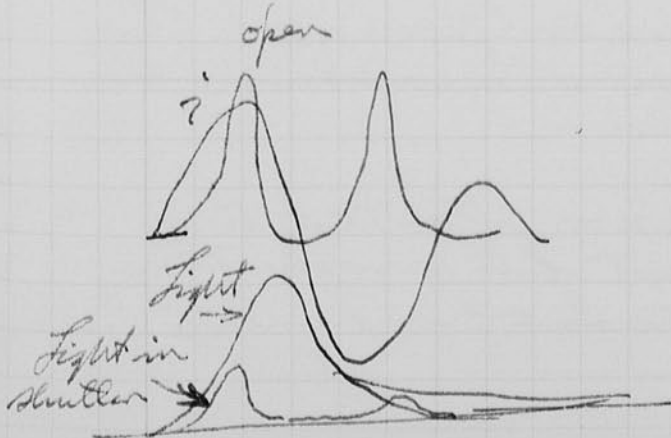
29 wedding anniversary

1/8" tube f16. as per page 99.
 .07 mfd at 2KV? into XP-2 flash tube.



this is a 1/6 modrup of the arrangement for the Holloman air base. Experiments will be made a reduced scale first before the field tests.

Revised & understood by me Mar 8, 1956 Peter A. Miles



Small Flash Lamp.

Comparison Sylvania 5413. 0.12 WS.
500 volts 1 mfd.

$$5413 \text{ Area} = 2.3 \text{ sq cm.}$$

$$\frac{0.125}{2.3} = .054 \text{ WS/sq cm}$$

$$\text{Small lamp, } .01" \times 2.54 = .025 \text{ cm}$$

$$\text{length } 0.1 \quad .25$$

$$\text{area} = .02 \text{ sq cm.}$$

Breen want watt sec .04 watt sec in
small lamp.

$$\frac{500^2 C}{2} = .04$$

$$C = \frac{.08}{.25} \times 10^{-6} = .32 \text{ mfd.}$$

XP-2 14

$$\frac{0.1 \cdot 2000^2}{2} = .7 \text{ watt sec}$$

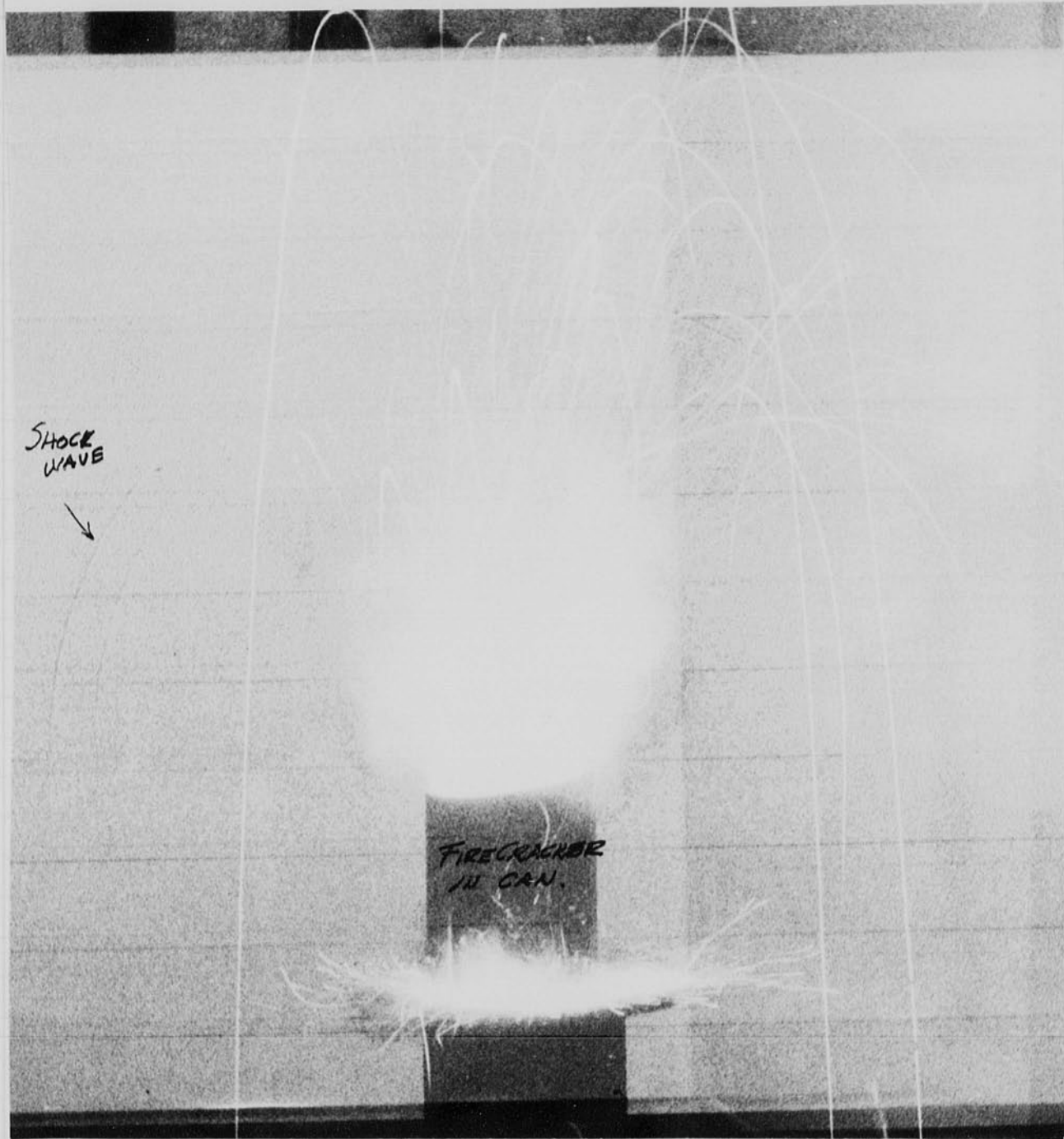
Above made during conference with John Breen and about a small light source for a digital computer device. I gave them two very small source tubes.

Xenon 0.1" long and 0.01" diam with tungsten electrodes.

Also an XP-2 type of tube with 10 cm of gas pressure.

The photo of the firecracker turned out very well. The shock wave is shown as it leaves the ~~metal~~ cylinder that surrounds the firecracker.

Bill Mac Roberts has now started the conversion of the 20 flash unit for production. ~~Dr~~ Des Hausen sent a manover from E.S.&B. to help with the work.



Shock wave from firecracker. Taken with
the set up of page 99.

Silhouette of subject with shadow of
shock wave on the background.

Mar. 5, 1956.

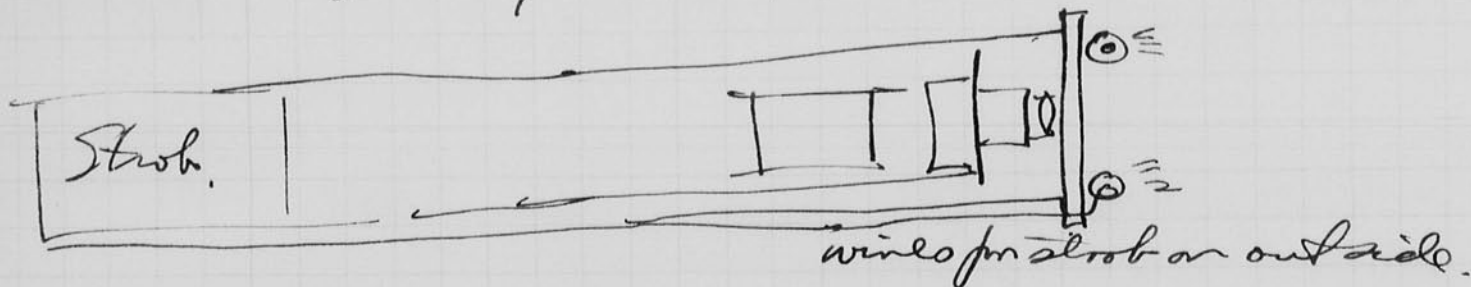
David Edgerton.

Geo. LeCompte started working again with me full time. David Ray Swanson will be busy on the 5 flash equipment for the magneto optic shutter!

A few shadow photos were taken last Sat with a set up similar to that of page 99. The subject was a 22 caliber bullet in flight. I could see the shock waves on the front of the bullet silhouetted against the back ground screen.

Mar. 7, 1956. A Mr. Biladeau came in Monday with a brass box camera for use in a gas well. I showed him my deep sea cameras which took his fancy at once. Since then he has stayed in Boston and is helping us to make a unit for trial.

Bill is working tonight on the affair. We are using two of the plastic encapsulated lamps on the front of the camera. An 18 RPM motor is being used to get a 2 or 3 sec cycle ~~light~~ time. We are using 25 mfd in each lamp, at 450V.

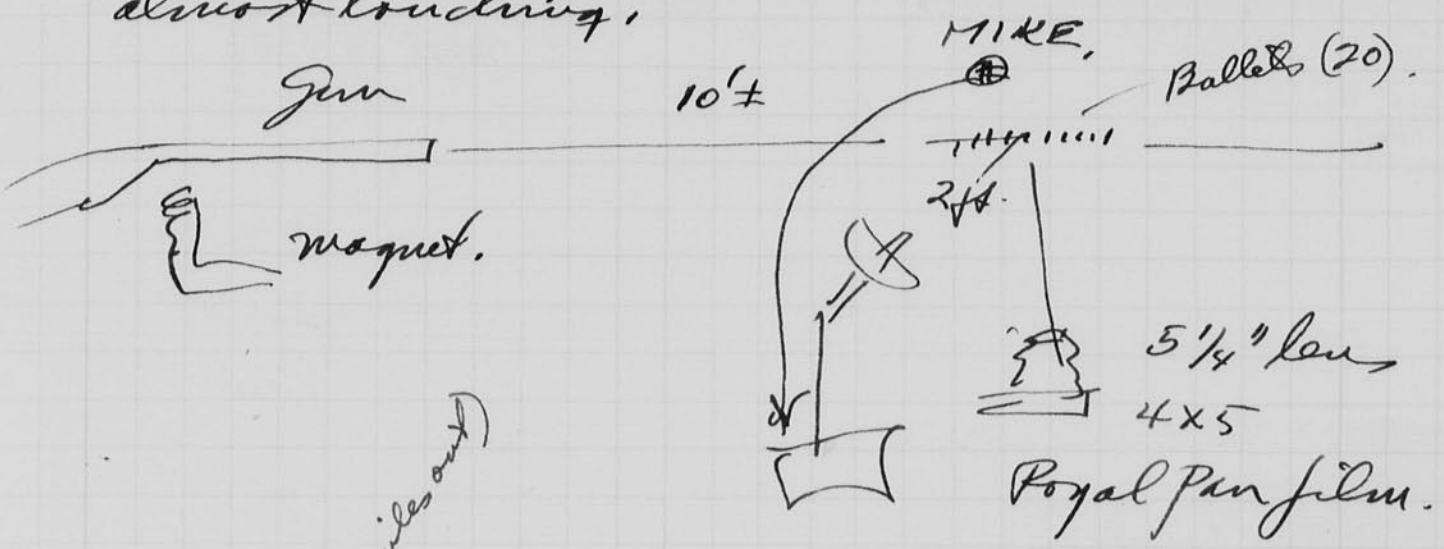


this unit will fit into Bilbo's gadget that goes on the end of the cable into the gas well.

Biladeau

Bill finished the 20 flash unit today and saw trying it tonight on bullets. The device runs ok ~~at~~ 100 KC.

22 cal bullet at f8 and f5.6 with lamp in spherical reflector at back position (wide beam) Photos at 33, KC show bullets in steps and almost touching.



March 10, 1956.

Worked with Bill today on the 20 flash. Changed tube # 6. which was missing tube # 12 was missing on the last tests. This tube seems ok now.

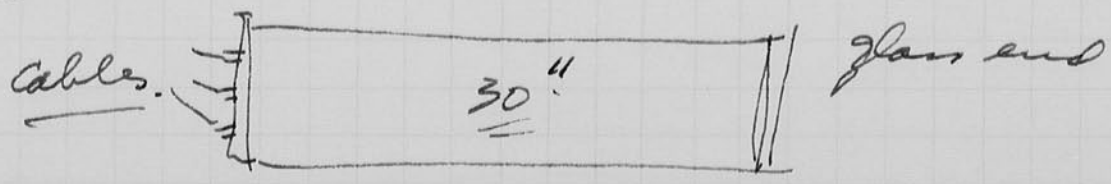
W.J. Biladeau
Windsor Mass.
also north Adams.
Remond Pa
Star Route
Kettle Creek
Dorsey Calhoun
20 miles out

Biladeau took the camera yesterday afternoon. It had two plastic impregnated tubes in the front. Exposure at f5.6 seems ok in a pipe on Trix film.

This will be tried in our ~~old~~ well in Pennsylvania where there is trouble in the drilling.

Conference yesterday at EGBG 160 Brookline Ave Boston on the servito meter, Clark, Dennis Randolph, Edg. Wychroff. Plan to complete the model for final tests.

Light and Hartman came in to discuss television casing. I suggested a glass case.





Phi Mu Delta
 Club Polaroid
 for Carnival
March 10, 1956.

Plotted from
 John Debes
 Ronald Karley

Jimmy Boylance
 Marty Wickel
 Jim Statterly
 John Crews.

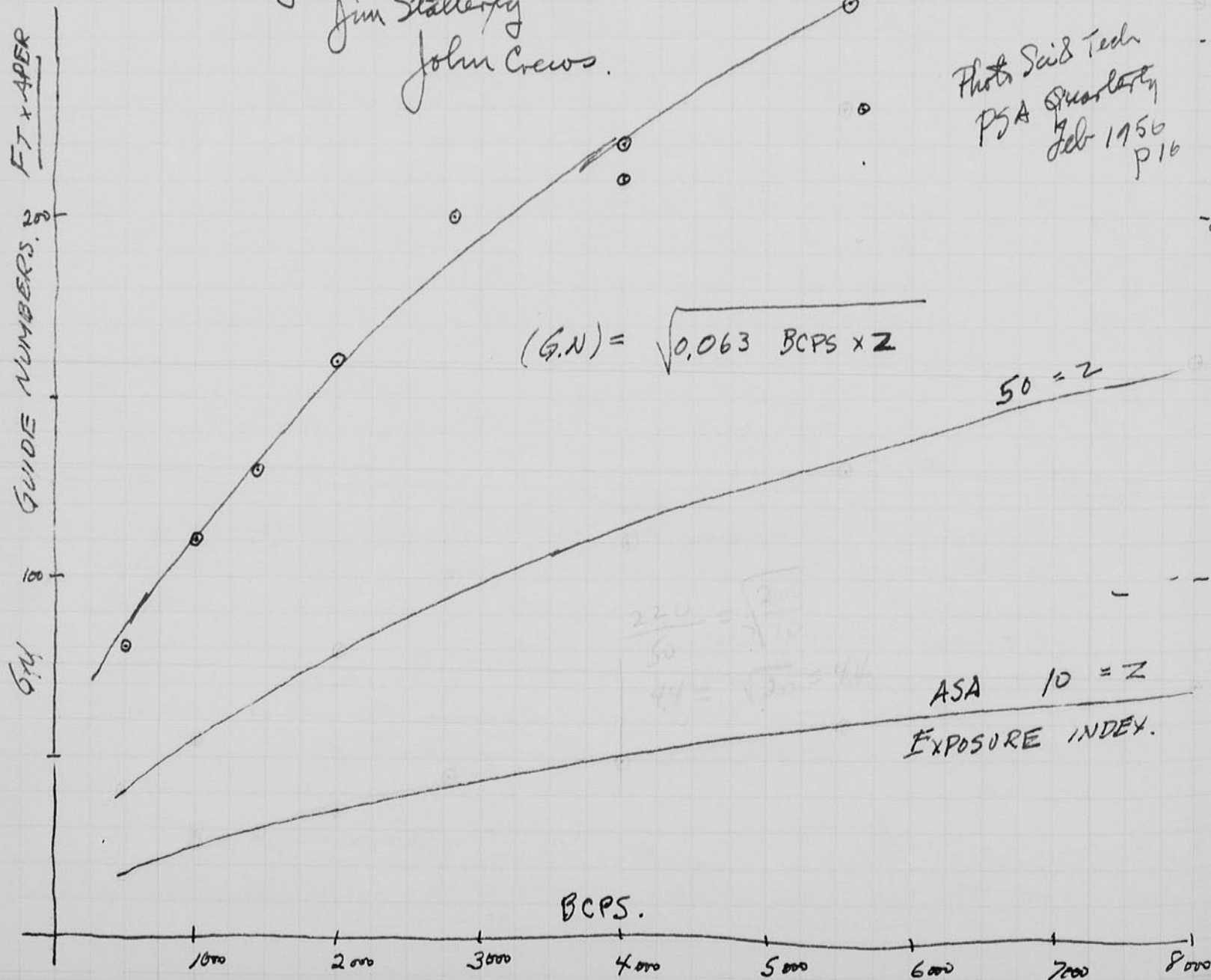


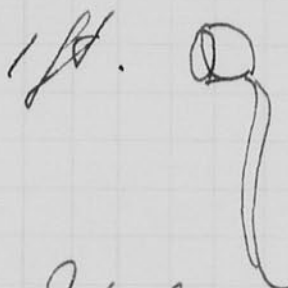
Photo Sci & Tech
 PSA Quarterly
 Feb 1956
 P16

Mar 15 1955 Sonar output.

Camera as used in Ocean. 1955.

Experiment in air

Sonotone battery 6 volt 5 cell.



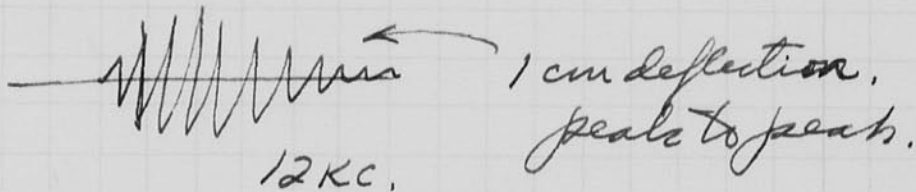
JT-30 ceramic
mike.

Input #1.

.035 volts = 1 cm.



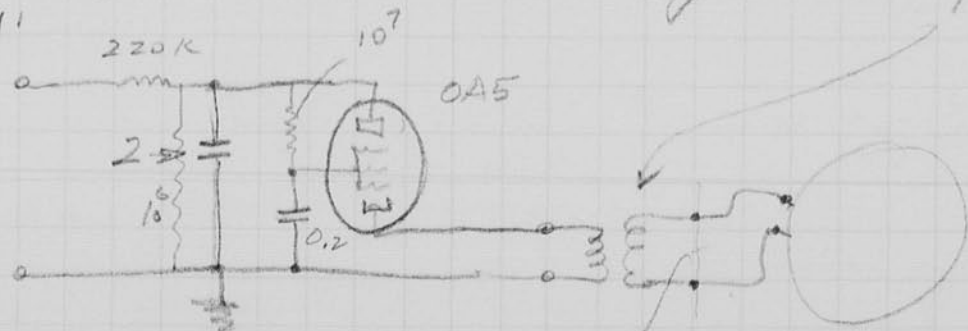
513 D # 1180.



Brush Shure mike

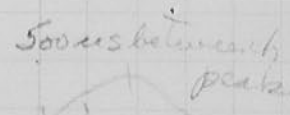
at 1 ft Signal peak to peak = 0.8 volts.

Sat
March 16 1955. New transducer EDONO X20100 connected
Snow Storm to driver with transformer 1/2 3131 B13
yesterday!
Prod!
T. 70175-1



| | | |
|-------------------------|------------|---------------|
| $L_s = 295 \text{ mh.}$ | $DQ = 4.4$ | 1/E T 70175-1 |
| 0.75 mh. | | V 11825 |
| $= 2.9 \text{ mh.}$ | 4. | 292-1388 G1 |
| 4.1 mh. | 5.3 | 292-1388 |
| 1.0 h | 3.8 | 15/1 ? |

Sec shows →
Sec. Inductance
and capacity of crystal are too
low in freq.



Sec SF
11
Newtn

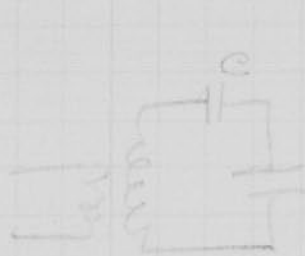
Pri. 4 - 1 Sec.

4/E T70481-2 400 mh, L_s
 4/E 3163-81 210 mh,
 T70150-1

Phone to Geo Rand. Mar 22 56
 Suggests contactor into series L.R. circuit. or Strobotom.
 Transformer has 7000 mt.
 Requires 24 mh.
 D.C. Resistor 3 meg. → 1 meg.

This transformer has too high a secondary inductance since the sec and 1 crystal oscillate at

10,000 cycles
 $f = \frac{1}{100} = \frac{1}{4} = 2,500 \text{ cycles.}$
 MS.



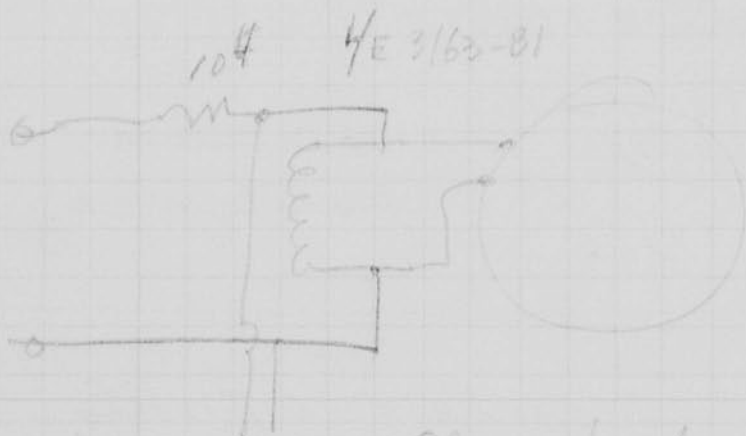
$$2\pi\sqrt{LC} = \frac{1}{12,500} \text{ sec}$$

$$C^2 = \left(\frac{1}{12,500}\right)^2 \frac{1}{(40) \cdot 10^{-6}} = \frac{1}{1.6 \times 10^5}$$

$\frac{10^8}{40} \cdot \frac{1}{1.6} = \frac{1}{1.6 \times 10^5}$

$$C = \frac{1}{1.3 \times 10^4} = \frac{10^{-6}}{.013}$$

$$= 80 \times 10^{-6} \text{ farads}$$



at 5600 cycles

$$\frac{2.9 \cdot 10^4}{2.55 \cdot 10^4}$$

Scope shows peak at 5600 cycles
 Increases 20% when 104 ohms is shorted.
 ±
 Also small peak at 15.2 KC. due to crystal.

4/E T-70173 has resonance at 56000 cycles open air

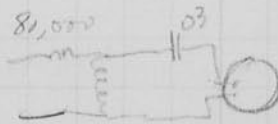
+ E00 + X20100 " " 46000 cycles

X20100 has peak alone at 15000 ±

Series, C3 coil with X20100 and trans 5000.

.0015 " " " 11,000

.001 " " " 11,600

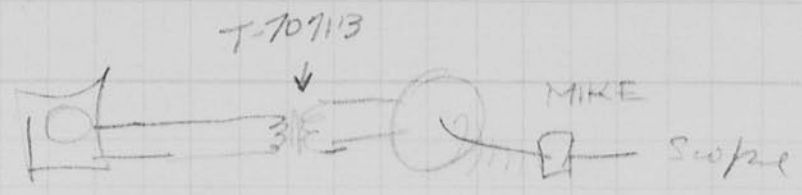


tried with pulser - one pop then the capacitor shorted (1000 volt rating)

$$T = \frac{1}{f} = \frac{260 \times 10^{-6}}{3}$$

$$f = \frac{3}{260} \times 10^6 = \frac{260 \mu s}{3 \text{ cycles}}$$

$$26 \overline{) 30} \\ \underline{26} \\ 40 \\ \underline{26} \\ 140 \\ \underline{130} \\ 10$$



peak at 17.6 and 14.9 Kcycles, also at 3200 strong.

~~$$3200 = \frac{1}{2\pi\sqrt{LC}}$$~~

~~$$(3200)^2 \cdot 10 \times 10^{-6} = \frac{1}{(6.28)^2 \cdot 2 \cdot C}$$~~

~~$$C = \frac{1}{10 \times 10^{-6} (40) \cdot 3} = \frac{10^{-6}}{120} = .008 \times 10^{-6} \text{ farads crystal.}$$~~

desired $f = 4500$

$$20 \quad C = \frac{1}{(4.5)^2 \cdot 10^6 \cdot 40 \cdot 3} = \frac{10^{-6}}{240} = .004 \times 10^{-6} \text{ farads.}$$

$$\begin{array}{r} 40 \\ 40 \\ \hline 220 \\ 180 \\ \hline 40 \end{array}$$

$$2\pi\sqrt{CL} = \frac{1}{12,000}$$

$$(6.28)^2 \cdot .004 \times 10^{-6} L = \left(\frac{1}{12,000}\right)^2$$

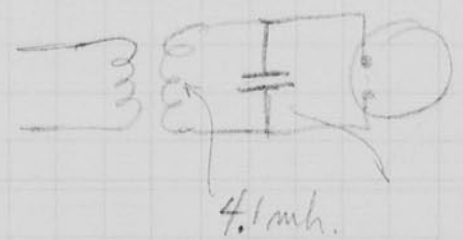
$$L = \frac{1}{(12,000)^2 \cdot 6.28^2 \cdot .004} = \frac{1}{24} = .04 \mu h$$

$$\begin{array}{r} 1.44 \\ \cdot 16 \\ \hline 23.04 \\ \underline{10} \\ 13.04 \end{array}$$

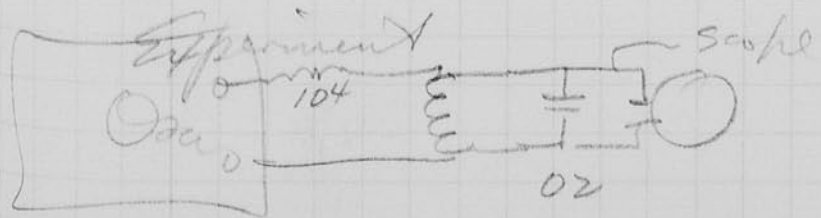
$$CL = \left(\frac{1}{12,000}\right)^2 \frac{1}{(2\pi)^2}$$

$$C = \frac{1}{(12,000)^2 \cdot 2\pi \cdot .004} = \frac{10^{-6}}{23.0}$$

$$= \frac{144}{23.04} \cdot .16 = .04 \times 10^{-6}$$



4.1 μh.

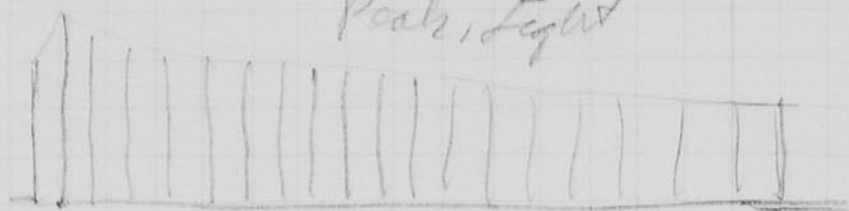


Resonance at 12.8 Kc, (also perfect at 15.2) Kc.

Cont
Mar. 17, 1950 20 FLASA. UNIT.Sawyer
ReportTest made at 100 KC - Some irregularity
of peak light.

Test at 10 KC.

Peak, Light



$$\text{Peak light} = 5 \times 10^5 \text{ cps}$$

$$\text{Duration} = \frac{10^{-6} \text{ sec}}{1}$$

$$\text{CPS} = 0.5$$

$$\text{input} = 1.5 \text{ WS} = \frac{.03 \times (10^4)^2}{2} = 1.5 \text{ WS}$$

No Read,
C/S
9/36000

Mar 22 1956

Multiflash Magneto optic Shutter

David E. Edgerton
Leo La Compagnie
Ray Swansen.

Blue rotation *off*, with first lens
then went to Red rotation.

8 TURN S.#
copper

oooooooo

↑
1"

HOLE

↓

oooooooo



3 glass slugs 0.6 = 1.8" length.

"Pemberton" glass.

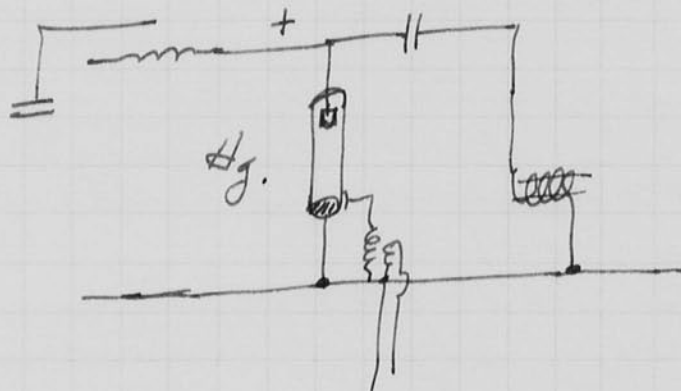
Capacity 0.3 mfd.

Voltage 20. KV.

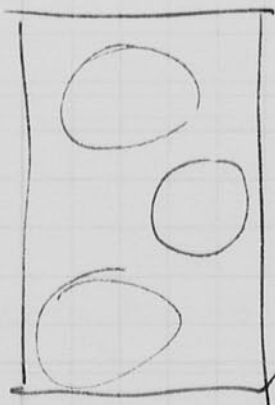
W.S. = 60 W.S. 5 flashes.

= 300 W.S.

0.3 20KV.



Secondary coil to a
flash tube FT-118.



March 31 1956

April 1, 1956 Easter Sunday. There is 2 feet of snow on the ground!

David Grogan.

I left by car (P13380 was Plymouth Station Wagon) on Sat. Mar. 24 for Newark airport to take the Eastern plane for Charlotte N.C. to see my daughter Mary Lee Dixon and family. The going was rough by auto since a 10 in. dr. snow storm was in progress. However I did make it. The 20 flash unit was in the back seat of the car for delivery to the Army Chem center at Edgewood Maryland.

Monday - Returned by train to Newark from Hickory N.C. Visited Sam Pogin at Picatinny Arsenal. Dover N.J.

Gave talk at Lever Bros Research plant at Edgewater N.J. at 4:30 pm. Movie of Underwater and of nuclear explosions were shown.

I drove to Chad's Ford Pa to spend the night with my sister Margaret Robinson and family.

Tues - am Saw Winston Johnson at the Mech Division at Dupont. Wilmington.

Tues aft. at Aberdeen met to see Kent and several other people.

Wed. delivered 20 flash unit to Army Chem center. Heard lectures at 10 am by Odell, Stuart, Jameson, Peterson, and Maheary. on body armor developments.

Thurs Mar 27. ~~Had~~ Ran the 20 flash unit on tests. David Grossman is in charge of the instrumentation section.

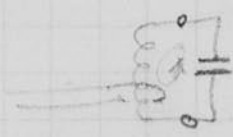
Friday - again visited Aberdeen then picked up my son Bill in N.Y. Bob is home from Uni of Rochester. now a junior. He will be 21 in May!

Sec Inductance H/E transformer T70173-1
3131B13

320 mH.
Q = 4.4 DQ.

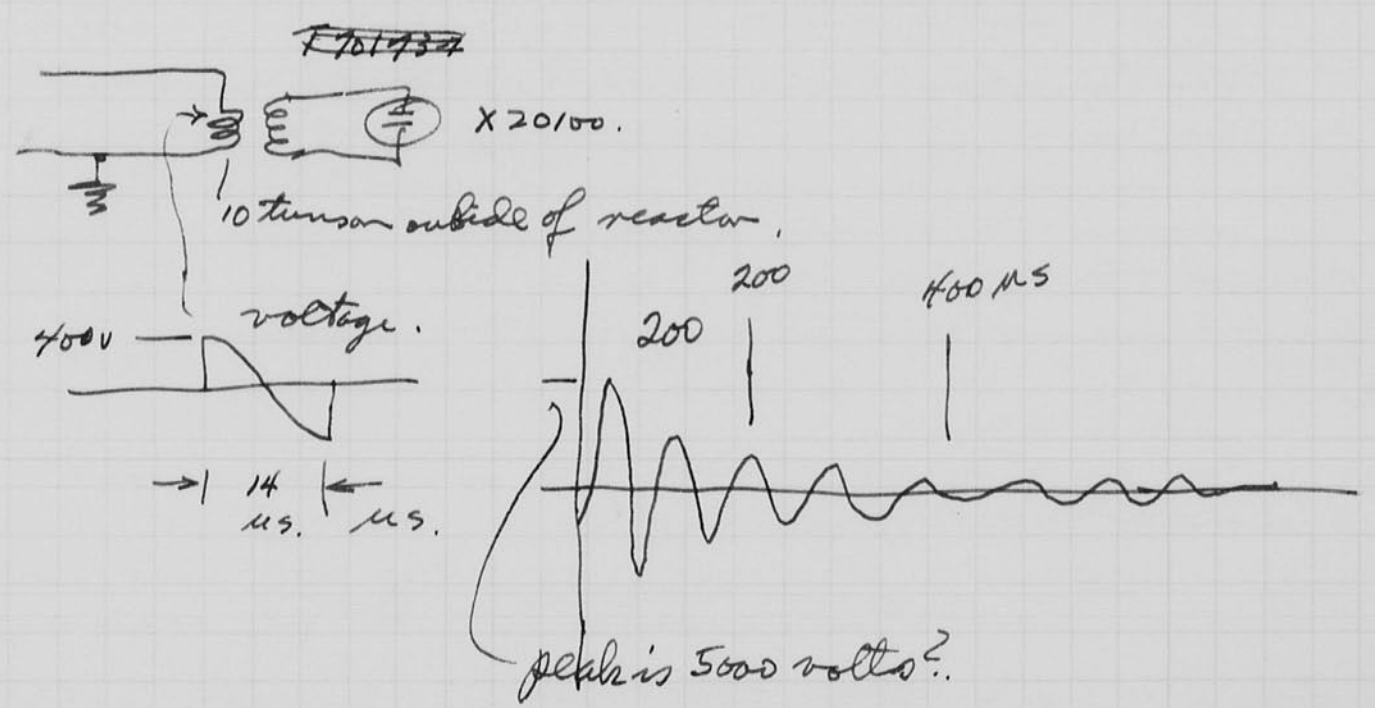
Trans 292-1388.

Sec. 44 mH.
Pri 40 mH.



Open coil
with loose square

27. MHz. This shows
Resonance with
Edo Transducer
at 12 Kc. X 20100



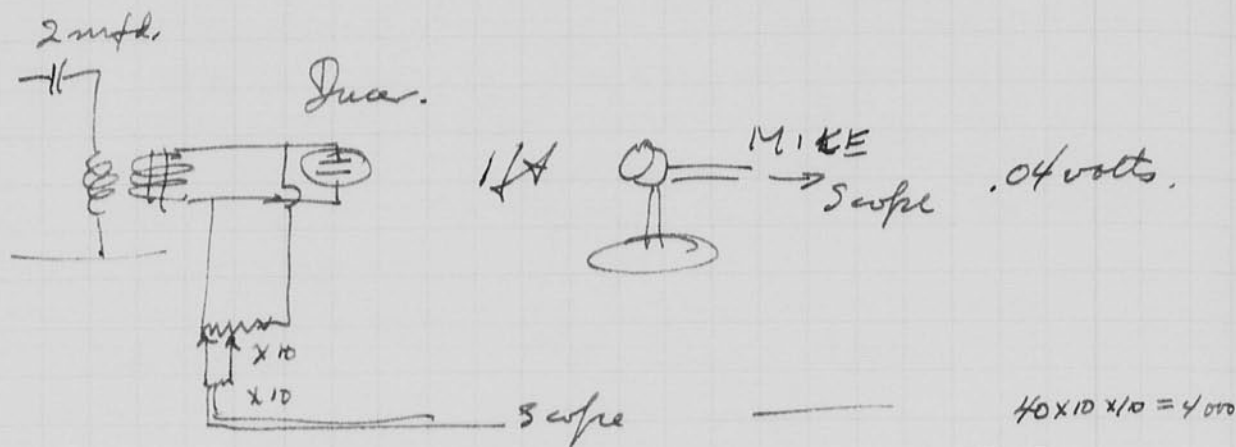
112 April 7 1950.

David Edgerton

53 years old yesterday!

Transducer experiment.

continued work on transducer.



10 turns on old coil =

$20 \times 10 \times 10 = 2000$

20 turns - result about the same.

Old transducer as used last year gave about 1/2 the voltage but a longer pulse.

Inductance = 27 mh.

$f = 12000$

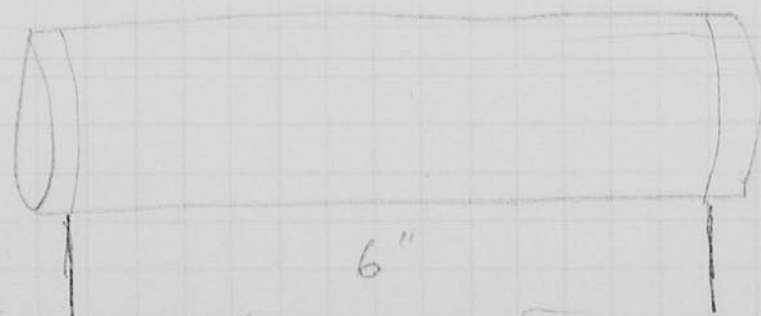
$\omega = 2\pi f$

$\omega^2 = 4\pi^2 (12000)^2 = \frac{1}{.007 \times C}$

$C = \frac{1}{.027 \times 10^6 \frac{144 \times 4\pi^2}{153 \times 10^8}} = .00654 \times 10^{-6} \text{ farads}$

#22
#25
28 far inches

$\frac{27}{16} = 1.6875$
2"



$F = .0072$

$L = F d N^2 \text{ microhenry}$

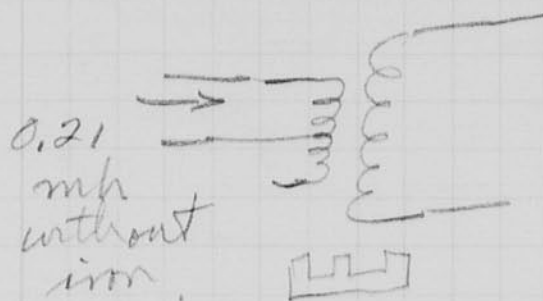
$L = .0072 \times 2 \times \frac{(28 \times 6)^2}{168} = 407 \text{ mh}$
(27,000 mh)
28,200

$\sqrt{\frac{27.1}{.4}} = \sqrt{66.3} = 8.15 \text{ layers}$

Transformer tests.

Apr. 13, 1956. 113

H.E. Edgerton



15.8 mh without iron.

Distance 2 ft. Crystal open Bush.
 $V = 0.4$ peak to peak.
 $P \approx 4$ cycles above $1/2$ way.

With old coil $V = 0.3$ peak to peak.

Apr. 14 1956

H.E. Edgerton

Ranging system for distance measurement.

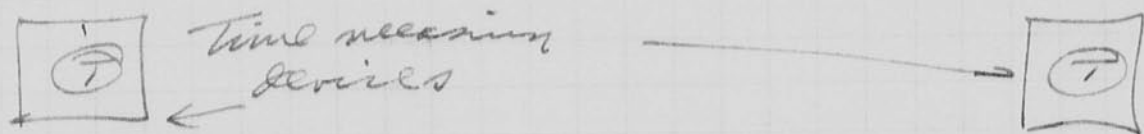
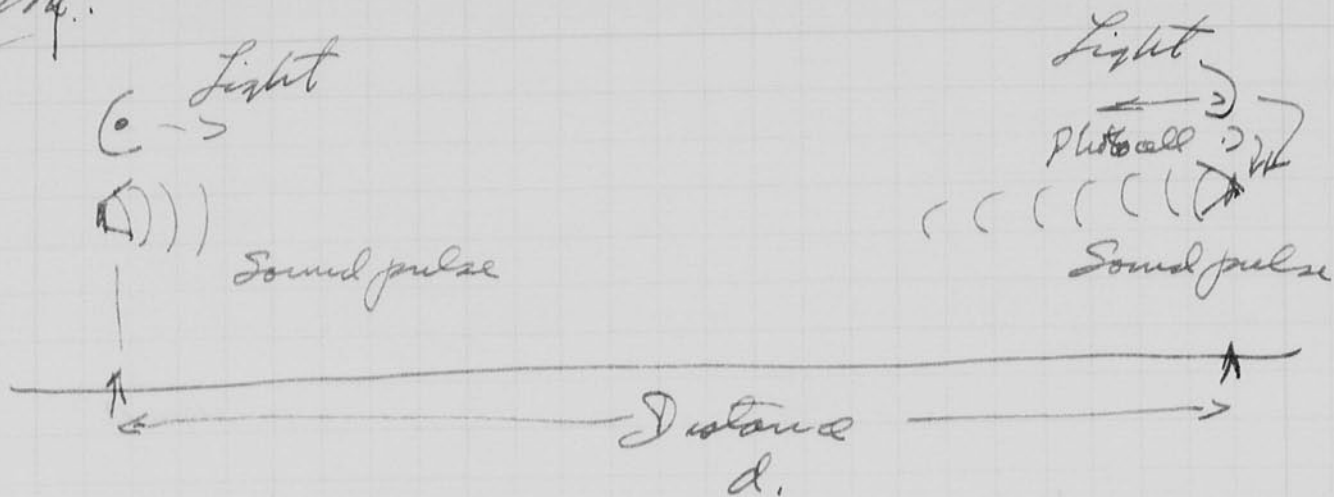
after there is a requirement for measuring short distances accurately. Radio pulses are out because of difficulties in generating high frequency pulses. Sound is inaccurate since the velocity of the air due to wind is bad. Also the velocity of sound varies slightly with temperature and pressure. Light can also be used, accurate measurement cause considerable difficulty unless a very good time resolver is used.

I was discussing the above systems at length with Mr. [redacted] of Stewart Warner Co. John Chicago who was brought in by Bauman of the M.I.T. Industrial Train.

One scheme occurred to me that might be practical. I propose two stations each with a stroboscope and a power generator. Radio could also be used to trigger the sound generators which are of the sound pulse type. An interval of time measuring system at each end would then measure the travel time. An average would be proportional to the distance when the pressure and temp corrections are put in.

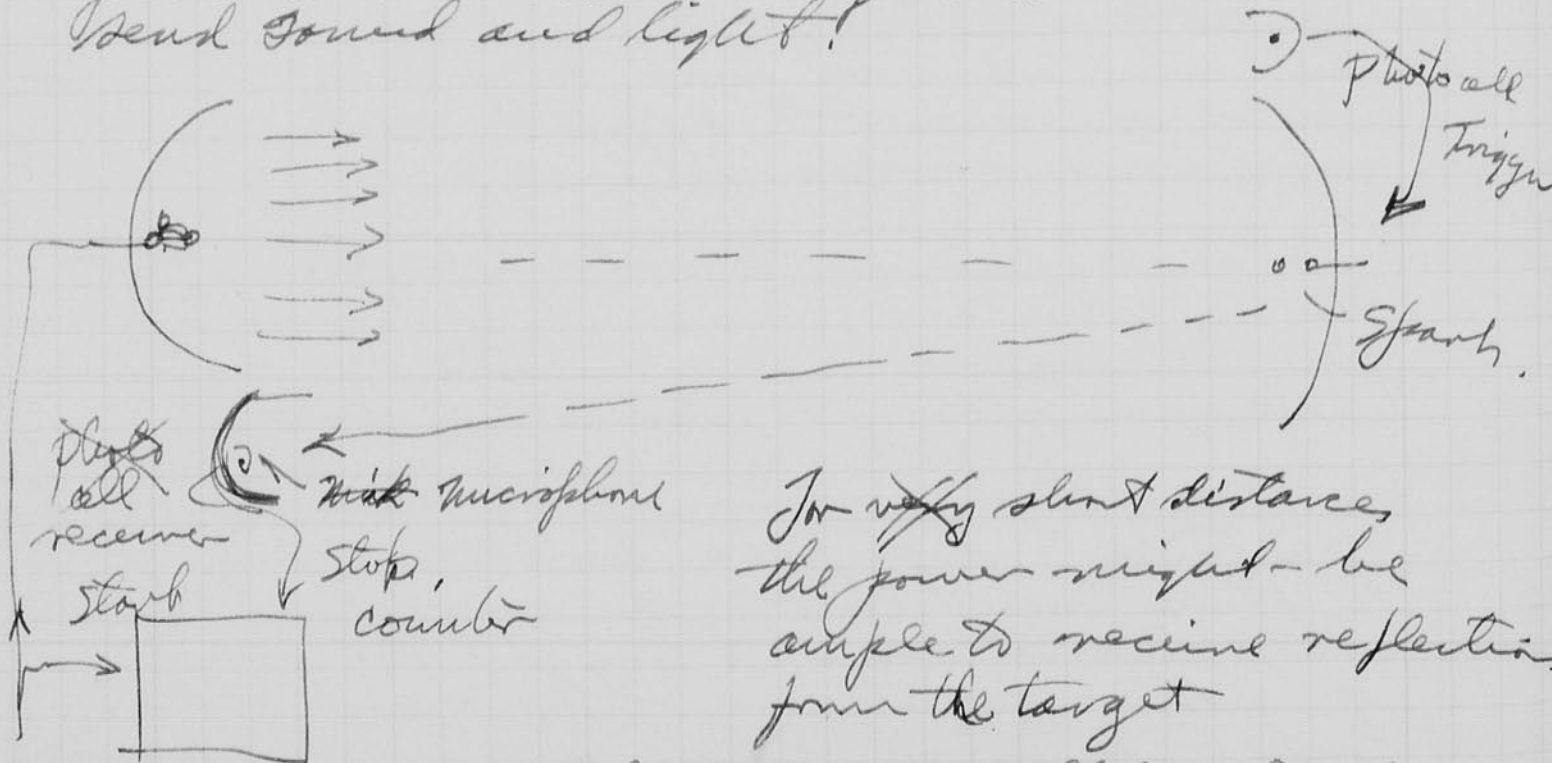
Cont.
H. S. E. S.

Distance measuring device



$$T = \frac{d}{v} \quad d = vT \quad v = \text{velocity}$$

I propose that a spark could be used both as a light source and as a pulse generator. The same reflector would send sound and light!



For very short distances the power might be ample to receive reflections from the target

The units should be identical so that either end can be a transmitter of the initial pulse.

Designed & understood
by me & my 15'6
Peter & Phineas

Apr. 17, 1956

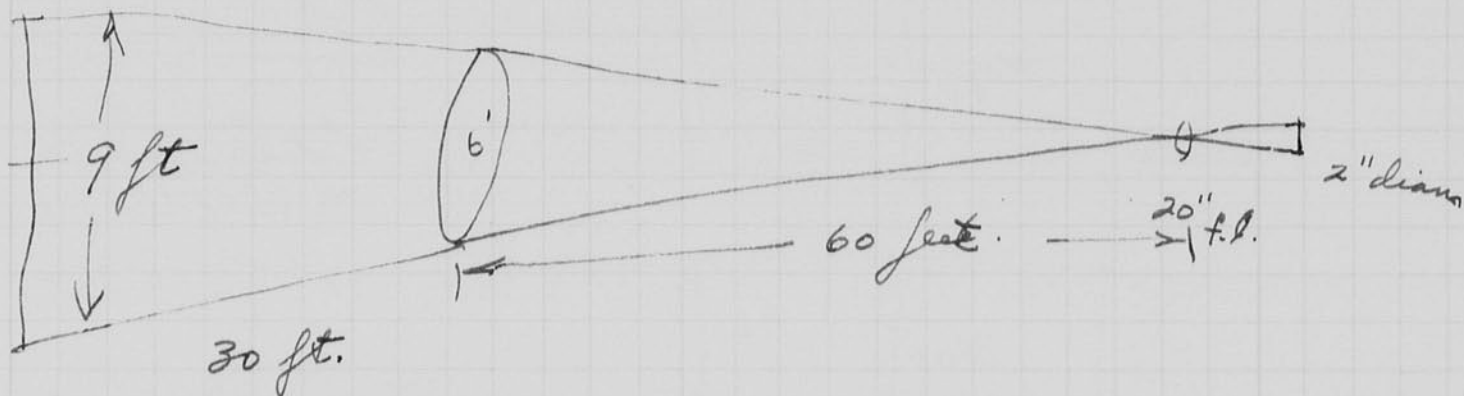
Hollowan setup.

Hewlett Packard

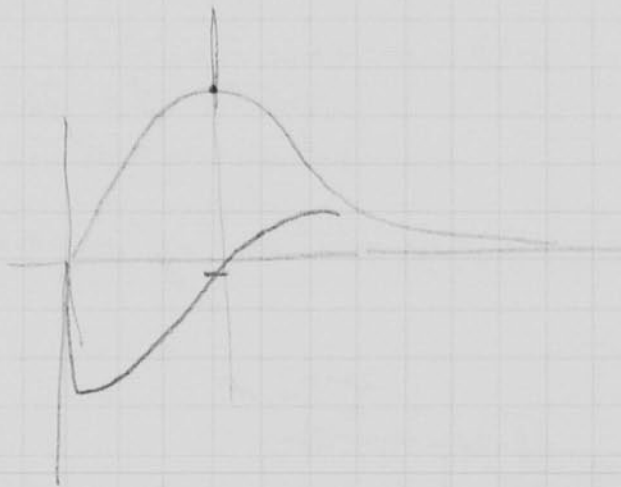
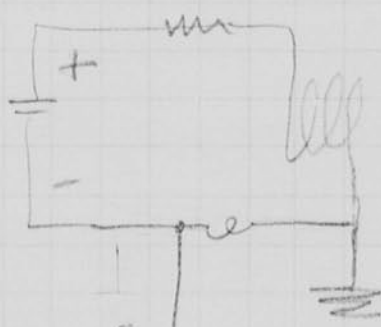
Sup 99 97.

Field of view = 6" diam

Try camera lens of 20 inch focal length.
1 inch diam slug.



Scotch light screen.



Sparks.



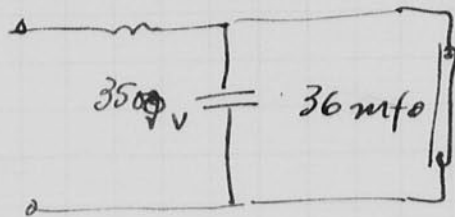
Ordered to +
understand of me
May 8 '56
Hewlett Packard

116 Apr. 21, 1956

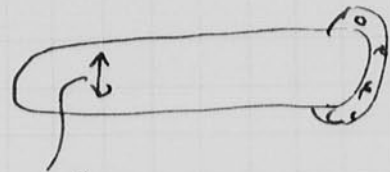
David Edgerton

Bill MacRoberts

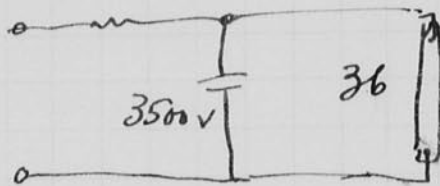
Roundy of the David Taylor Model Basin was here Apr 18 and Apr 20 to discuss design of the strob driver for propeller studies. He worked with Bill on the measurements, layout etc.



FX-1



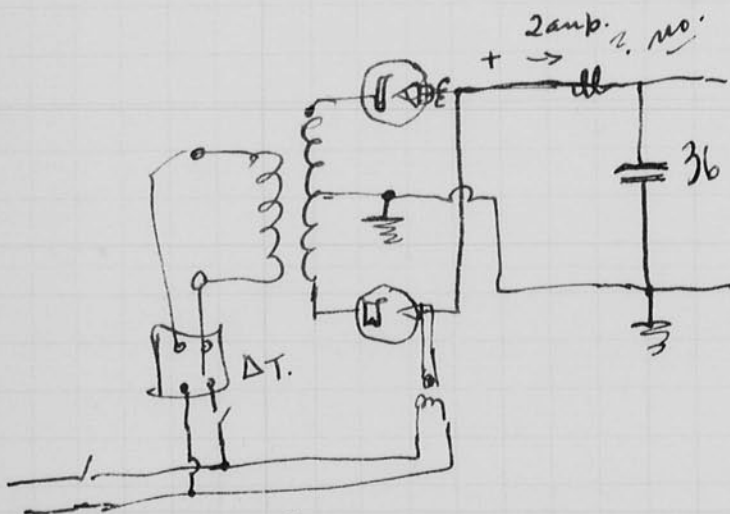
1" diam inside to hold the FX-1 flash tubes.



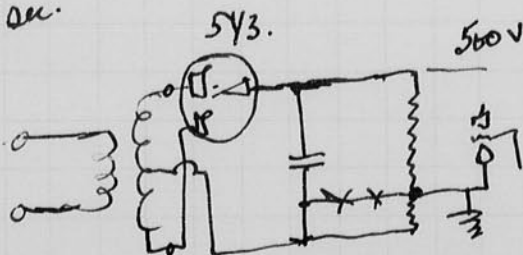
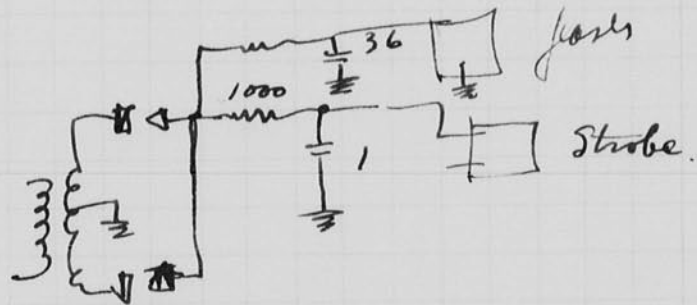
FX-1

also reconnected for strob at 1 mfd 3500 up to 30 flashes/sec for visual observation.

alternate set of outlets for surge flash.



DT 10 sec. or 15 sec.

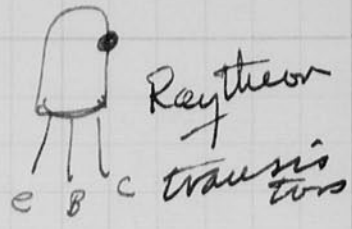
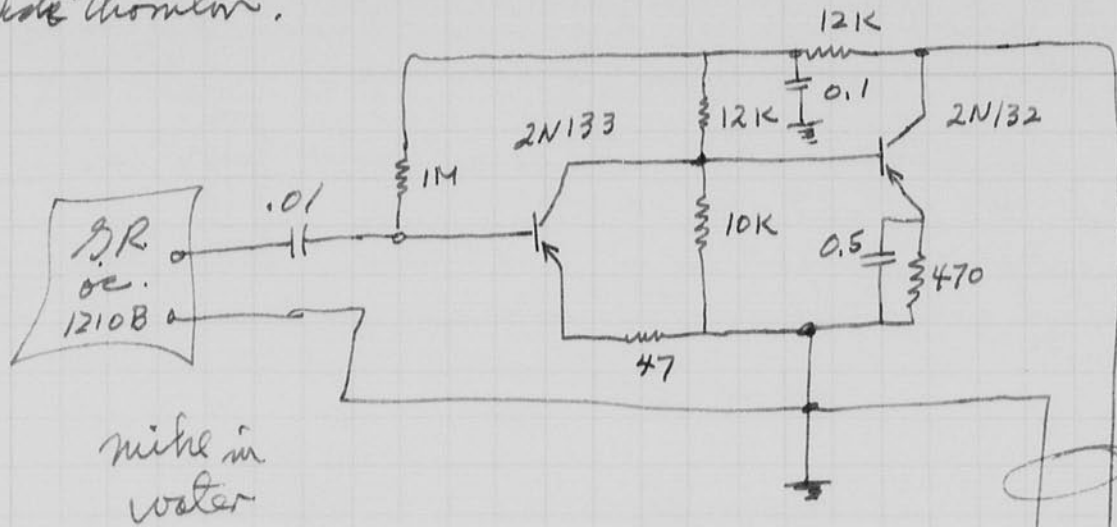


2D21

Transistor amplifier for Sonar.

April 22, 1956. 117

John Dick Thornton.

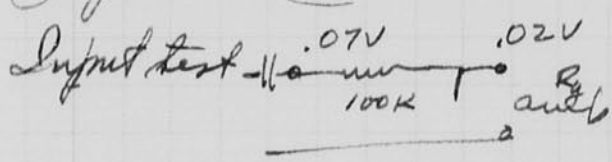


micro in water

amplifier in tube.

cable

Input = 0.005 volts.

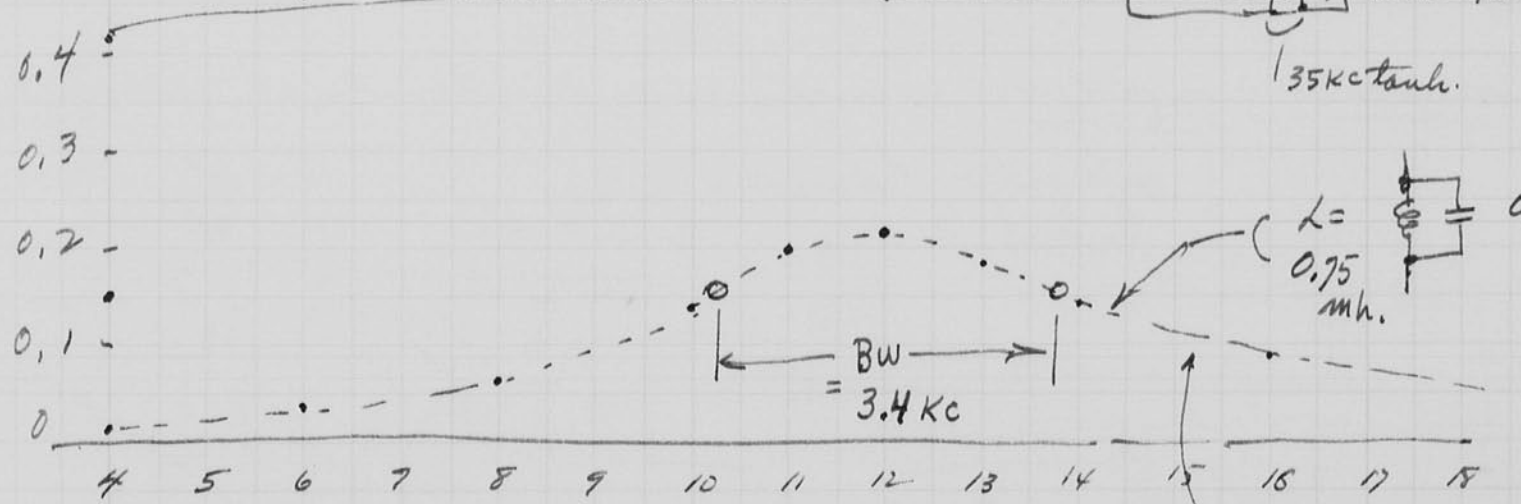


then $R_g = \frac{.02}{.05}$

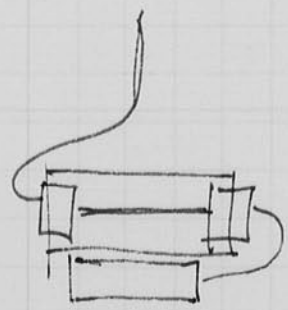
$R_g = 100K \times .4 = 40,000$

gain = $\frac{.46}{.005} = 92$

Volts output.



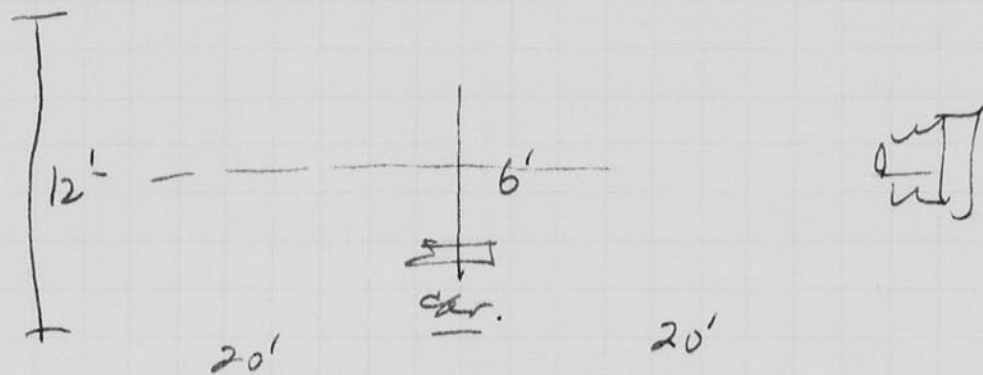
gain = $\frac{.22}{.005} = 44$.



April 26, 1956 Warner Houghton and Robt Phillips of
 G.E. Co Lynn came in yesterday about a
 photo problem of turbine blades during
 fracture. 60,000 r.p.m. = 1000 r.p.s.

LY 3-6000
 EX 2259
 4679
 G.E. phone no.

We discussed a drum camera and a
 gated 501 unit at 10 K.C.
 Sync might be a problem. They suggest
 a rapid overload on the air pressure on the
 driver.



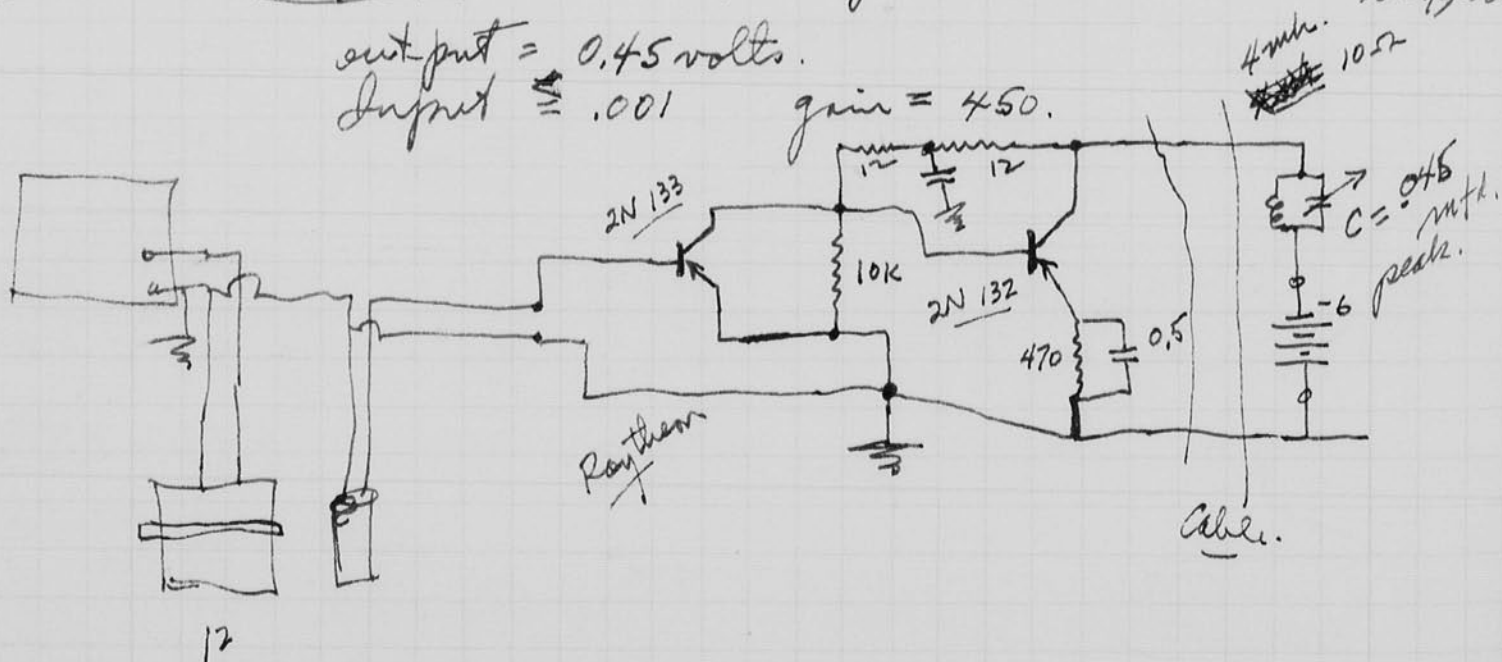
Conf with Rona and Lecompf about Hollowman.
 Decided to try above system. Rona will make the 12' screen.

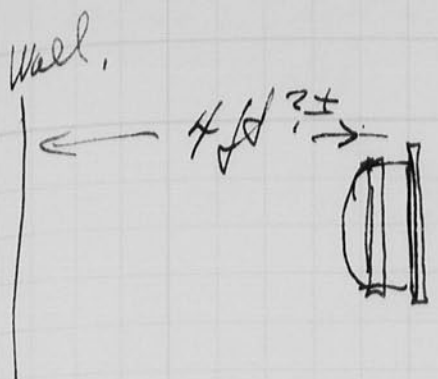
Transistor amplifier, as modified by Mac Roberts at Thornton's suggestion

output = 0.45 volts.

Input \leq .001

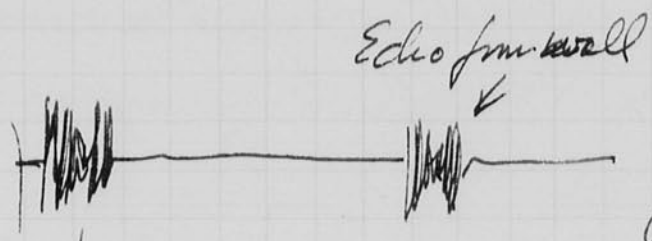
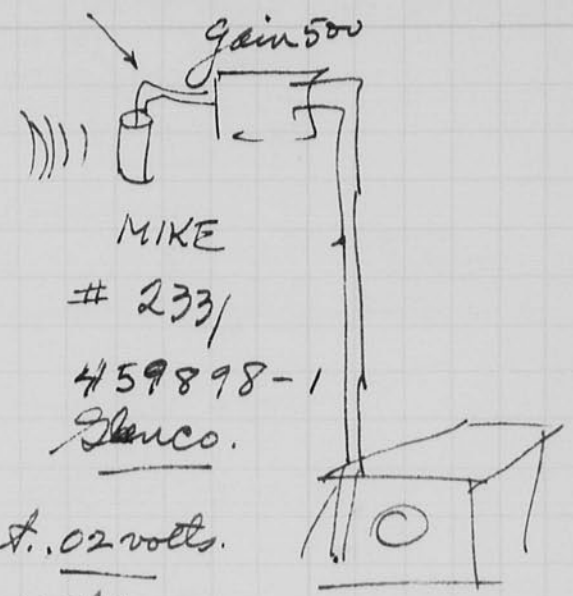
gain = 450.





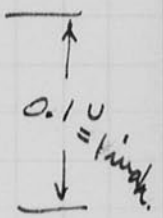
21 feet to.

$v = \frac{.020}{500} = 40 \times 10^{-6}$ volts, peak to peak.



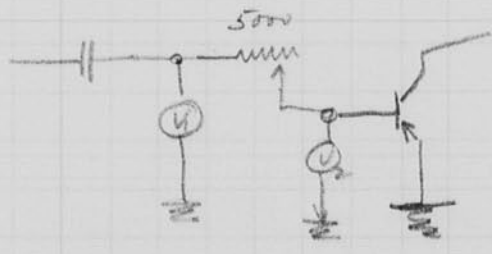
Input .02 volts to scope

Initial bang has double peak
Also double peak on echo.
Due to Reflections in driver??



Tuning changed from 045 to .03. Gain increased especially first peaks. Now get 0.1 volts into scope from both side of transducer.
0.10 volts both side of transducer
0.22 volts front side " "

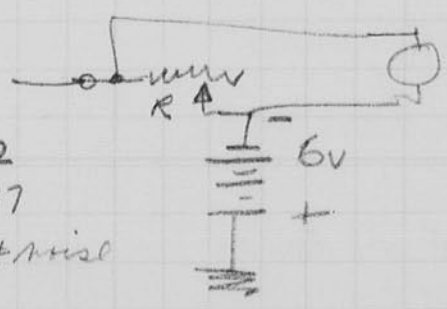
Input impedance



$V_1 = 9.10$
 $V_2 = 0.05$

$\frac{5000 + R}{R} = \frac{0.10}{0.05} = \frac{2.1}{1}$
 $5000 + R = 2R$
 $5000 = R$

Input shorted
output 5000 Ω $V = 0.02$
open $V = .027$
noise = 60 cycle + noise

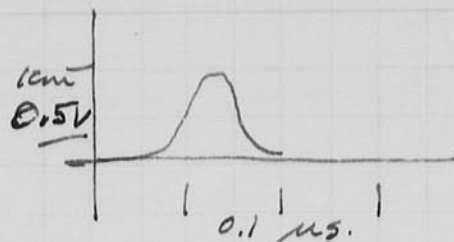
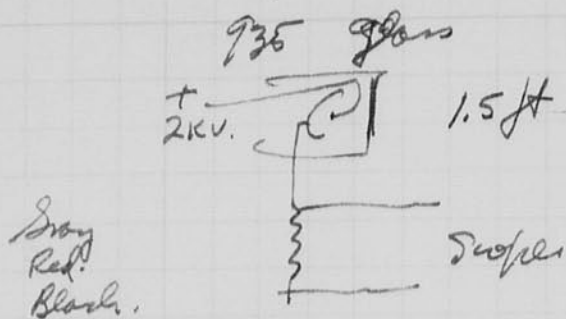


Ballantine model 300

| R_L | V | V_{in} |
|-------|------|----------|
| 1000 | 0.2 | 1.18 |
| 2000 | .285 | |
| 3000 | .31 | |
| 4000 | .31 | 2.1 |
| 5000 | .29 | |
| 6000 | .26 | |
| 7000 | .23 | |
| 8000 | .19 | |
| 100 | | .2 |

May 6 1956
Havelk Experiment.

Double flash tests. #6.



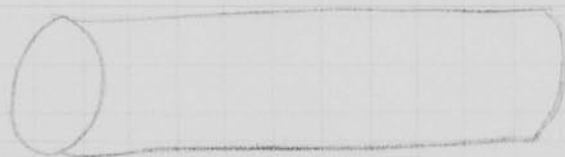
with air gap as used in
standard equipment
2307C-3.

an XP-2 flash tube was now
substituted. $\frac{1}{4}$ " gap in vacuum
at 1 atmosphere.

The peak light was about
1.5 volt compared to 0.5 volt
as per above air gap tube.

The duration was about the
same except the trail off was
higher..

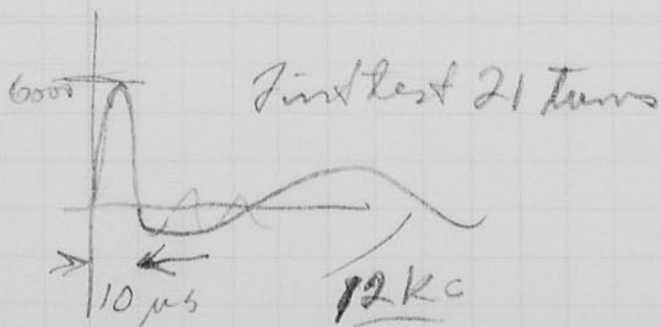
Tests of Sonar setup.



Sec. 738 turns
small wire
one turn.



Primary 38 turns



May 12, 1956

Harold G. Edgerton
R. Aljazi

Deep sea sonar.

121

Water temp = 50°F

Equipment installed in the Charles on the
MIT Boat house.

Distance to transducer about 80 ft.

Received at Dumont scope from transistor amp = 1.5 ^{peaks.} volts \pm .

Noise voltage = $.01$ volts \pm from the river.

Note: the amp. has a band width of 3 or 4 kc.

A motor boat at the center of the river - (1/4 mile from mile)
gives about $.05$ volts into our system.

We found useful signals from the transducer when it was
2/3 of the distance from the boat house to the Longfellow
Bridge.

May 19. - I showed motion pictures of the underwater research
to the M.I.T. club at Sterling Mans. Sterling dinner.
Last night. Wilson of P.L. was there. also Prof Chapman's
daughter Mrs. Woodward.

My last class in 605 is Monday.

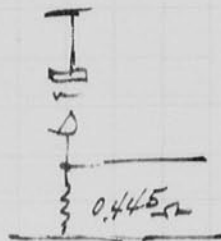
122 May 19, 1956.

A. E. Edgerton.

501 with Short tube.

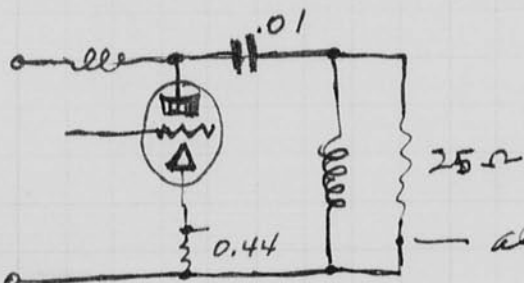


1 volt. = IR = I x .007 I = $\frac{1}{.007}$ = 140 amperes peak.



$\frac{46 \text{ volts}}{.44} = 100^+ \text{ amp. into pulse transformer.}$

with .01 mfd into FX-2 I = $\frac{34 \times 3}{0.44} =$



. C
.02

Electron.

LFE

T 70487-2 NEWTYPE.

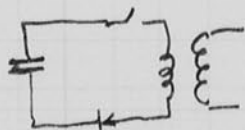
0.43 ~~0.38~~ mh. pri.
.025 mh. sec.

OLD POTTED TRANS

.600 turns
.04 mh.

at 1,000 cycles.

also in series with ~~EM~~ XP-2 tube.



$I_m = E \sqrt{\frac{C}{L}}$

The old transformer has better iron and seems to give a preferred result. Is this worth the difference in performance?

Deep-Sea Camera for Libreville French West Africa
tests 1956 summer
on Calypso.

123

H.G. Edgerton

M.I.T. May 26, 1956.

Lens Leica 35mm 378310 with "Baker" corrector
Lens removed from the carrier (Elmar).

Same camera as used in 1955 summer.

Elmo Elmar increased in size.

Motor for camera 7100D 6 volt 4.5 RPM. Hansen.

June 10, 1956.
H.G. Edg.

Graduation was on Friday at M.I.T.

Bill is back from Columbia where he is a grad student in water.
He is working at Hyannis with John Light, teaching aqua lung
and selling diving equip.

Bob came home last weekend from Rochester where he just
finished his junior year in physics. He helped me at G.S.
Lynn on Monday and Thursday. We took movies at 12,000
flashes/second of the bursting of a small turbine wheel with
blades or pins. A titanium cylinder caught the blades.
Fracture occurred at 60,000 r.p.m.

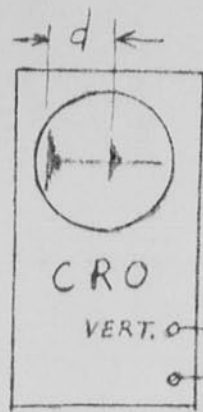
Film XXX at f 2.8 . . . 01 mfd at 6000 on each 501.

Lamps about 7 ft.

Two 501 units used in push/pull driven
from an oscillator.

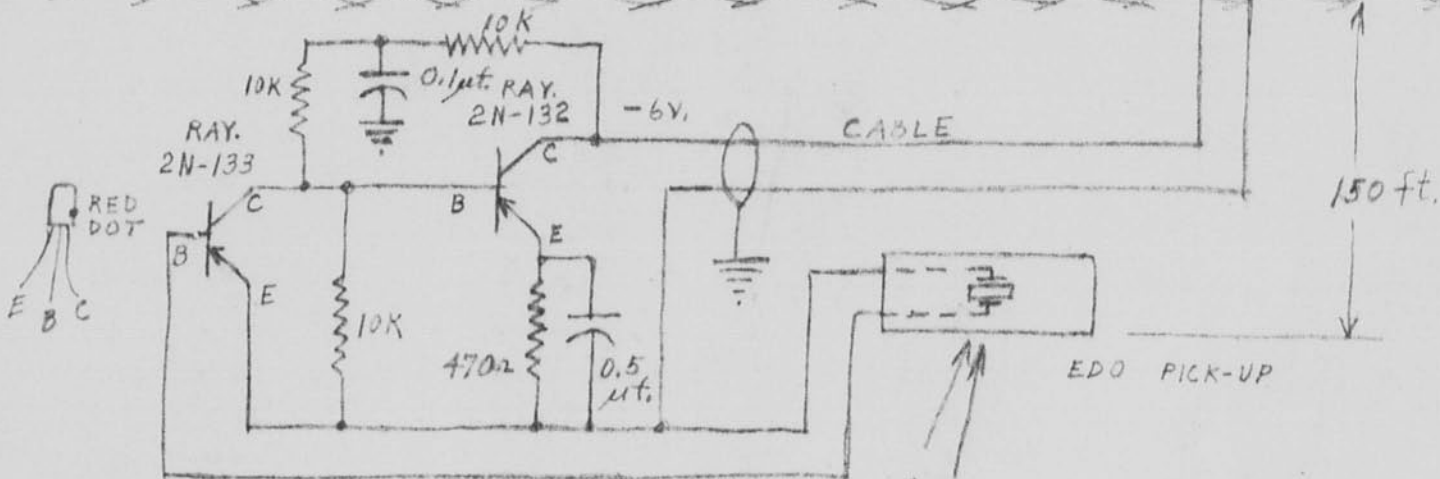
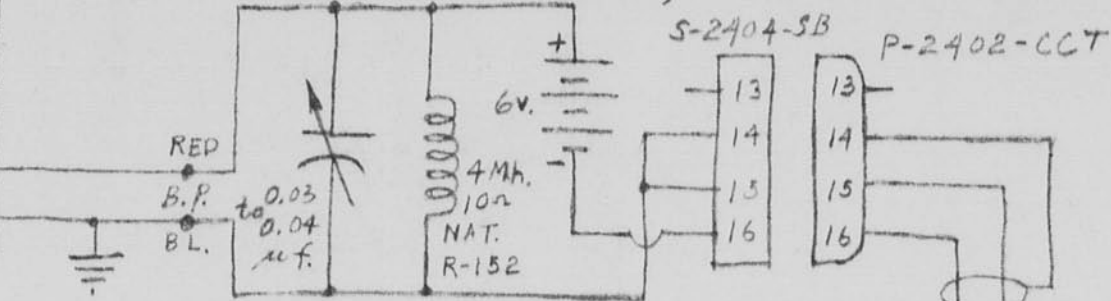
Deep Sea Camera
1956 Sonar Hook-up.

E. Mack,
June 12, '56.

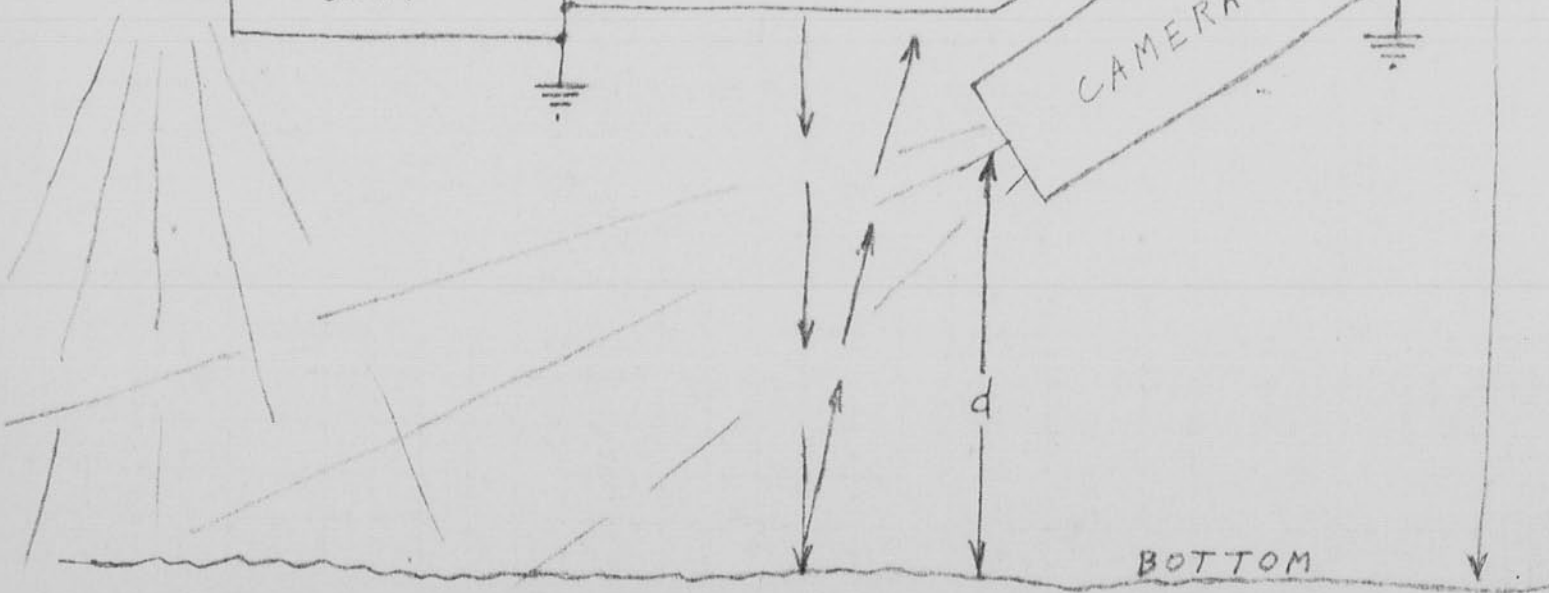
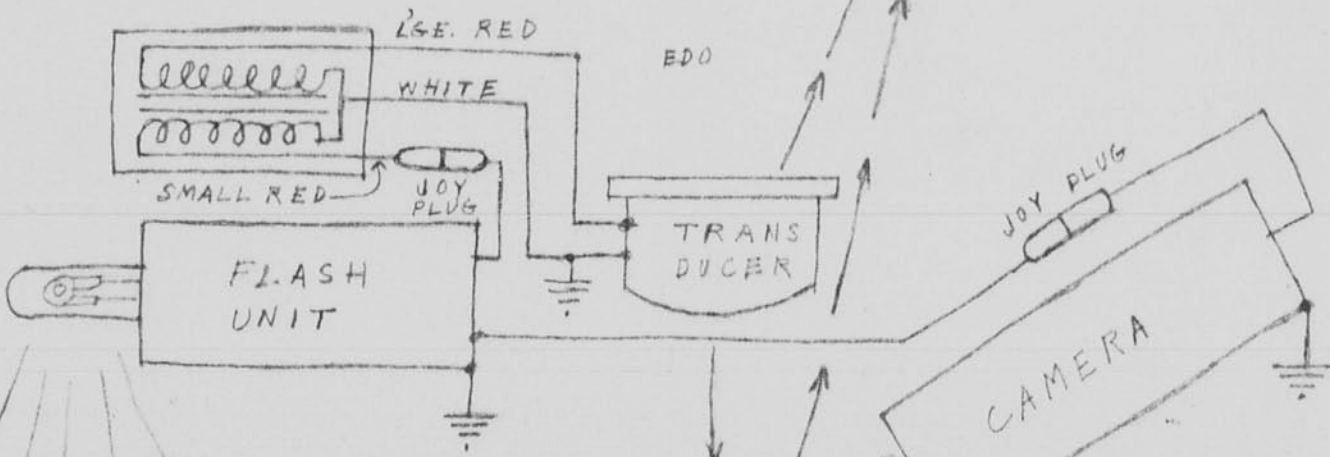


TUNED CIRCUIT (12KC)

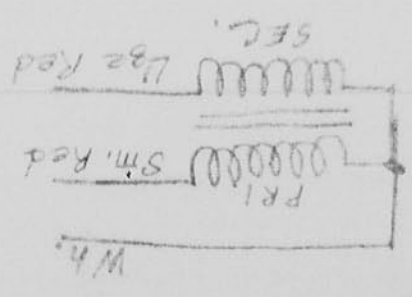
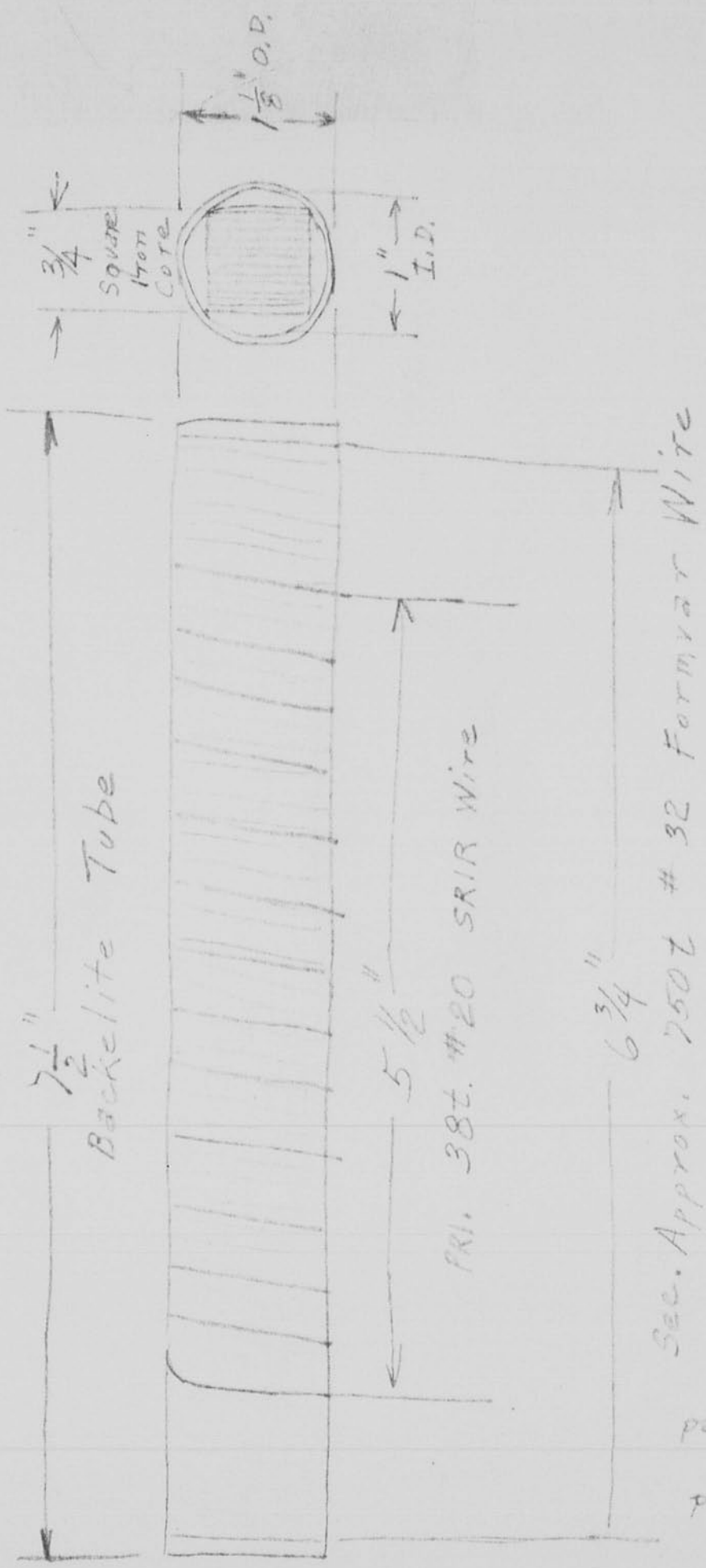
JONES CONN.



150 ft.



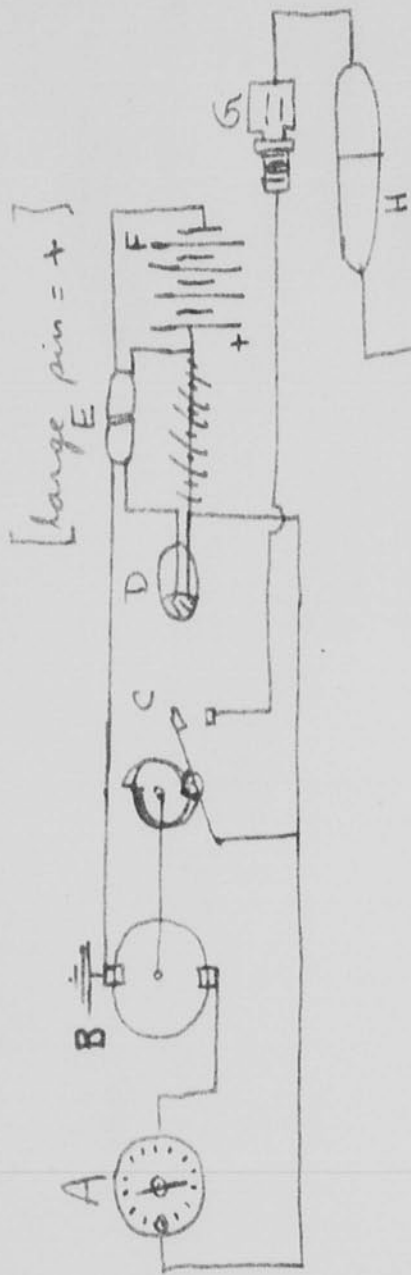
BOTTOM



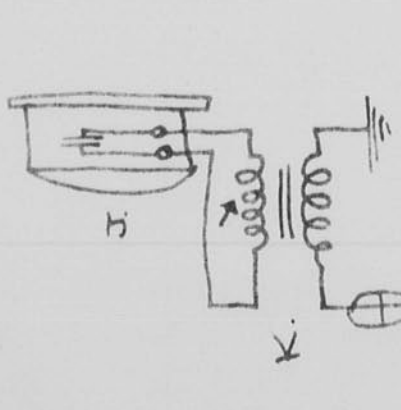
Sonar Transformer

Pot with Scotchcast #2 in $1\frac{7}{8}$ " I.D. bakelite tube $9\frac{1}{2}$ " long. (Uses approx. 1 lb. Scotchcast)

June 12, 50
E. MacR.



- A. MARK-TIME 2 hr. switch
catalog no: 5201 M.H. Rhodes, Inc. Rockefeller Center N.Y.C.
- B. Hansen Motor # 7100D 6V. d.c. 4.5 R.P.M.
- C. MICROSWITCH # V3-101 with # JV-5 actuator
- D. Hg switch E. Jones plug S-302 ct P302 ct
- F. 4 Yardley Silver Cells # LR-20 6V. total
- G. Conax MFG 3/32" Bore
- H. NO103M NO103F JOY PLUG
- I. Conax M.P.G. 3/32" bore.



- J. TRANSDUCER
EDO # X-20100
- K. EDGERTON
TRANSFORMER
TUNED TO 12 K.C.

TRANSDUCER AND CAMERA 1956 - CALYPSO

June 3, 1956
Bob Edgerton HEE ✓

Prepared by GR
Date 6-14-56



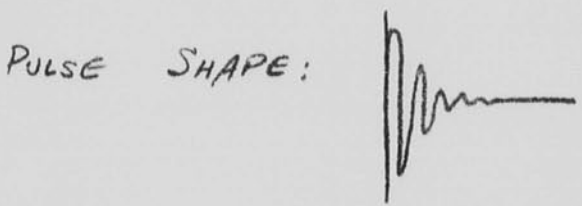
Report 2883
Page

TESTS OF DR. EDGERTON 35,000 FT. DEEP SEA
CAMERA WITH EDO TRANSDUCER # X-V0100

SOURCE LEVEL (12KC) = +114 DB/1 MICROBAR

PER VOLT RESPONSE OF TRANSDUCER = +41 DB/1 MICROBAR
(FROM PREVIOUS CALIBRATION)

CALCULATED VOLTAGE ACROSS DUCER = 114 - 41 = +73 DB
= 4500 VOLTS
AT PEAK OF PULSE



MAXIMUM ENERGY: BETWEEN
10 & 14 KC

CALIBRATION OF SONOBUOY HYDROPHONE & TRANSISTORIZED
AMPLIFIER (ATTACHED):
R_R = -49 DB/1V/1 MICROBAR

RESPONSE OF HYDROPHONE ALONE = -96 DB/1V/1 MICROBAR
(FROM PREVIOUS CALIB)

GAIN OF TRANSISTOR AMPLIFIER = +47 DB

TESTS WITH AN/UDN EQUIPMENT ON BARGE (USING UQN
RECEIVER ONLY):

GAIN OF UQN = +96 DB

WITH SONOBUOY HYDROPHONE CONNECTED, RECEIVING RESPONSE
OF SYSTEM IS: -8 DB/1V/1 MICROBAR AT 12KC.

APPROX CALCULATION OF RECEIVED VOLTAGE AT 35,000 FT.:
60 MICROVOLTS. THIS IS ABOUT 30DB ABOVE NOISE
LEVEL OF UQN.

June 16⁷ 1956

~~435 E. 1st St.~~

Bob, my son, is working in my lab in Bldg 20 at M.I.T. this summer. He will be under Gernsmeiner and MacRobert.

Bill is working at Hiram's with John Light on a diving project. The group has a stove and a boat for taking out tourists etc.

Wang, Lou and Jan were in Boston for the past two weeks. They returned June 16 by air to Wash and then by train.

Esther and I leave for Honolulu ~~next~~ tomorrow morning via Newark where we pick up Esther's mother Clem Garnett.

I am scheduled then to go to Zuni with and then on July 10[±] go west to Abidjan Africa to meet Cousteau on the Calypso. We have a deep sea photographic experiment to be done off Africa where the bottom is 20,000 feet down.

Aug 18 1956 Sat aft.

Harold Edgerton,
M.I.T.

Summer Schedule so far.

Left June 18 for Nebraska

Left June 20 Wed from Nebr. for Honolulu after spending 2 days in Aurora with my parents Mr. & Mrs. Frank Edgerton

June 26 Left Honolulu for Euiwetoh

29 .. Eui for Bikini & return later

July 6 at Mack tower

Coral Head at Euiwetoh

July 10 left for Guam via Kwajalein

" 13 left Guam for Tokyo

" 16 left Tokyo for Paris via Air France

19 .. Paris for Abidjan F.W.A.

July 26 - Aug 5 at sea on study of Romanche trench, on Calypso.

Aug 2. Telegrams recd from Dugan about death of Bill Edgerton, went down at island harbor, in a diving equipment of Dr. Christian Lambertson of the Uni of Pennsylvania - 12 feet deep!

Aug 2, 3, 4, 5. Calypso went full speed to Dakar, then con aboy, where a french military plane took me to Dakar. Cousteau went with me on this trip.

Aug 6, 7 to Paris via VAT and to Boston via PAA, arrived 9:30 am at Boston airport.

Aug 8. Bill's funeral - Fessenden park church Mount Auburn Cemetery.
We sure miss that Bill

Aug 12 Took Bob to Trapp Music Camp Stowe Vt.

" 15 Visit to Hyannis to see John Light and the Capt Jameson, the ship that Bill worked on this summer. He taught about 140 people how to dive.

Aug 16 Jean Michel Coostean visited us in Belmont and saw M.I.T.

Aug 21, 1956. Director meeting Aug 20 9:30 to 2 pm.

- | | | | |
|---|---------------------------------|---------------------------|---|
| 1 | 2 ³ / ₄ " | Mild splash. | } high speed Jastax with 501 .01 mfd at 110 acor motor. |
| 2 | 2 ³ / ₄ " | " " | |
| 3 | 2 ³ / ₄ " | | |
| 4 | 4 ¹ / ₂ " | | |
| 5 | 6" | drops seen to show crown. | |
- Jastax has no prism

Daylight Kodachrome. 2 #2 photo floods.
5 ft at f4 for General scene.
1/2 ft at f11 or 16 close up.

| | | | |
|---------|-----|-------|-------------|
| 16 fps. | f22 | 1 ft. | close up 6" |
| 32 " | f16 | " " | " " |
| 64 " | f11 | 1 " | " " |

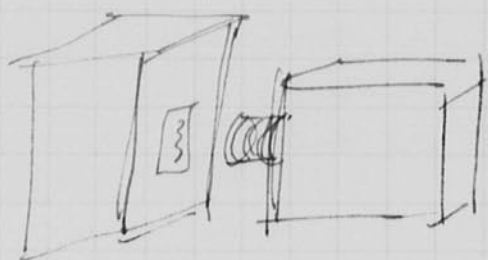
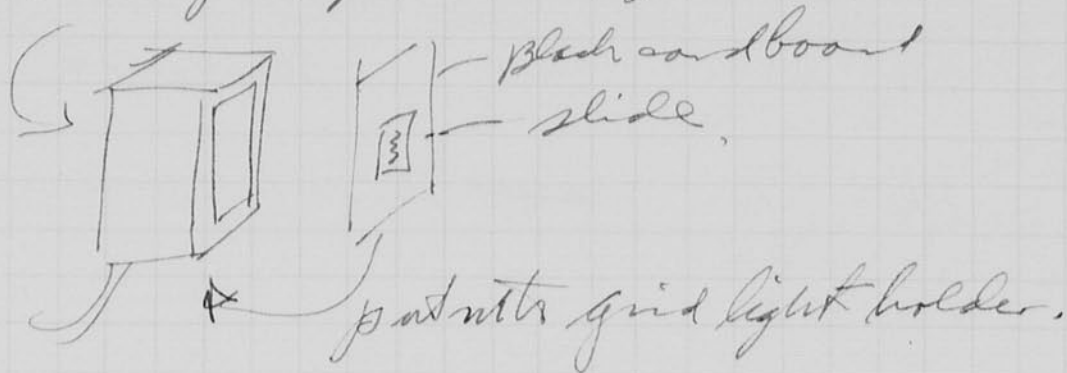
other shots with Daylight Kodachrome. Guide no about 20 ±
of setups

Aug 23 1956

Copy of 2x2 slides. Kodachrome Slides.

Ray Swanson

Aristogrid light 4x5 size.



Camera,

f 2.2 16 fps Daylight

f 2.2 8 " " "

4.5 16 f.p.s. copies.

Indoor film also used.

Slide copy

f 4 - 8 f.p.s.

f 4 - 16 f.p.s.

of two slides.

E. H. D.

and Tussell.

High speed movies. - Projection bulb on table. Stripes.

Lamp 2 ft f 4. 01 mfd 8KV. 90v on variac camera 4 ft.
#1 Telea #1 sup lens on the lens. 2" f 4. f 2

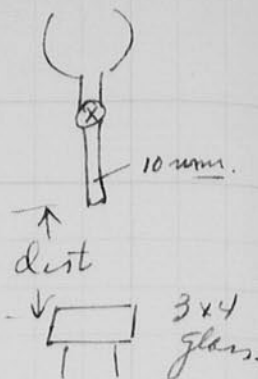
#2 closer. f 4.5 110v on motor

#3 Same as 2 f 4. 115 on motor. Fastax film Dupont, type 931.

#4 " " " 115 on motor.

Drops.non fat milk.

| | | | | | |
|------|--------|-----|-----------------|--------------------|------------|
| # 5. | 7" | 5.6 | Dupont 931 | Crown. | |
| 6 | 9 1/4" | f56 | " | of milk. | 3x4 glass. |
| 7. | 9 1/4" | 8 | set? | Fairly thin crown. | 115V |
| 8 | 9 1/4" | 8. | | crown? | 100V. |



Thursday Aug 24, 1956.
#55.

movies of "Splash" book Worthington
25 guide factor 2 bulbs.
18 1 bulb.

orange movie

1st scene - front light with white background.

2nd " side light 95 to 100 degrees f11

| | f | D. | Motor | E. | Subject |
|----------------|-----|-----|-------|-----|--------------|
| High Speed | | | | | |
| 3/4. #1. xxx | 2. | 10" | 85V | .01 | orange. 8x5" |
| 1.5/4. #2. xxx | 2.7 | 10" | 85V | .01 | " 8x5 |

Friday Aug 24 1956 to New York to get Bill's things.

" night at Robinsons with Mary Lou, Jan at Chadsford Pa.

Sat. finished Bill's things - Saw Pat, Gunther at 611 west 114

Sun. Sorted Bill's things. Bob Silverberg was in the apartment.

Aug 28 1956
H. Edgerton


movies of milk drops.

Pouring of milk scene. High speed also Regular.

Film Box f Speed. dist Light.

1. Plus X 60ft. 2.8 80 volts. 4ft. 1/8. Spout too low. scene also shot with Pathé at 16 fps. 2 photo floods at f 5, 6 6 to 7 feet from subject.

2. Same as other but with beaker higher.

3. Plus X 100ft f8 80 1 1/2 10" Closeup of drops forming on dropper. ^{ok.} 

4. Plus X 100ft f8 90 1 1/2 10" Splash. ok.

5. Plus 100 GN 40

all processed at Back Bay
Harris. Cohen.

Aug 29 1956. H.E.S. cont movies.

| | | | | | | | |
|-----------|--------|-----|----|-----|-------|-------|---------------------------|
| Expok. #1 | Plus X | 100 | f8 | 90 | 1 1/2 | 9" | Splash Regular milk 7" |
| Expok #2 | Plus X | 100 | f8 | 90 | 1 1/2 | 9" | " drops " 7" |
| Expok 3 | " | " | " | " | 1 1/2 | 9" | Johnson Subject. " med 7" |
| Expok 4 | " | " | " | 85 | " | " | Cup with milk. 7 1/4" |
| Good. 5. | | | | 80 | | " | " " " " |
| 6 | " | " | f8 | 95 | 1 1/2 | 9" | cup marble. 7" |
| 7 | " | " | " | " | " | " | " " " " 11" |
| 8 | TriX | " | f4 | 115 | 4 1/2 | 2.5ft | 22 Bullet on steel plate. |

Sept. 5, 1956.

Harold S. Edgerton

The movie was spliced together over the weekend. I have bulb breaking photos. also orange jaeel being removed to show the jets from the skin. other sequences of milk splash photos were made showing crowns and jets.

Bob left in (P13,380 mass) Plymouth for Rochester Uni on Sept 4 early in morning. Bob has a job as Down Advisor this year at R.V.

Today I went to see Bill Barth with Jameshamer. Barth is the main person at Photor who are making a strobe type setting machine. For years we have helped this company with flash tube designs etc.

Defence 1956 D 1956 F 1956 G

Sept. 7, 1956

Conf. with D.T.M. regarding Prop. photography. Roundy.

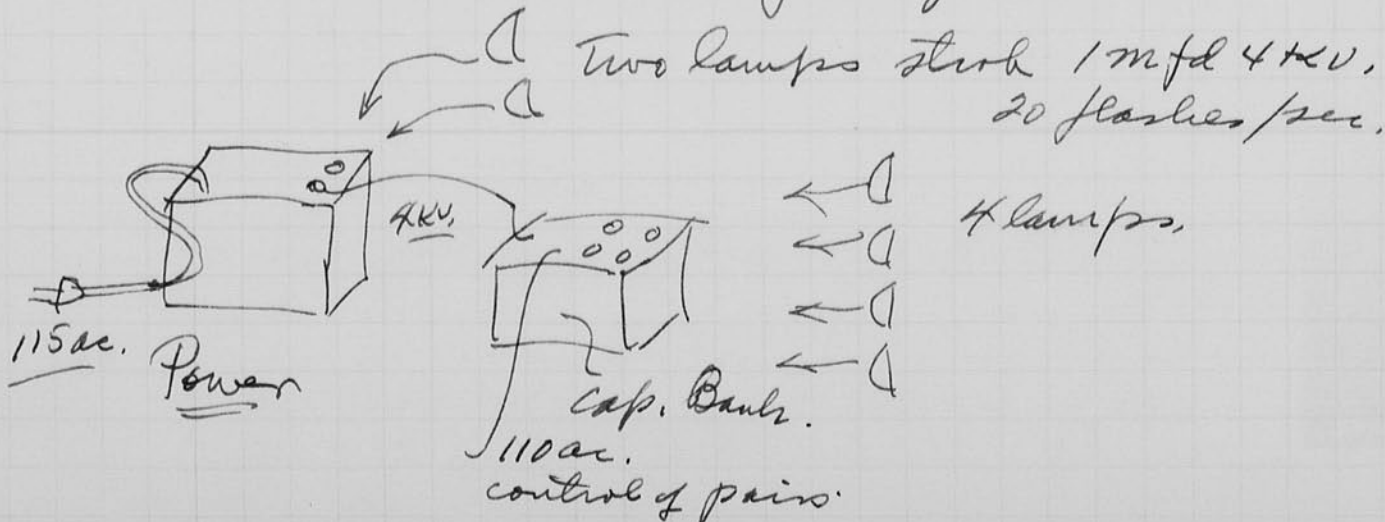
18 or 19 of Nov. Key West Florida

Friday preceding "Norfolk D.L. 1. Slip."

December install "Albacore" submarine.

Jan. tests of propeller.

Portsmouth drydock for installation.



Sept 7 1956.

H.E. Edgerton - I leave this afternoon PAA Flight
to London from Boston, my wife Esther goes too.

Oct. 9. 1956 Ret'd last Sat Oct 7 at 1030 on PAA flight 55 from Newark Ireland.

- Sept 7 left for London in aft with Esther. Wadlington Hotel London.
- 10 High-Speed Photo Congress talk on XP-2 flash tube.
- 11 Lecture in Royal Inst. on Flash.
- 14 Banquet Rembrandt Hotel.
- 15. Left for Frankfurt. Germany. Frankfurt Hof Hotel.
- 16. Sunday Dr. Fander, Margot, Kempfle, Pogrell.
- 18. Eindhoven N. Wamholty.
- 19. with Pogrell to Wiesbaden Heiman
- 20 Darmstadt & Stuttgart
- 21 Weil am Rhein with H. Schardin
- 22. To Vienna Herald 2 Seilergasse St
- 23. Int. Sci Film Conv.
- 24. - 27
- 28. left for Cologne - Dom Hotel.
- 29. Photo Lima
- * 2 To Paris D.R. Constant m.m. Cloupeau y. just curie La Porte
- d. 5 to Boston PAA 55.
- 6. home at 1030 am met by H. Sloaner and John Haramundaris.



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<http://libraries.mit.edu/archives/>

talk
sea.
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as

Edgerton XIV 105 Oct 1956

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Explorer Photographs
25,000-Foot Sea Floor



The New York Times
Capt. Jacques-Yves Cousteau

9/12 or so, Capt. Jacques-Yves Cousteau reported yesterday that he had obtained three photographs of the ocean floor at 25,000 feet below the surface. They were described as the deepest pictures ever made. The French underwater explorer described them in the French Consulate, 934 Fifth Avenue. The photographs were made recently in the Atlantic off Equatorial East Africa on Captain Cousteau's latest oceanographic expedition for the Paris Museum of Natural History and the National Geographic Society of Washington. The camera was a special device invented by Dr. Harold Edgerton of the Massachusetts Institute of Technology. "The pictures show no sea monsters, I am sorry to say," Captain Cousteau reported. "They do show rocky shelves with little mud. That was unexpected, for we had believed the bottom covered with organic mud. We saw also many organic pebbles on the rock. The pictures also indicated plankton as abundant as in surface waters." Times.

Oct 9 56. Lloyd Breslau came in to talk about a thesis for plankton nears in the sea. Breslau spent last summer on one of the ships of Lamont Lab. He mentioned Bob Menzies a biologist from Lamont as being interested in the problem.

SERVICE PIN AWARDS

| | |
|----------|--|
| 5 YEARS | Ken with Whitney Noel B. McLean |
| 10 YEARS | Hans Lilly Lillian McKee Onorio Rubino |
| 15 YEARS | Conrad Henselder |
| 25 YEARS | |

6-5-56
7-4-56
7-14-56
7-31-56
7-1-56
6-4-56
6-11-56
7-2-56

A little boy arrived at the home of Ruth and Nick Medical (Engineering) to the delight of the whole family. The little fellow is Kenneth Nicholas—his name is Kenneth Nicholas—have a birthday June 9. The Medical's have a little girl, Lynette, age 4 1/2 years. Congratulations and best wishes to the Medical family.

The Al Bach's are the proud parents of a brand new daughter—Susan, who arrived on June 9. Susan weighed 6 lb. 11 oz. and was greeted 2 1/2 years ago.

Research of the research organization with obtaining financial support for geographic institution, the group charged for

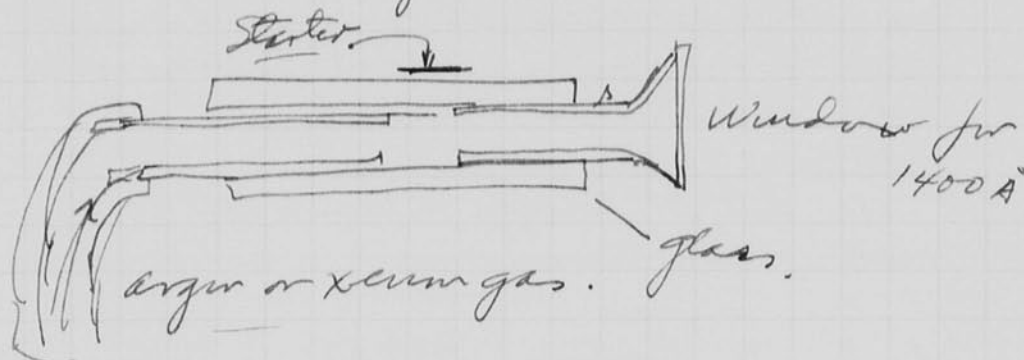
AFRICA

Harold Edgerton.

My wife Esther left this morning for Hickory N.C. to help our daughter Mary Lou with a new baby boy William Palmer Dixon who arrived Oct 11.

Two men from Arco were in this morning to talk flash lamps. They wish to work at 1400 angstroms to measure the light absorbed by the O_2 molecule. When O_2 goes to O or to a compound, the absorption changes in the 1400 angstrom band.

I suggested a concentric arrangement that should be easy to make and use.



They propose to make a few experiments along this line.

Oct 16 '56. Test of Philips tube See Human Retina with a Discharge Lamp

H. J. Van Boort

N. Warmholtz

J. E. Winkelman

London

Brit. Museum.

Medical & Biological Illustrations

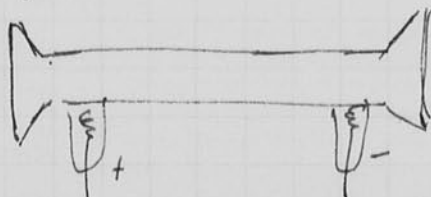
Tavistock Square

July 1956 vol VI no 3 p 166.

W.C. 1

Nov 1 '56
Mafflines

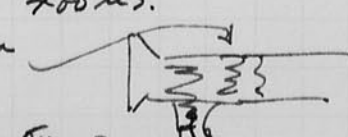
Tube no. ?



Calib. 25 mfd 1500 volts FX-1 2×10^6 c.p. peak light. $\frac{3.25}{10.0}$ cm.

| | | | | | | |
|-------------|----------|-----------|-------------------|--------|-----------------------|----------------------|
| 25 mfd 1500 | (? tube) | peaklight | 3.6×10^6 | c.p.s. | Duration .36 μ s. | $1.2 \times 3 = 3.6$ |
| 500 mfd(e) | 500 v | " | " | " | " | + ? |
| 500 mfd(e) | 450 | " | " | " | " | 400 μ s. |

Tube shows white deposit on anode area inside of the tube.



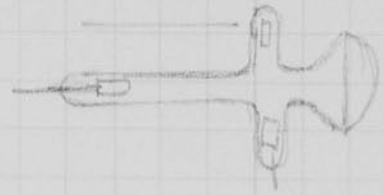
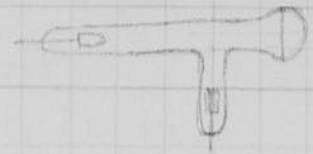
1000 450

$\frac{3.2}{3.3} \times 10^6$

500 ? \pm

The reading and the side view of the tube.

| | C | V | C.P. Peak | Dur _{ms.} | C.P.S. |
|------------------|------|-----|-------------------------------|--------------------|--------|
| <u>Side view</u> | 1000 | 450 | $\frac{3.3}{3.3} \times 10^6$ | 500 | 500 |
| <u>end view.</u> | 1000 | 450 | $\frac{1.8}{3.3} \times 10^6$ | 500 | 250 |
| <u>end view</u> | 2000 | 450 | $\frac{2.1}{3.3} \times 10^6$ | 800 | 310 |
| | 2000 | 450 | $\frac{1.7}{3.3} \times 10^6$ | 950 | |



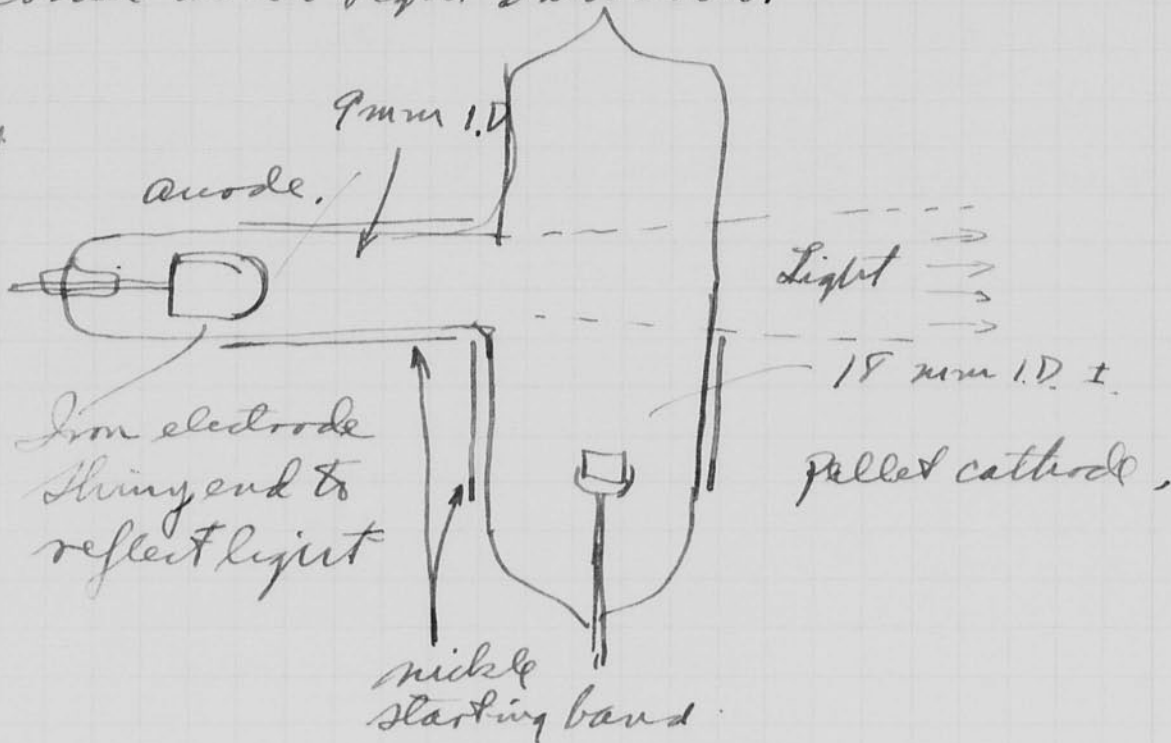
138 Oct. 18, 1956

Microscope Lamp.

Harold Edgerton.

Today I pumped a microscope lamp of a new type as shown below. Tests were also made as recorded in the Light Data book.

Scale about 1 to 1.

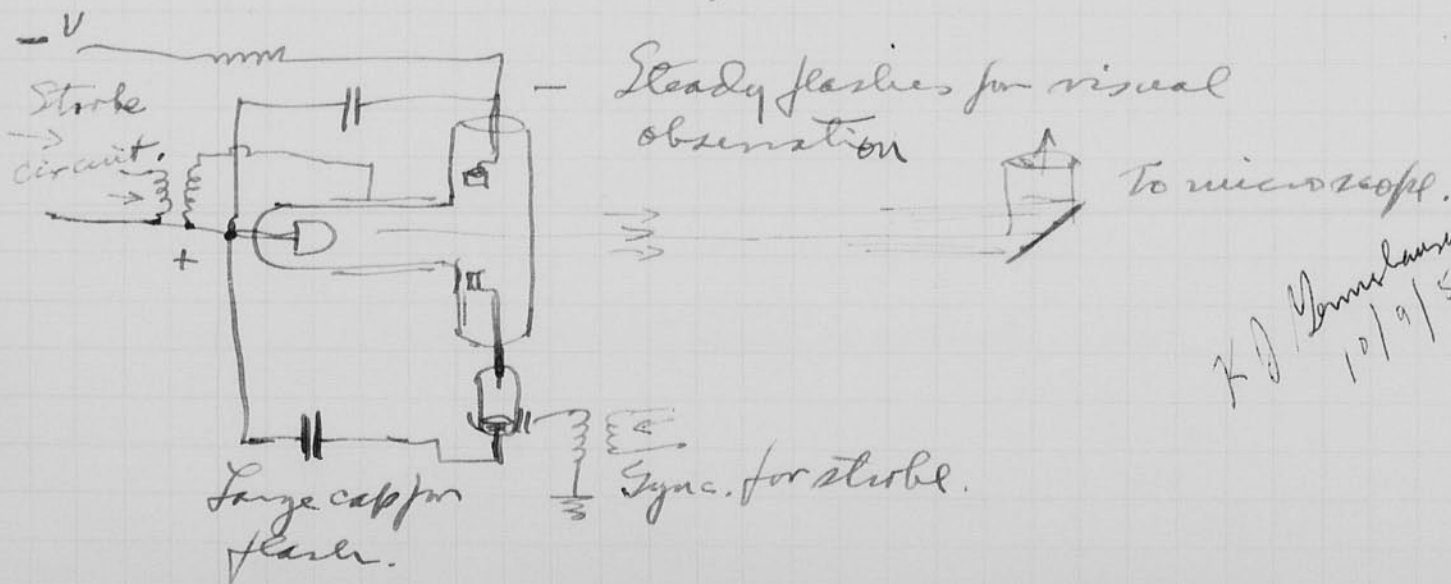


Nov 156
No. 156

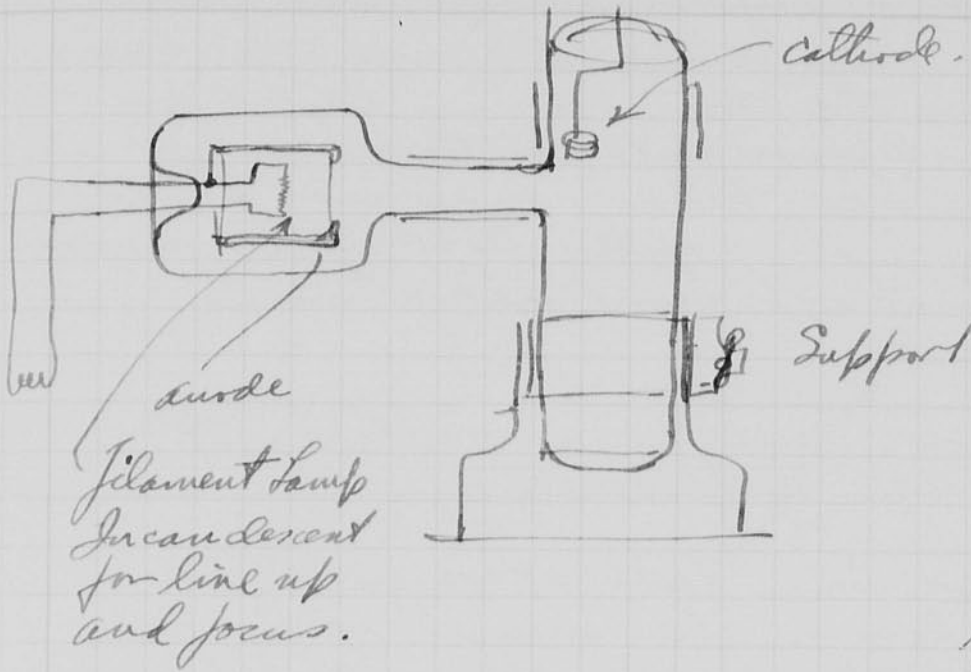
This was pumped by Bill Mack and I. Filled with Xe and at 10 cm.

2000 mfd (electrolytic) at 475 volt gives a 400 us flash with long afterglow and a 2×10^6 c.p. peak.

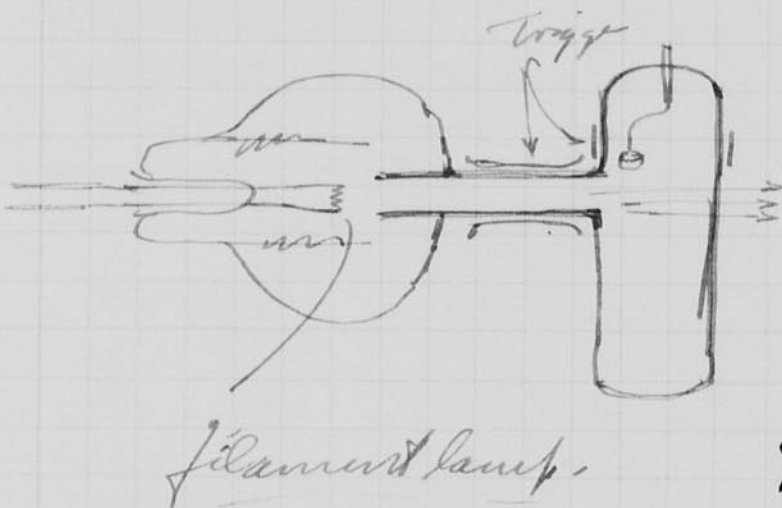
When run as a strobe, the arc does not fill the tube at 30 mfd at 1500 volt. Either the pressure must be lower or the energy greater.



F. D. Danneberg
10/19/56



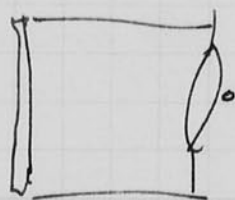
K. D. Gammshauer
10/19/56



The filament, if rugged can withstand the push of the arc during the discharge.

Exposure tests for Navy silhouette equipment

Navy ord. fab.



XP-1 0.465 mfd at 1000 volts.

0.2x10⁶ cps. 0.12 cps.
1 us.

Subject.

Super ortho X plates Eastman, 5 min 1:1 De庄ob.

Scotch light screen.

Exposure at De庄ob = 0.49

a second plate was exposed with 0.465 mfd at 2000 volts. D = 0.8

a xxx trix type B plate was exposed with 0.465 at 1000 volts D = 0.51

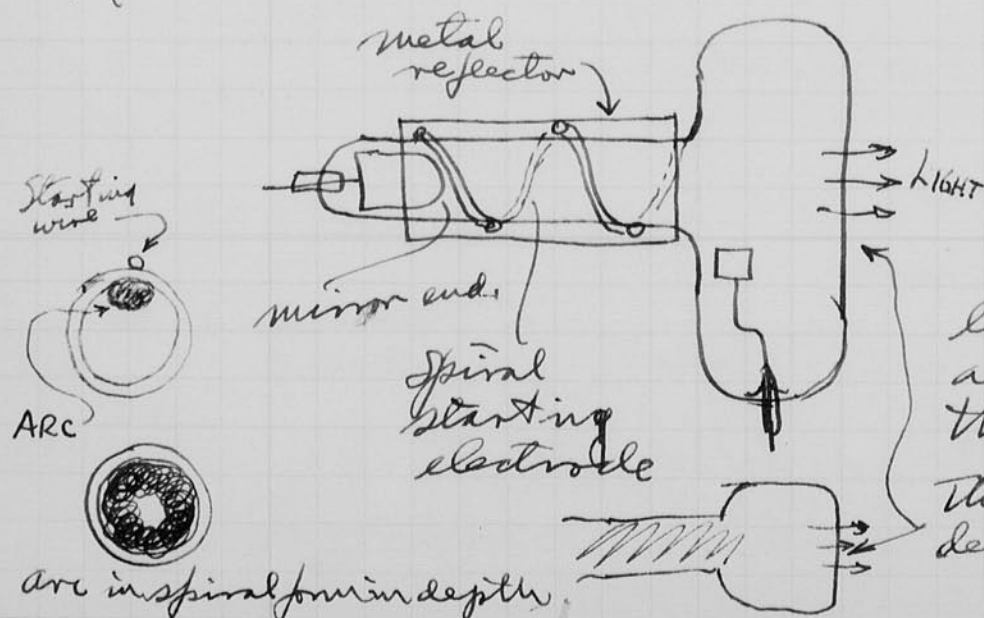
The lamp of page 135 seems to have great promise for microscope illumination. One problem is the continuous light for focus and alignment. If the tube is operated as a stroboscope, the arc does not fill the entire cross section of the tube if the pressure is up so that efficient operation is experienced.

Here are some suggestions to overcome this difficulty.

The arc in a tube always tries to take a position on the inside of the tube adjacent to the place where the trigger electrode is on the outside. If a straight wire is used the arc will be straight. With a spiral, the arc may be a spiral especially if the pitch is large say longer per turn than the diameter.

If the arc spirals on the inside, then the end view will look like a solid ring of light on the inside of the tube. Now the energy per flash must be increased until the arc comes effectively to the center of the tube. Thus the appearance of the arc from the end of the tube shows a solid circle of light.

Nov 1, 56
 H. J. Gumbel
 11/1/56



It may be necessary to reduce the pressure so that the arc will fill the tube.

Absorption will be less from the gas with a lower pressure in the tube.

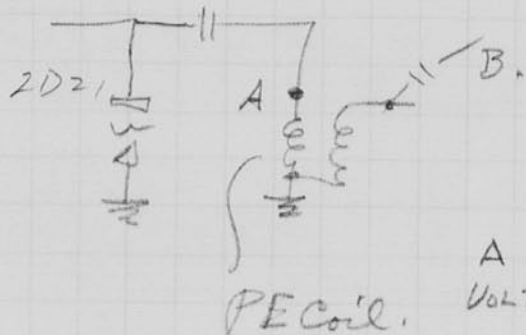
This wall could be flat if desired

Oct 19 1956
H. Edgerton.

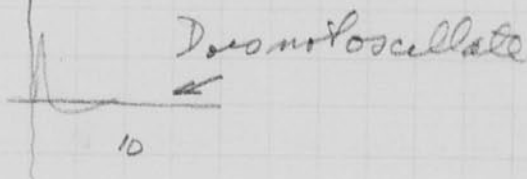
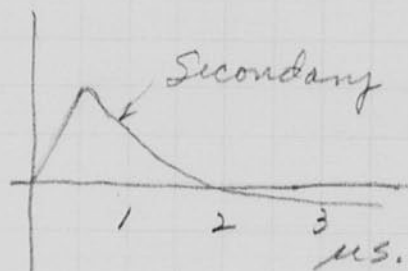
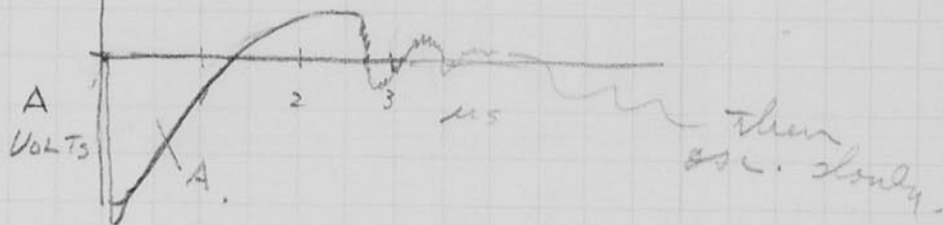
Double flash equipment

Observed voltage in primary of spark coil. It shows some jitter from .02 mfd into 2D21.

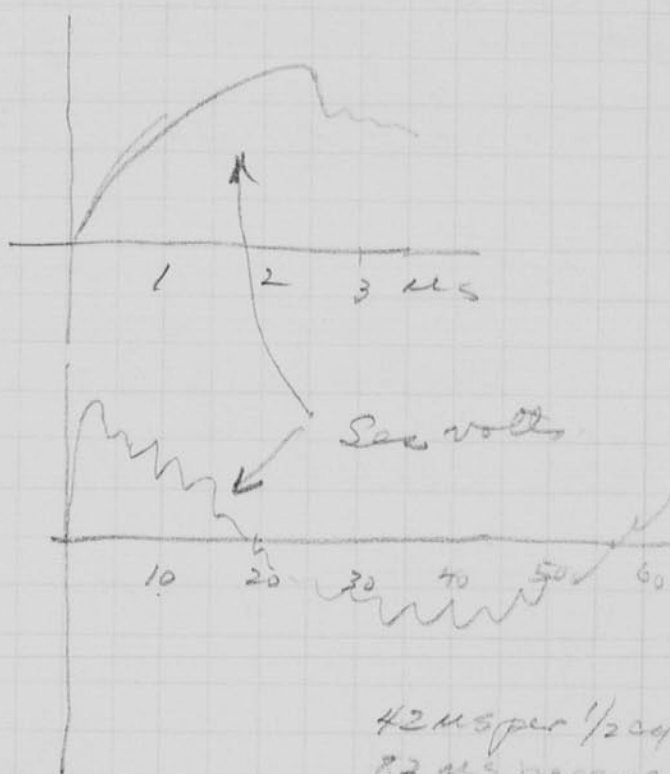
2 put on a PE model edvic.



could not see sparks on sec with ~~spark~~ screw driver! very low voltage?



LFE coils.



42 μs per 1/2 cycle.
82 μs per cycle.

1. Conclusion - Sparks seems weak on Double flash.

the spark capacitors or .02 increased to .02 + .05

now we have 1/4" spark.

Rapid rise of voltage in 1/2 μs .
no jitter of sparks.

2. Delay of 1st flash depends upon the gap settings
with 1/32" delay is about 1/4 μs .
with 1/8" " " " 1 μs .

.07 mfd on spark coils.

now used 2 feet of wire to XP1 gap $\frac{1}{8}$ " x even
It did not flash until I used a third detector,
also used 3500 and 7000 across it to allow
the gaps to fire.

XP-1 gave 7 volts from light. 2ft no filter
Red Black Brown resistor.

XP-2 gave 3 volts from light same cond

Duration of above is about $\frac{1}{2}$ us.

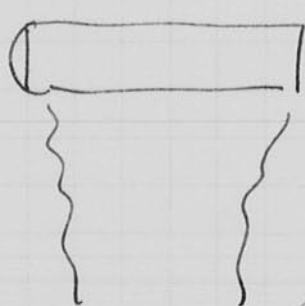
(XP-1 20 volts at $1\frac{1}{2}$ us from 0.5 mfd at 2KV.)
as used for photo tests p 139.

thus we need more energy by a factor of $3 \times 3 = 10$.
cap 0.05 mfd instead of .005 ✓

Mandan Oct 21 1956
Harold E. ...

Polaroid copier for Kodachrome
slides.

the problem is to obtain a simple
reliable system for copying color slides
into Black and White Polaroid prints.



Polaroid body

75mm lens at
4 to 1 about?

Shutter and lens with ~~to~~ ~~400~~ ~~ok~~ X N6
X sync
above at f 4.5.
now at f 8.

1" ← Kodachrome slide on
glass
1" ← ground glass
1" ← FT-105

| C | V | Comment |
|------|-----|-----------------|
| 1 | 500 | thin |
| 3 | 500 | thin |
| 5 | 500 | ok but thin |
| | | ok X N6 |
| | | above at f 4.5. |
| | | now at f 8. |
| 30 | 400 | thin |
| 230e | 350 | over exp. |
| 230e | 250 | ok. |

To adjustable flash
unit as per table.

X
Synac

req of miss Lunt. (Sally)

c v f

230 250 8 overexposed.

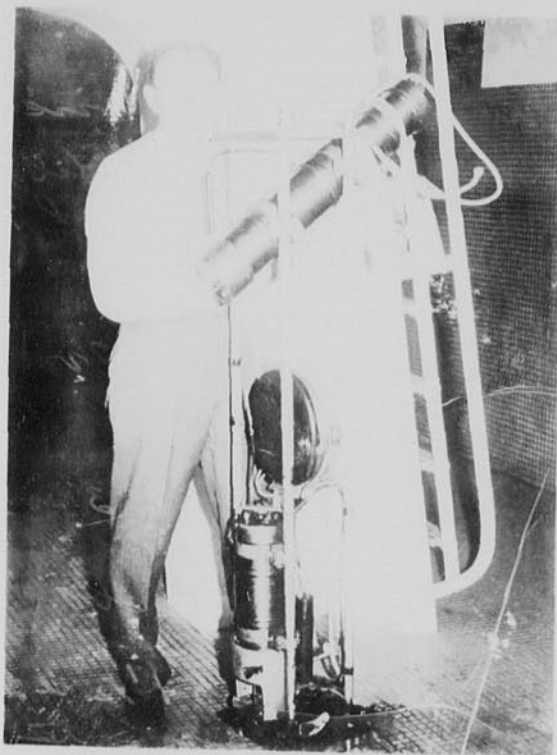
230 250 11 overexposed

230 250 16 fine

Bob and camera

230 250 16 fine.

me →



Camera
and
Battery
6 volt
Silver cell

Sonar.

Flash
Lamp

→ f8 230 mfd 250 volts.

- Nylon anchor line
+ many colors

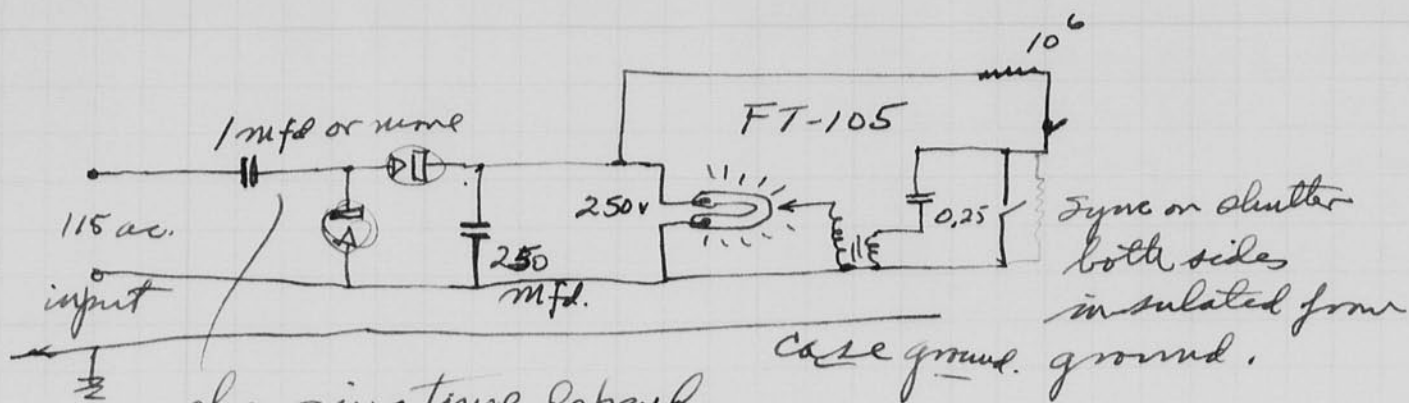


Bob
Edgerton
+

Lamp.

Declared & undervolts by
me Nov 1, 56
RSP Lines

at Edo Plant June 1956.

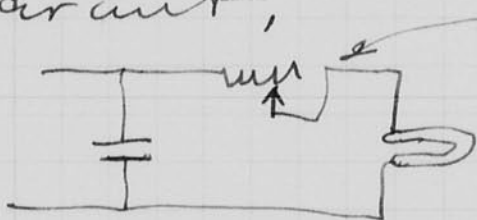
ac circuit for copy device.

charging time depend upon the size of this capacitor. Increase to a size that gives satisfactory action in charging.

This device should be perfect for slide copying of color onto color.

The integrating exposure meter should be fine for setting the light level to a constant value.

To adjust output continuously - use a series resistor in the discharge circuit,



Resistor to adjust output. Use about 10 ohms for large variation.

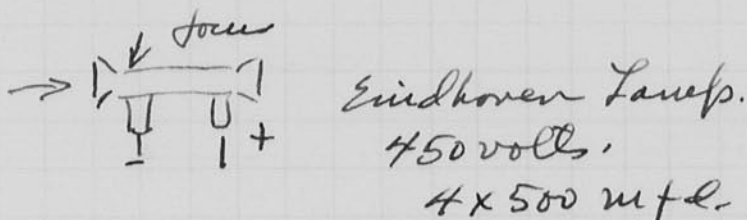
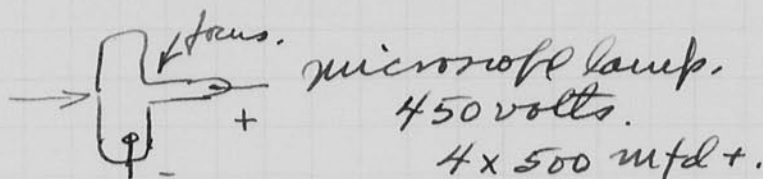
Nov 15
1945

Oct 21 1956 cont
A.E. Dygdon

Brightness tests of lamps with camera.

145

FX-1 100 mfd 2000 v



camera 4x5
Panatomic film
f 32
Filter 2.85 density (3).
DK 1:1 6 min.

All on the same negative!

Oct 30 1956. A.E. Dyg.

I went to Rochester on the 25 with Chas Wydroff. We visited EK John Niemeyer to discuss film scratches on the N.S. cameras as used at Eriwetok.

I discussed high speed shutters with Weber of Wollensak who has a new prism device in the 1 to 10 μ s range.

At Bausch and Lomb I talked to Dave Richardson and spoke about the retina camera I propose to make a lamp.

At Wollensak I arranged for a shutter with insulated contacts (X) and an f8 opening.

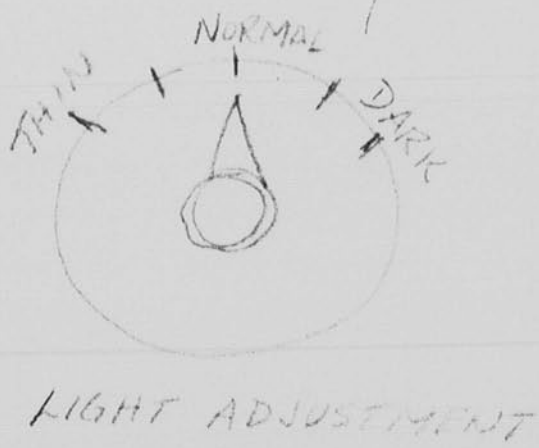
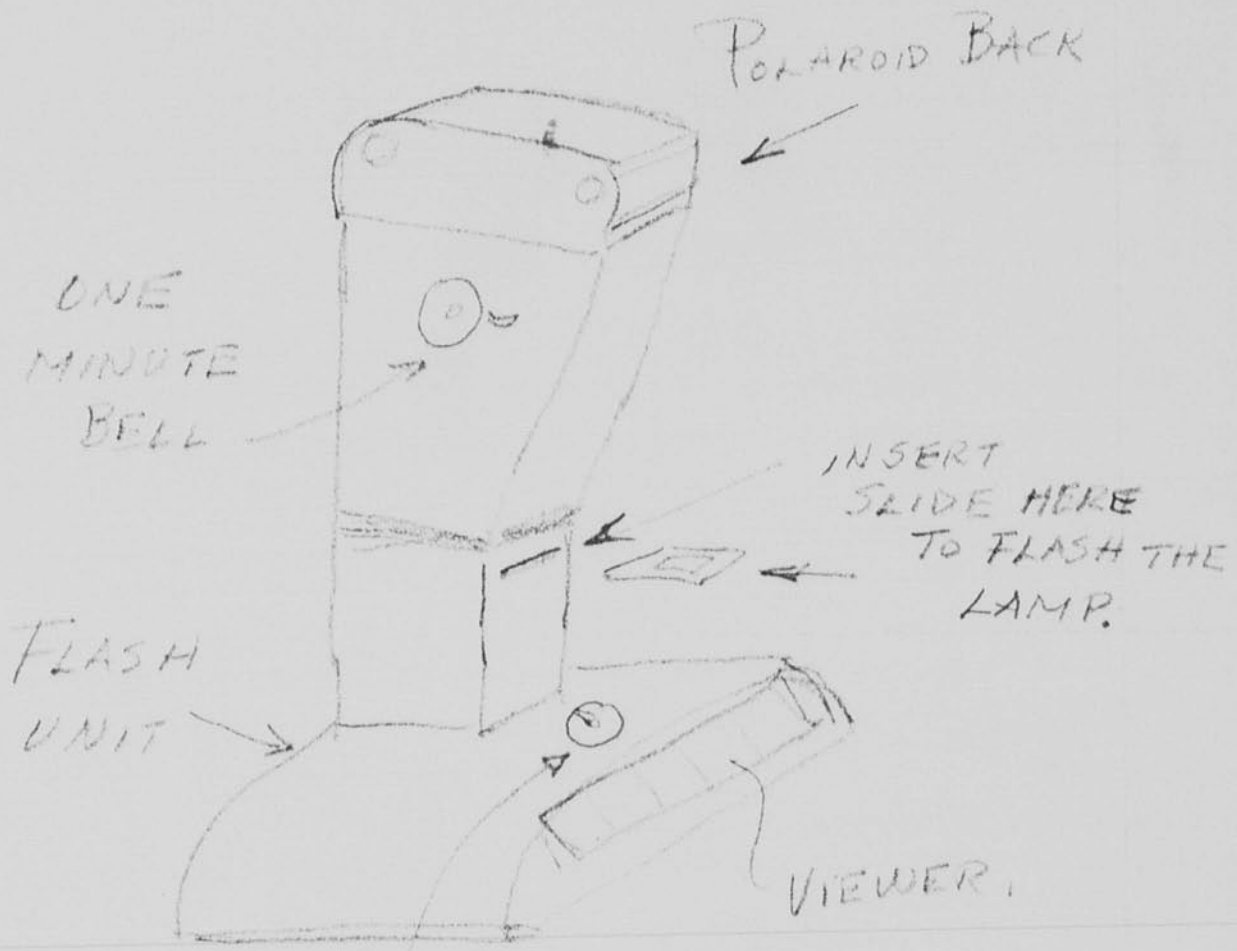
The color transparency to Polaroid film printer looks very good.

I now include the following features.

1. no shutter - the slide goes in a light trap door
2. The slide trips the flash lamp.
3. An electrical ~~control~~ method will be used to control the amount of light.
4. a photoelectric device is proposed to read the light and to set the exposure.

5. a viewer on the base will enable the user to see about 6 slides while the one minute is going on for processing.
6. an automatic device is to be used to ring a bell 1 minute after the film is pulled.
7. There could be a ~~coin~~ coin release to make the device work. Polaroid in large rolls could be provided.

Nov-1-52
M.H. Jones

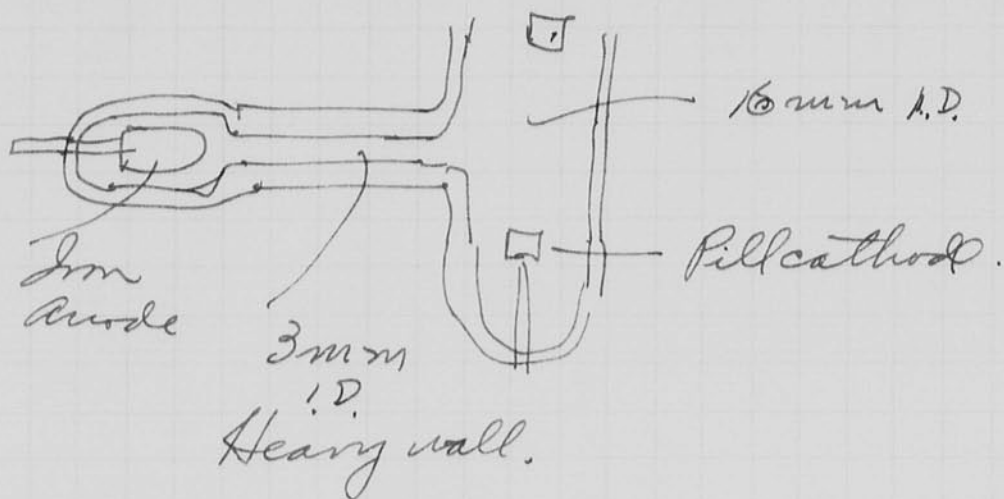


H. EDGERTON
 OCT. 30, 1956.

Nov. 8, 1956.

Harold Edgerton.

Progress continues on the microscope tube. I built two new ones over the weekend, as below



Above pumped
Hydrogen heated to remove oxides.

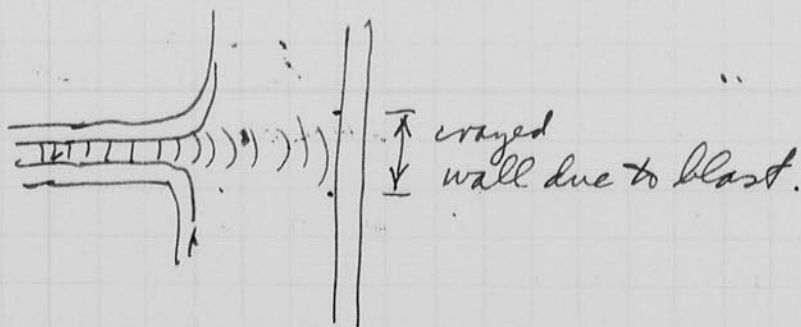
Run at 100 W.S. at 500 volts to
drive out gas. 5 cm X 20 cm gas.

Sealed off at 20 cm X 20 cm gas.

Severe crazing at 200 watt seconds.

I noted a circle of crazing on the
wall opposite the end of the capillary.
Also the anode is surface melted
showing drop running down toward
the end of the tube.

The circle of crazing is about 3x the
diameter of the tube.



down spectrum and I set up an experiment tonight with a projected image onto photocell so that we could measure the light as a function of space.

with 5 mfd at 1500 volts, there was about 25 microseconds delay when a path length of 1 cm was traversed.

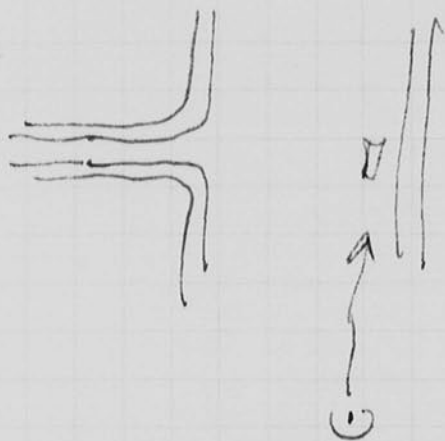
$$\frac{1 \text{ cm}}{25 \times 10^{-6}} = \frac{10^6}{25} = \frac{40,000}{40,000} \text{ cm/sec.} = 400 \text{ meters/sec.}$$

= 1200 feet/sec.

or 1000

about the velocity of sound.

At 100 mfd at 500 volts, the velocity was about 1/3 the above. The nature of the wave was different in the area away from the jet.



photocell 1 looks at end of capillary
photocell 2 looks at edge of the tube.

Nov. 28, 1956 Rtd from 2 weeks in west on Sunday Nov. 25.

Nov 13 Cleveland

14 Los Vegas 8 P.M.

15. Sanbia

16. Los Alamos.

17. Los Angeles Sat

18 " Sun

19. Livermore

20 Denver

21 Aurora Nebraska with F. S. Ely et al

22-23-24 " Bob from Rochester

Esther

Dec 7 1956 Open house in 20D102 for 670 students. I just gave a series of 5 lectures on electronic flash etc.

1. Stroboscopes - tubes etc.
2. Electronic flash - guide factors.
3. Short flashes - microseconds
4. High frequency strobs. movies etc.
5. Magneto optic and Per cell shutters.

Dec 19, 1956

Harold Edgerton

I have been working on the new stroboscopic circuit

This was to have 4 scales as set by Gernsmauser some years ago.

I thought of two scales. One was to be a wide range job from 300 to 14,000 with low accuracy. The other was to go from 900 to 4000 with 1% accuracy.

Thurston thought this was U.S. and suggested 6:1 scales with a improved upper speed. I tried the unit in the back room and found it went ok from a S.R. oscillator up to 600-700 cycles with 15K and 0.05 mfd.

Proposed scales

| | | | |
|--------|---|------|--------|
| 21,600 | - | 3600 | R.P.M. |
| 3600 | - | 600 | " |
| 600 | - | 100 | " |

The last scale will probably be optimal.

Gernsmauser suggests a blading oscillator or a thyristor oscillator for the driver.

Dave Cablander has been helping with these experiments.

Last night I shot some Ektar color (ASA 24) photos of the pool. Chas. Ballman did the diving from the high board. I used f11 on 18x10 film.

Cop 180mf at 4KV on FT 503 in a spotty reflector at each side of the subject.

Some photos were taken at f16, all were sent to Niemeyer at E.K. Rochester N.Y.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering

Subject 6.20
Special Lectures

"Short Duration Electronic Flash Equipment"

Wednesday, November 28, 1956
10-11 a.m.-- Room 5-217
and repeated at:
2-3 p.m.-- Room 3-303

"Electronic High-speed Photography"

Friday, November 30, 1956
10-11 a.m.-- Room 5-217
and repeated at:
2-3 p.m.-- Room 3-303

"Electronic High-speed Shutters"

Wednesday, December 5, 1956
10-11 a.m.-- Room 5-217
and repeated at:
2-3 p.m.-- Room 3-303

Open House in Stroboscopic Light
Laboratory

Friday, December 7, 1956
4 to 6 p.m.

Notebook # 23

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 ___ and ___.
inside back cover

Item(s) now housed in accompanying folder.



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FX-1 STANDARD FLASHTUBE

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FX-1 PERFORMANCE DATA

| | | |
|----------------------------------|---|--|
| <i>RECOMMENDED RATINGS</i> | Energy Input | 300 watt-seconds (100 μ f at 2000 volts) |
| | Total Output | 1400 horizontal candle-power-seconds |
| | Expected Life | 5000 flashes at 200 watt-seconds |
| | Flash Duration | 150 μ s at rated input (1/3 peak) |
| <i>OPERATING CHARACTERISTICS</i> | Starting Voltage, Min. | 700 volts |
| | Self-Flash Voltage | 1500 volts |
| | Flash Rate, Max. | Once every 5 seconds (300 watt-seconds, 40 watts) |
| | Spectral Output | Daylight in quality (I.O.S.A., V. 36 No. 7 190-379, July 1946) |
| | Tube Resistance | Nominal 2 ohms (loading greater than 30 μ f, 2000 volts) |
| <i>PHYSICAL CHARACTERISTICS</i> | Envelope | Vycor |
| | Source Volume | Diameter 1 mm I.D. and 6 inches long |
| | Gas | Neon at 20 cm. Hg. |
| | Maximum Tube Length | 8-5/16 inches |
| | Maximum Diameter | 9/32 inch |
| Mounting | Kit base clip No. 101001 ("Littlefuse") | |



TYPICAL CIRCUITS TO OPERATE THE FX-1 FLASHTUBE

EDGERTON, GERMESHAUSEN & GRIER, INC.

140 BROOKLINE AVE.
BOSTON 18, MASS.

License information relating to the manufacture and sale of this type of circuit is available upon request.

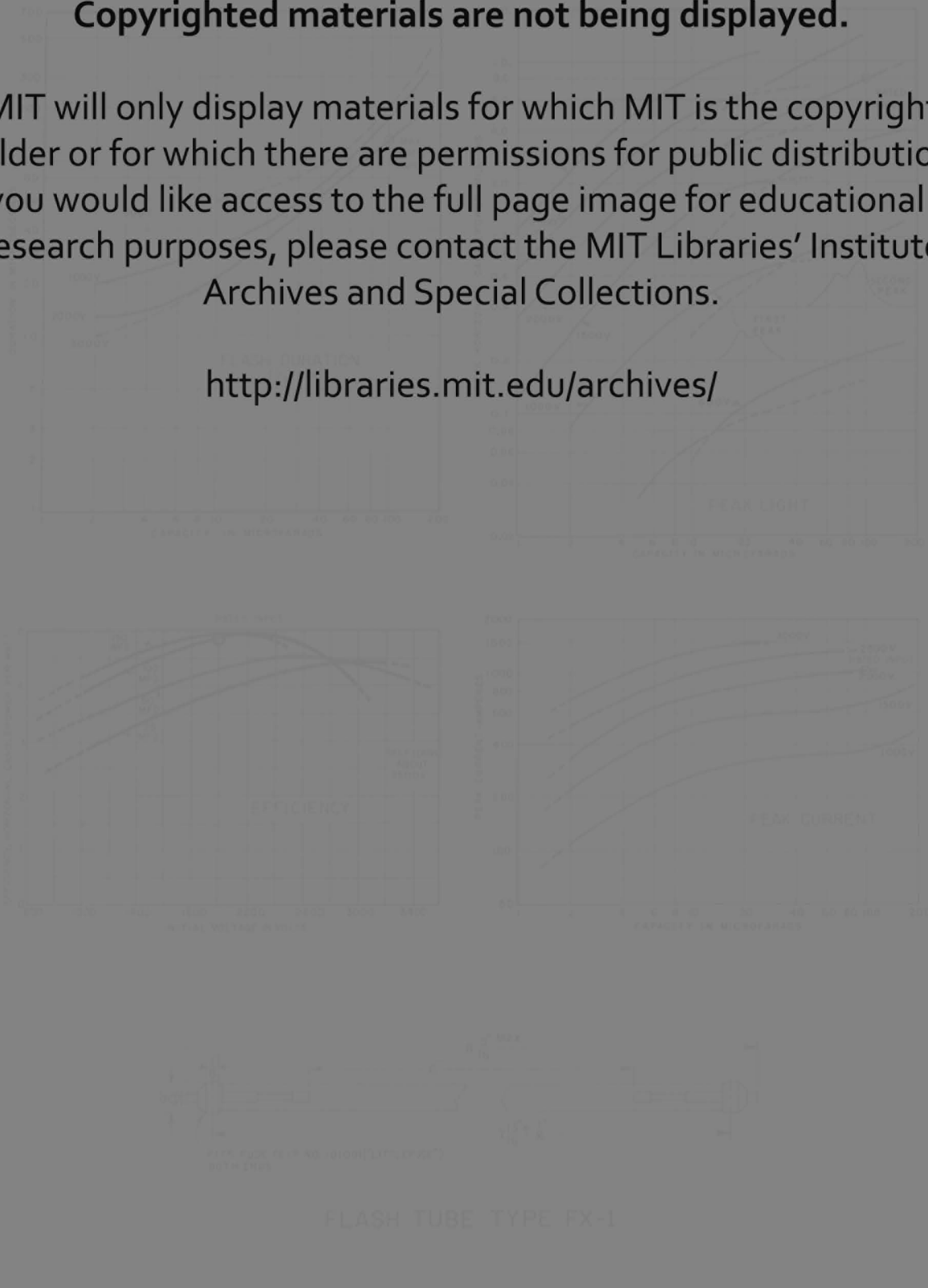


TYPE FX-1

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FLASH TUBE TYPE FX-1

EDGERTON, GERMEHAUSEN & GRIER, INC.

150 BROOKLINE AVENUE

BOSTON, MASSACHUSETTS