

HAROLD E. EDGERTON

PAPERS

MC 25

Series III

Laboratory Notebooks

Number     

Dated August 4, 1952 to Oct. 19, 1952

Massachusetts Institute of Technology

COMPUTATION BOOK

NAME	Number
HAROLD E. EDGERTON	

Course UNDERWATER PHOTOGRAPHY

Used from AUGUST 4 1952, to Oct. 19 1952

Book No.  
August 4, 1952

Notebook # Aug 4, 1952 - Oct. 19, 1952

### Filming and Separation Record

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## NAVY-TYPE MODEL B

30 cu. ft. tank, 18" x 30" x 30" (30 cu. ft.) tank, lighter harness with tapered steel hardware, and no safety air reserve warning. Designed for shallow water use (to 35 ft.).  
Average diving time: two hours. \$275.00

## JUNIOR MODEL C 30+1+1+10

features a smaller (30 cu. ft.) tank, lighter harness with tapered steel hardware, and no safety air reserve warning. Designed for shallow water use (to 35 ft.).

Diving time up to one-half hour. 100.00

## HOOKEH MODEL S 103+7+0

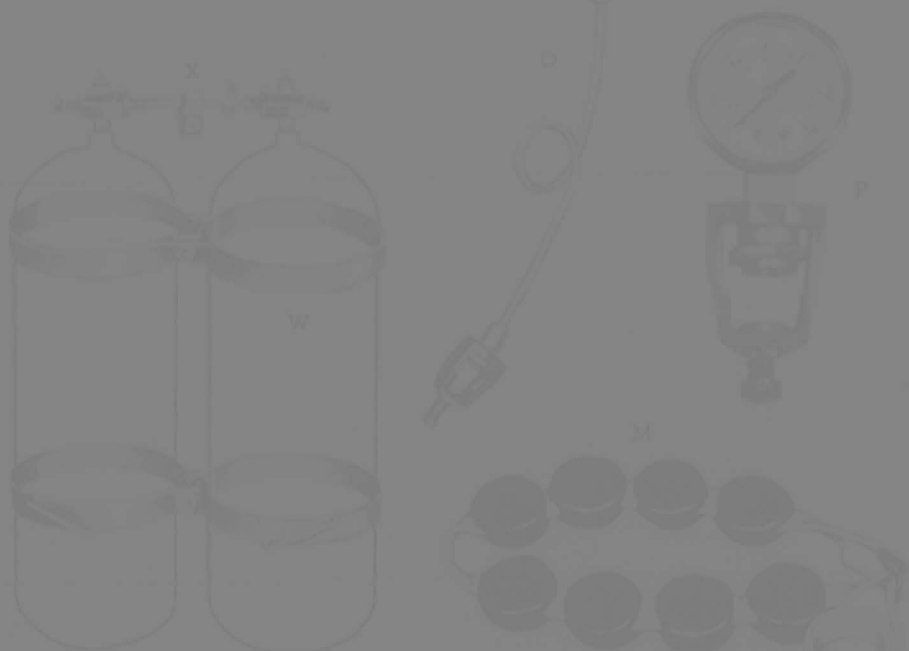
made so that the regulator only is strapped to the back of the diver. The air supply is fed through an air hose from two tanks or a small 150-pound compressor. Designed for work in limited areas during long periods of time, or where high-pressure compressed air is not available. 127.50

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All component parts of the Aqua-Lung can be purchased separately.

(A) Junior Tank, 10 cu. ft. . . . . 20.00

(B) Spare Junior Tank Block #4-E-410 . . . . . 40.00

(C) Spare Junior Tank Valve with air regulator . . . . . 25.00

(D) Spare Junior Tank Valve with air regulator . . . . . 25.00

(E) Spare Junior Tank Valve with air regulator . . . . . 25.00

(F) Spare Junior Tank Valve with air regulator . . . . . 25.00

(G) Spare Junior Tank Valve with air regulator . . . . . 25.00

(H) Spare Junior Tank Valve with air regulator . . . . . 25.00

(I) Junior Tank, 10 cu. ft. . . . . 22.50

(W) Set of metal bands which join two tanks together, with bolts and nuts . . . . . 17.50

(D) Spare Junior Tank Valve with air regulator . . . . . 25.00

(DS) Hookah Regulator, with hoses, mouthpiece and harness . . . . . 75.00

(T) Air Supply Output Pressure Regulator, for Hookah, with input and output gauges . . . . . 30.00

(G) Hookah Air Hose, 50-ft. length . . . . . 27.50

(V) Hookah Air Hose, 100-ft. length . . . . . 50.00

(Y) "Self-Contained Diving" booklet . . . . . .95

(Z) Tank Valve Teflon Washer . . . . . .30

The following accessories are not included with either (A), (B) or (C), and their choice is left to the needs and discrimination of the diver:

(O) Filler Attachment, to connect the Aqua-Lung to any standard compressed air supply fitting . . . . . 12.50

(P) Pressure Gauge, to indicate tank content before or after diving . . . . . 12.50

(Q) Combination Filler and Gauge (O and P), to permit simultaneous refilling and pressure reading . . . . . 20.00

(M) Weight Belt, adjustable to 8 pounds, advisable to offset the buoyancy of the Aqua-Lung. Effortless descents mean air saving, thus longer dives . . . . . 6.00

(N) Additional One-Pound Weight Piece . . . . . .75

(R) Depth Gauge, wrist type, for exact reading of diving depth down to 140 feet . . . . . 3.50

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3. Should any water seep into your mouth, swallow it, if deep under water.
4. Do not let the mouthpiece dangle in the water, as it would fill with water and make diving unpleasant.
5. Head and regulator should both be either above or under water, as air loss would otherwise occur.
6. Beginners and users of the shallow water unit should stay within 80 feet of depth.
7. Observe the safety curve rules and decompression tables if more than 1 cylinder of air is used below 30 feet during any 12-hour period.
8. Although record dives have been made to 300 feet, amateur divers should not exceed 130 feet.

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Under water the slightest change in depth causes variations in pressure... make breathing difficult. Again, it is an established fact that it is impossible for the human chest to withstand an outside pressure (exceeding the pressure within the lungs) of more than 6 ft. of water. That is to say, if a normal man tried to breathe under water by means of a hose inserted in his mouth and connected with the air at the surface, he would be unable to expand his lungs after he reached a depth of more than 6 ft. In view of this, the sensitivity of the Aqua-Lung regulator has been fixed to cause it to respond to a very slight difference of pressure (2 to 4 inches of water); therefore eliminating all breathing difficulties, regardless of depth at which the Aqua-Lung user is operating.

### Exhaling problems in regard to the design of the apparatus

This difference of pressure sufficient to operate the regulator corresponds, of course, to a displacement level of two or three inches of water. If, therefore, the outlet for the exhaled gases happens to be above

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- #1501 "Standard" Arboletes (1 set of elastical), practical range: 14 feet (line spear: 35 feet) . . . . . 25.00
  - #1502 "Deluxe" Arboletes (2 sets of elastical), practical range: 20 feet (line spear: 50 feet) . . . . . 35.00
  - #1503 "Junior" (small size for boys and women) . . . . . 22.50
- Spare Parts:

#1511 Standard Spear, complete . . . . .	4.95	#1555 Check spearpoint body . . . . .	.75
#1512 Deluxe Spear, complete . . . . .	7.25	#1556 inner stainless barb . . . . .	.35
#1513 Junior Spear, complete . . . . .	3.25	#1557 spearpoint tip . . . . .	.65
#1514 1-barb spearpoint . . . . .	1.50	#1558 handle . . . . .	3.00
#1515 2-barb spearpoint . . . . .	2.25	of Deluxe . . . . .	3.25
#1516 3-barb spearpoint . . . . .	2.75	#1559 bottom grip screw . . . . .	.15
#1517 4-barb spearpoint . . . . .	3.50	#1560 complete grip . . . . .	3.25
#1520 Standard Nylon Line (14' to 30' in. dia) . . . . .	.75	#1571 string screw . . . . .	.15
#1521 bare spear shaft . . . . .		#1572 string line . . . . .	.50
of Standard . . . . .	2.50	#1573 spring string . . . . .	.20
of Deluxe . . . . .	2.80	#1574 center grip tip screw . . . . .	.15
of Junior . . . . .	2.20	#1580 center grip bottom screw . . . . .	.15
#1522 inner spring . . . . .	.25	#1575 center grip . . . . .	.75
#1523 trigger . . . . .	.75	launcher screw . . . . .	2.50
#1524 bar-line screw . . . . .	.60	#1577 center grip complete with base . . . . .	1.35
#1525 side ring . . . . .	.45	#1580 elastic string, each . . . . .	
#1526 compressing bushing . . . . .	.20	of Standard . . . . .	1.50
#1527 barb ring . . . . .	.15	of Deluxe . . . . .	1.25
#1528 outer stainless barb . . . . .	.25	#1571 long Deluxe elastical . . . . .	1.50
#1529 safety lever . . . . .	.10	#1582 square screw . . . . .	.10
#1530 safety body . . . . .	.25	#1584 hand stop . . . . .	
#1531 safety eccentric disc . . . . .	.15	of Standard . . . . .	4.50
#1532 safety spring . . . . .	.25	of Deluxe . . . . .	4.95
#1533 top grip screw . . . . .	.15	of Junior . . . . .	3.95

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*Agua-Lung*

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The Aqua-Lung, because of its special features, is unique. It represents the greatest advance to date in underwater breathing equipment. Among its many advantages is that it uses compressed air and operates on the open circuit principle, i.e., the air is breathed in from a cylinder and exhaled into the water, in the form of bubbles. No chemicals are involved. The mechanism controlling the air supply is completely automatic.

The Aqua-Lung must never be confused with similar equipment using oxygen and certain chemicals. This latter type of equipment operates on what is known as the "closed circuit" principle. Oxygen from a cylinder on the back is breathed in, and the exhaled gases are absorbed by a purifying device containing caustic soda.

Use of oxygen limits diving to 33 feet of depth, as this gas is extremely dangerous under greater pressures. Should the chemicals become moistened, the diver's lungs would be burned.

No such limitations or dangers are associated with the Aqua-Lung. The user is free of breathing worries.

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### Easy breathing is imperative regardless of swimmer's position in the water

When submerged, the difference in pressure of a few inches of water can become very important. The underwater swimmer must never experience the slightest difficulty in breathing, nor must there be any leakage of the precious life-giving reserve of air regardless of the position of the swimmer's body (head upward or downward, or whether he is on his back, stomach or side). The efficient, automatic valve in the Aqua-Lung completely takes care of all this.

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Check your classified directory under heading "Oxygen". Most firms specializing in compressed gases can compress air. Linde Air Products, National Cylinder Gas and Puritan Compressed Gases have been very cooperative.

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### Aqua-Lunging in California

Buster Crabbe (l.), Capt. Hal Messinger (r.), formerly of the U.S. Navy, and, in the center, the author. Malibu, 1949

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### FLOATING KNIVES with sheaths

- #1301—Knife, large, sharp stainless blade . . . . . 4.50
- #1302—Dagger, long, double-edged blade . . . . . 4.95

Neither of these buoyant-hordled weapons can be lost, as they float back to the surface. Handy for work above or under water. French imports.

### SNORKLE TUBES

Made of plastic with rubber mouthpiece. An ideal device for skin divers. Permits breathing while keeping the eyes under water at all times, thus preventing glare of sunlight from blinding the diver whenever he looks up to reach for air.

- #1401—Straight type . . . . . 1.95
- #1402—Features a ball attachment which automatically seals tube when immersed . . . . . 2.95
- #1411—Molded mouthpiece only . . . . . .85

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### Decompression problems

Among the gases in the air we breathe, such as oxygen, carbon dioxide, nitrogen, etc., only nitrogen dissolves mainly into the bloodstream. The quantity of nitrogen dissolved in the body during submersion is proportional to the depth obtained, and to the duration of the submersion.

If a diver or underwater swimmer ascends quickly after a long period of submersion, the dissolved nitrogen is released within the body in the form of bubbles or gas. When in large volume, these bubbles cause "the bends" or "caisson disease", as mentioned earlier, resulting in weakness, dizziness, pains in the back and legs, painful constriction of the chest, and have been known to cause lesions of certain tissues.

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### Non-corrosive parts

All practical underwater equipment should, of course, be constructed of materials that resist the severe corrosion of sea water. Materials used in the Aqua-Lung more than meet this requirement.

### Suitability of harness

The harness supplied with this equipment insures that the cylinder and the regulator for the air supply are properly positioned on the wearer's back and will not cause physical discomfort or other inconveniences, even when the swimmer's head is pointed down. Its design is the result of long experiments in search of the ideal harness for such work.

The Aqua-Lung, therefore, meets all the conditions set forth for ideal underwater equipment. Evolved over many years of practical underwater experience, under all conditions, this apparatus successfully combines the skill and ingenuity of invention and industry with the practical needs of the diver and underwater swimmers. The result is equipment which may be used by any average swimmer with complete confidence, giving him the widest possible freedom under water.

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### The intoxicating effect of great depths

At depths of 150 to 200 ft., some individuals begin to experience a feeling of being doped, accompanied by a sensation of numbness. This is due to breathing nitrogen in the air under pressure. Harmless in itself it can become dangerous only because it may affect the swimmer's faculties and reflexes, weakening his natural instinct for self-preservation. The condition passes off as soon as the surface is reached. Here again, this can be avoided by refraining from descending to depths of over 130 ft. Experts with specialized training do, of course, descend to greater depths than this, but because of their training, are more protected against the risks.

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### DIVING OR UNDERWATER SWIMMING

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All these hazards are eliminated in the use of the Aqua-Lung.

It should be understood at the outset that anyone physically fit and in good health, as is required for most sports, can dive and swim under water with the Aqua-Lung.

#### Pains in the ears

Regarding pains in the ears, this may be considered of little importance and can be eliminated by certain simple measures. As previously mentioned, as a swimmer goes deeper, pressure naturally increases on his body, which is indicated by its restricting effect on his lungs. The rest of his body remains practically insensible to the increased pressure, though it is to be expected that flexible cavities containing air or gases, such as stomach, intestines, etc. will be slightly deformed, but without noticeable inconvenience to the swimmer. On the other hand, sinuses and ears (cavities with bony structures) fortunately are equipped by nature with tubes connecting them with the windpipe. Consequently, the air pressure within these cavities automatically adjusts itself to the variations in pressure imposed on the body and maintains equilibrium. Normally, sinuses are not affected by submersion unless the diver or swimmer has sinus trouble, or is afflicted with a severe cold in the head. In such an event, he would be advised not to undertake underwater excursions until the trouble has cleared up.

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Navy dell, A. E. D.T. member cutting through  
an Aqua-Lung, long rubber Program 800 and



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**ATTENTION**

**ALWAYS USE COMPRESSED AIR**

**NOT OXYGEN**

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### (2) Description of the apparatus

The complete Hookah consists of:

- (a) <http://libraries.mit.edu/archives/> as the Aqua Lung regulator. As in the case of the latter, this regulator feeds the diver through a corrugated hose and mouthpiece assembly. A specially designed harness allows for attachment of this regulator to the user's back.
- (b) an air flow regulator with two gauges, mounted on the compressed air source, which may consist of either
  - (1) an air bank of one or more high-pressure compressed air tanks, or
  - (2) a low-pressure compressor with a small storage tank (150 p.s.i. or more)
- (c) a rubber hose which connects the Hookah to the air flow regulator.

This rubber air hose features fittings at the ends which permit it to be attached to the Hookah, at one end, and the air flow regulator, at the other. Additional hose lengths are available.

### (3) Instructions for use of the Hookah

- (a) Attach the air flow regulator to the compressed air source.
- (b) Attach the proper end of the air hose to the output side of the air flow regulator.

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UNDERWATER  
CAMERAS

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#1501 Viola case for the  
underwater camera and  
lens . . . . . 175.00

#1502 Viola case for the  
underwater camera and  
lens . . . . . 295.00

(Items above are usable  
down to 40 feet)

#1503 C.T.M. "CG-19": Mari-  
oral 35 mm professional  
movie camera with protot-  
ized housing (assembled to a  
small Aquolana II breath-  
er). Both spring and electric mo-  
tors. Camera can be removed  
for use on shore. . . . . 4,650.00

#1504 C.T.M. "CG-32": The  
famous monopicture cam-  
era used by Capt. Cousteau  
in the making of his prize-  
winning masterpieces. None  
better. Lab. Paris . . . 6,750.00

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### Harness

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- **Weight Belt**—pounds or more, adjustable by the manufacturer, and advisable to offset the buoyancy of the Aqua-Lung. Effortless descents mean air saving (this longer dive).
- **Depth Gauge**—reading of diving depth at all times (Boyle's law).
- **Dagger (floating)**—double-edged, rigid stainless steel blade with cork handle. Sheath designed to hook onto belt.
- **Res-Q-Pak**—the size of a cigarette package, attaches to the diver's belt and releases a 2-foot plastic water wing upon squeezing. CO<sub>2</sub> operated, it will float a 250-pound man.
- **Swim Fins**—a great variety on the market. A must.
- **Rubber Suit**—even in temperate climates, the water will be cold at depths of 50 feet or greater.
  - (a) short rubber suit covers the whole body except arms and legs. Satisfactory for summer use, and for water above 55° F.
  - (b) long rubber suit, same as above, plus arms, legs and boots, for any water temperature.To accomplish its purpose, a rubber suit must be worn over heavy underwear and sweaters.
- **Snorkle**—while the equipment is weightless under water, it is felt when cruising on the surface. The snorkle tube will allow the diver to breathe and swim right below the surface without effort, before or after the actual dive.

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Originated on the West Coast, this cold-water suit is the  
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Easy to put on and take off, through the extra-large back-entry  
chute. Available in four styles:  
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#1111—Extra heavy "Alaska" underwear for short suit 14.95

#1112—Extra heavy "Alaska" underwear for long suit 17.95

When  
Weight, height, waist, chest, shoe size, length of arm (cuffpit  
to inside wrist), length of leg (crotch to floor), circumference of  
arm (2" above elbow), circumference of leg (5" above knees),  
circumference of wrist.

#1131—Hydrous silicate of magnesium; sprinkle on both sides  
of suit for better preservation of rubber . . . per can .60



## THE PIRELLI SUIT

The only 2-piece suit available; en-  
ables the diver to get in and out  
without help. Used by the Italian  
Navy, and made by the most famous  
European rubber manufacturers. All  
vulnerable parts (knees, elbows, etc.)  
are reinforced, all seams vulcanized.  
Beautifully tailored in three sizes.  
Indicate height when ordering.

#1121—short arms and legs 47.50

#1122—long arms and legs  
with feet . . . . 60.00

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### (4) Weighting of the diver

The diver may attach weights either around his belt, or on his feet, according to the orientation in which he wishes to move through the water.

### (5) Maintenance

The Hookah maintenance instructions are identical to those for the Aqua-Lung.

### Warning

Hookah units must be operated only on compressed air, to the exclusion of all other gases, particularly oxygen, whose use in such apparatus is extremely dangerous.



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René Russoz and associate, Paul Arnold, diving off the "Volero IV" (C.S.C.), complete with Aqua-Lung, short rubber suit, and the deadly Arbalète.

Palos Verdes, 1950

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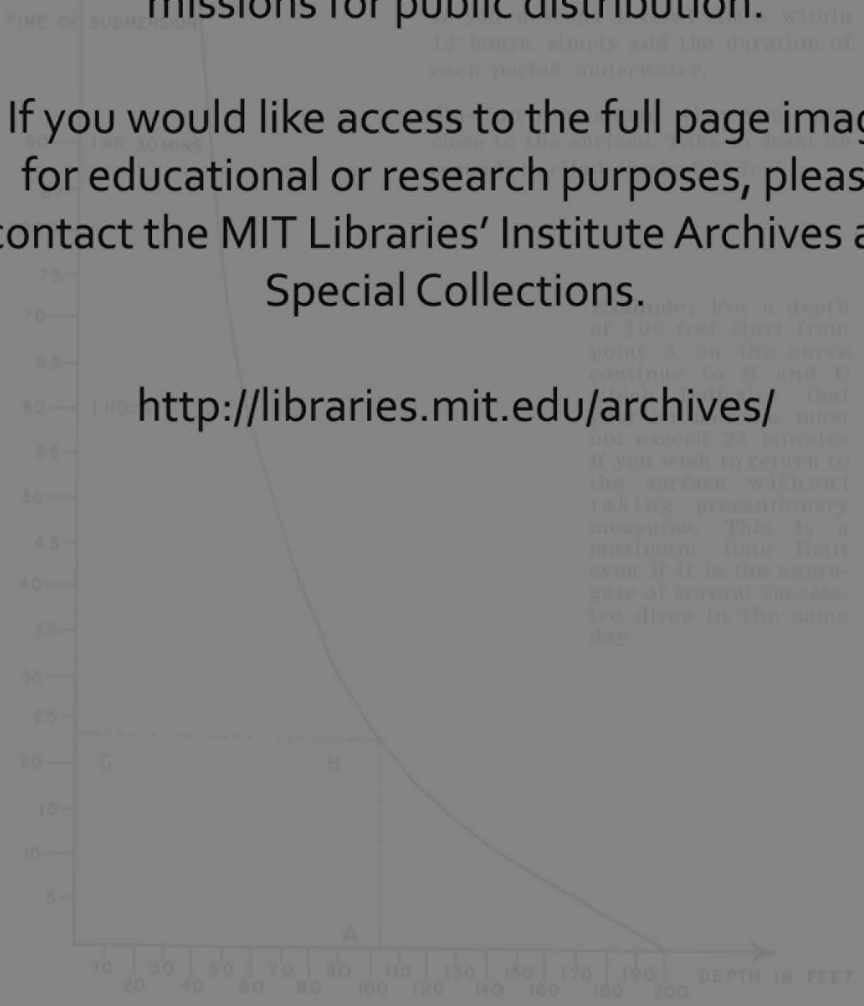
- |   |      |
|---|------|
| ±1901 "Shallow Water Diving," by Schenck & Kendall<br>(a review of all modern equipment and its comparative merit)  | 2.50 |
| ±1902 "The Sea Around Us," by Rachel Carson<br>(pleasant reading, packed with scientific data on the ocean)   | 3.50 |
| ±1903 "Diving to Adventure," by Hans Hass<br>(the most amazing book by the world's most daring diver)   | 3.75 |
| ±1904 "I Like Diving," by Tom Eadie<br>(an honest evaluation of the profession by a Navy diver)   | 3.00 |
| ±1905 "I Dive for Treasure," by Lt. Harry Rosenberg<br>(dreams come true, in scientific treasure hunting)   | 3.00 |
| ±1906 "Treasure Below," by Comdr. Edward Ellsberg<br>(full of suspense and submarine thrills)   | 2.75 |
| ±1907 "True Tales of Buried Treasure," by E. R. Snow<br>(authentic facts on many lost treasures)  | 3.00 |
| ±1908 "Submarine Spearfishing," by Legros<br>(complete manual on spearfishing techniques and experiences)   | 2.75 |
| ±1911 "Deep Diving and Submarine Operations"<br>by Sir Robert H. Davis (complete history of diving and<br>equipment. Beautifully illustrated, 700 pages.) | 6.95 |
| ±Y "Self-Contained Diving" digest, by Rene Bussac<br>(a guide for the neophyte diver, with scientific information)  | .95  |

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910-48 BINDING HEAD X-REF 891

910-52 BOTTLET TUBE 4 AS

910-19 PAUSE SIGNALING 891

910-48 BOTTOM BOX ASSEMBLY 691

910-43 DIAPHRAGM ASSEMBLY LP 395

910-13 GASKET 851

910-16 RINGS 175

910-17 BOX CLIP 151

910-40 TOP BOX ASSEMBLY 696

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951-2 AIR YOKE SCREW 281  
951-4 YOKE 635  
951-21 WADLE ASSEMBLY H.P. 300  
951-5 GASNET H.P. 351  
951-6 BODY 785  
951-8 GASNET 451  
951-3 PIN H.P. 451  
951-4 PIN SUPPORT H.P. 400  
951-11 WASHER L.P. 351  
951-12 NOZZLE L.P. 155  
951-14 HORSESHOE SPRING 451  
951-7 PLATE 110 401  
951-57 DAMPER GASNET H.P. 351  
951-8 SPRING PAD 301  
951-32 HORSESHOE ASSEMBLY L.P. 350  
951-13 HINGE SCREW 281  
951-5 SPRING H.P. 301  
951-20 HINGE PIN 301  
951-10 SPRING RETAINER 150



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### Duration of underwater operations with Aqua-Lung unit

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

	1 Cylinder	2 Cylinders
At the surface . . . . .	100 minutes	3 hrs. 20 minutes
At a depth of 33 ft. . . . .	50 "	100 "
At a depth of 100 ft. . . . .	25 "	50 "

With practice, these periods can, of course, be increased depending on the type of work performed. It is advisable to avoid undue motion as much as possible. This can be greatly facilitated by the rubber swim fins which permit almost effortless control and movement of the swimmer's body under water.

Economy of movement and effort (which conserves the air supply) can be achieved by ascending almost to the surface when an appreciable distance has to be covered, moving through the water, and then

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of AQUA-LUNG EQUIPMENT

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

## Regulator unit

The regulator unit is the heart of the Aqua-Lung apparatus, controlling as it does the life-sustaining air supply. It is a round box-shaped assembly of chrome-plated brass. Though small, it is equipped with separate high and low pressure stages, which automatically adjust and perfectly equalize the pressure of the breathed air to that of the surrounding water, and also adjust the flow of air automatically to the breathing rhythm.

It is absolutely impossible for the adjustment of the unit to change during operations. The regulator is very easily connected to the cylinder by means of a yoke. Under the metal cover of the regulator, easily removable, is the rubber flap valve for exhausting the exhaled gases.

## Mouthpiece for breathing

The rubber mouthpiece for breathing, also the result of much experimenting, is firmly held within the mouth and jaws and gripped by the teeth, while the lips close completely over the ridge.

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

Depth		Duration during ascent			Total
Surface to depth	Bottom to surface	100 feet	200 feet	300 feet	300 feet to surface
15 meters or 50 feet	2 hours	0	0	0	0
25 meters or 80 feet	45 minutes 50 minutes 1 h. 15. m. 1 h. 30 m.	0	10	15	31
		0	20	18	48
30 meters or 100 feet	25 minutes 40 minutes 1 hour 1 h. 15. m.	0	0	12	12
		0	16	16	32
		0	27	21	48
35 meters or 115 feet	18 minutes 20 minutes 45 minutes 1 hour	0	0	11	11
		0	16	16	32
		0	28	21	55
40 feeters or 130 feet	15 minutes 20 minutes 50 minutes 1 hour	0	0	0	0
		0	10	16	26
		0	28	28	56
		13	28	28	69

For depths exceeding 130 ft. the total time limit for remaining down without feeling ill effects, decreases rapidly. Only trained swimmers and divers should attempt descent to such depths. (See chapter, Hints on Diving or Under-water Swimming.)

Harold E. Edgerton  
Mass Inst of Tech  
Cambridge  
Mass.

August 4 1952.

Underwater photography  
experiments. —

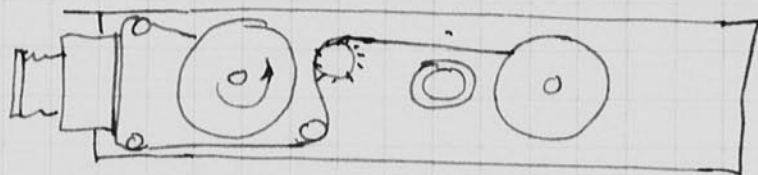


August 4 1952

Harold G. Edgerton

Woods Hole Ocean Inst. aboard "Bear"

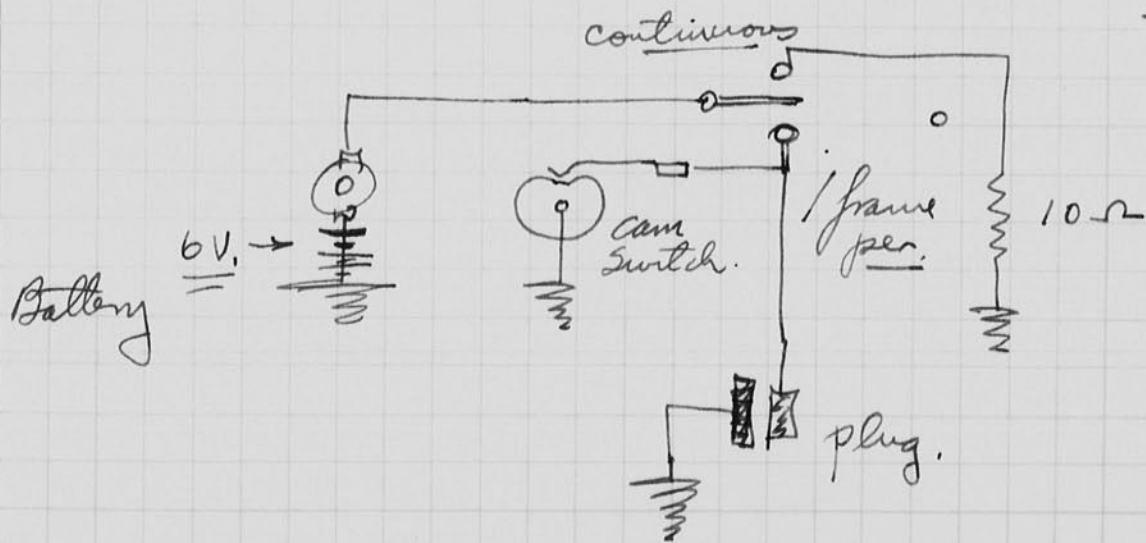
For the past few weeks an underwater camera and light have been made at M.I.T. J. Keeffe at the RLE machine shop built the stainless steel case. The camera proper was built on a panel that just fit into a 5 1/4" I.D. tube case. The camera takes a standard 100 ft roll of 35 mm film. A photo of the camera works was taken yesterday. I hope to put prints in this book later.



FULL ROLL

TAKEUP

A strip belt is used to the take up reel. The recycle time is about 2 1/2 seconds. A cam switch turns the camera off after a double 35 mm frame is wound. Recycling is arranged by a switch that shunts the cam switch



The 10 ohm resistor reduces the rate to about 1 picture for 5 sec.





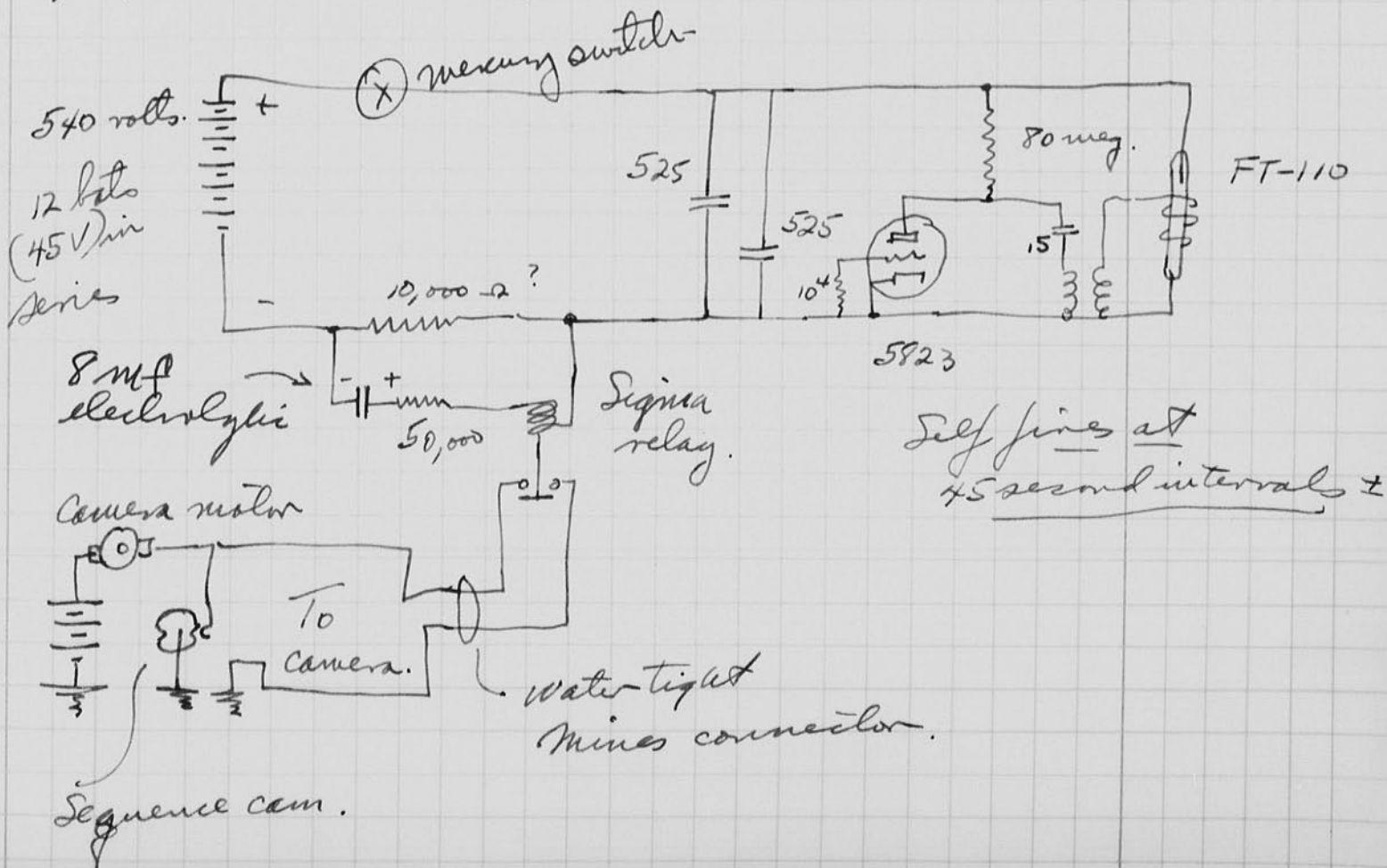
Aug 5 1952  
 "Bear" at WHOI.

Yesterday I drove from Cambridge to WHOI with my sons Bob and Bill together with the underwater camera and lights. We arrived about 9:30 am and after making some strengthening repairs for the clamps on one of the lights, went aboard the Bear where we spent the night.

After dark we lowered our camera and lamp off the stern of the Bear and allowed the equipment about 10 minutes of operation time. These photos were developed and showed little. One photo of the end of the boat above water was very good. One photo of the bottom was out of focus.

Two types of operation are possible with the camera. The first is described below.

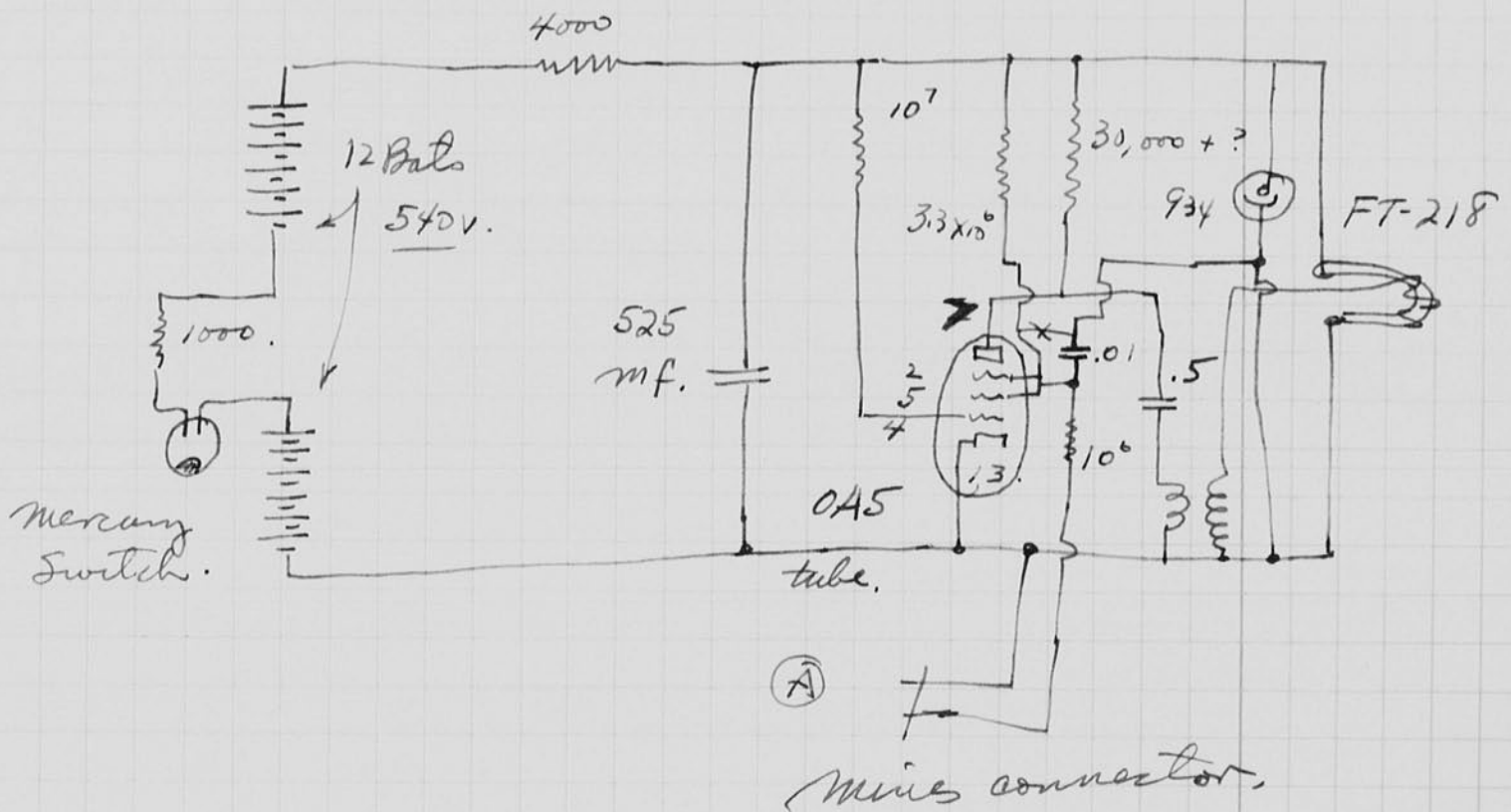
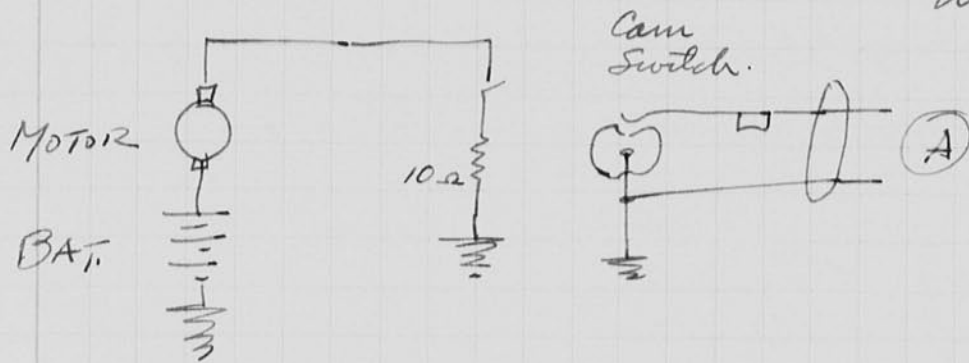
The strob lamp is arranged to flash at 45 second intervals.





The second method of taking photos involves a different flash tube equipment that is arranged to flash at 5 second intervals.

The camera now runs ~~with~~ continuously but with a 10 ohm resistor to slow it down from 2.5 sec to 5 sec per frame. The cam is used to fire the lamp as shown in the circuit below. An open circuit causes the strobotron tube to fire.





Aug 7 1952

9

on "Bear" about 50 miles south of Woods Hole.

We left on Aug 5 from W.H. Some time was consumed in testing a .800 # lead sphere on a flexible jointed cable for horizontal pulling with a Edo sound ranging device.

We have to while the Risk took off some of the sound men and a wrench operator. Then another delay while a mechanic came aboard to fix an inverter and the ice box.

In the afternoon we left Gayhead and headed south. A wind was blowing from the south and the waves were about 10 ft high causing the Bear to roll and pitch. We cruised south until about 1 pm the following day Aug 6, where we stopped when we sighted the canyon.

The canyon crew was also photographing the scattering layer. We did not pick up the scattering layer until we reach the position of the canyon.

The camera and light were hooked together and lowered to find the scattering layer. This apparatus is described on page 5 of this book.

From Tex Hoodley's book p 107.

Plus X film f 4

Scale set on 10 ft

(actually less than scale reading).

Roll 1

no shutter camera.

14.45 in water

14.59 270 meters 10° wire angle.

15.17 280 meters

15.31 290 meters

Vessel is rolling 20°-25°.

15.40 332 meters.

15.50 345.

16.02 Started the camera in to 300 meters after observing that the layer had risen since our 15.50 lowering. Stopped at 299 m



We thought the hobbing camera might be causing the scattering layer to change its position.

16.14. Started camera in at slow rate

16.29 250 meters. While bringing camera up noted on fallometer that scattering layer again got very heavy.

16.25 Started lowering the camera

16.29<sup>1/2</sup> reached 250 meters started lowering slow to 280 m reached at 16.30

at 16.30. it was noted that the S.F. had taken a sharp dip but had not thinned. We are lowering the camera 10 m more to 289

16.41 Fallometer (Volkman) ref to layer started up. Sharp layer.

(The chart will be interesting to study.)

17.52 up to 200 meters. ← notes omitted on scat layer

18.09 bring up to see if light is flashing OK. Back down.

18.26. camera @ 191 meters.

19.00 camera up and taken aboard ship.

The fast cycling camera was now rigged for closeup photos of the scat. layer. a lens extender was used giving about a 1 to 1 photo.

Plus X film f16 was used.

The winch was accidentally pulled up instead of down. The cable broke and dropped the camera and light to hit the rail of the ship and then the deck. Although the aluminum casting on the lamp was broken, I thought best to try the gear. It seemed to flash ok so we sent it over the side.

12

Roll 2.

2005 camera on and flashing.  
2038 down to 10 meters.

2043 startup slow.

Back to first lamp (45 sec)

Roll 3

2115 45 sec camera lowered to 21 meters

2200 camera lowered to 300 meters

2230 - 2235 camera lowered to 600 meters.

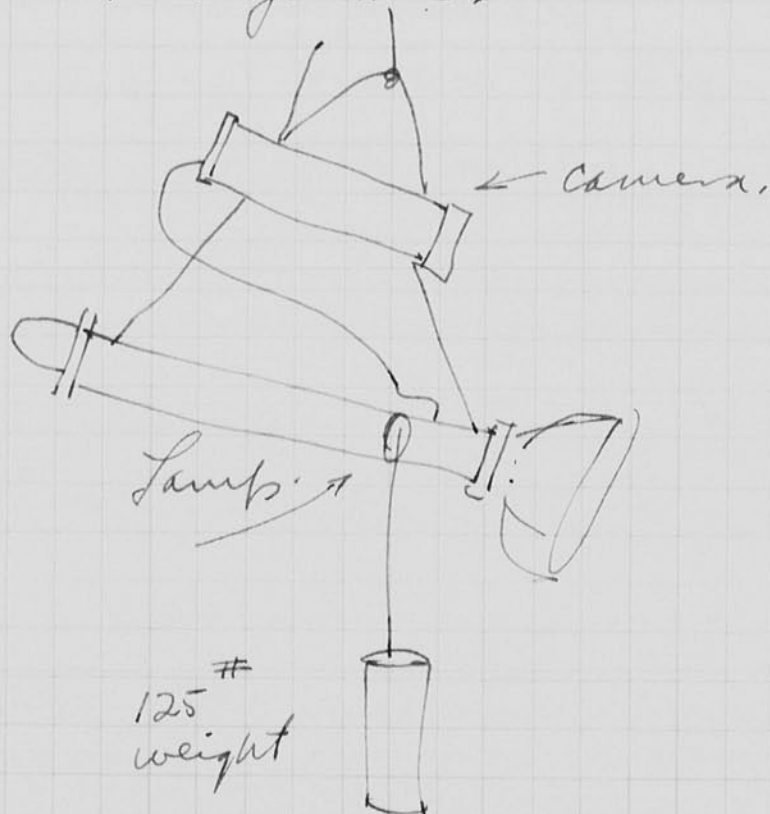
Brought up slowly, - flashing ok when  
brought about.  
Tini is this day.

Today we reworked the camera where it  
was broken in the gate due to the bumps  
on the deck yesterday.

The 10" aluminum reflector was  
installed on the 5 sec interval lamp.

Roll 4.

an attempt was made to photograph  
the bottom at 40-50 fathoms.



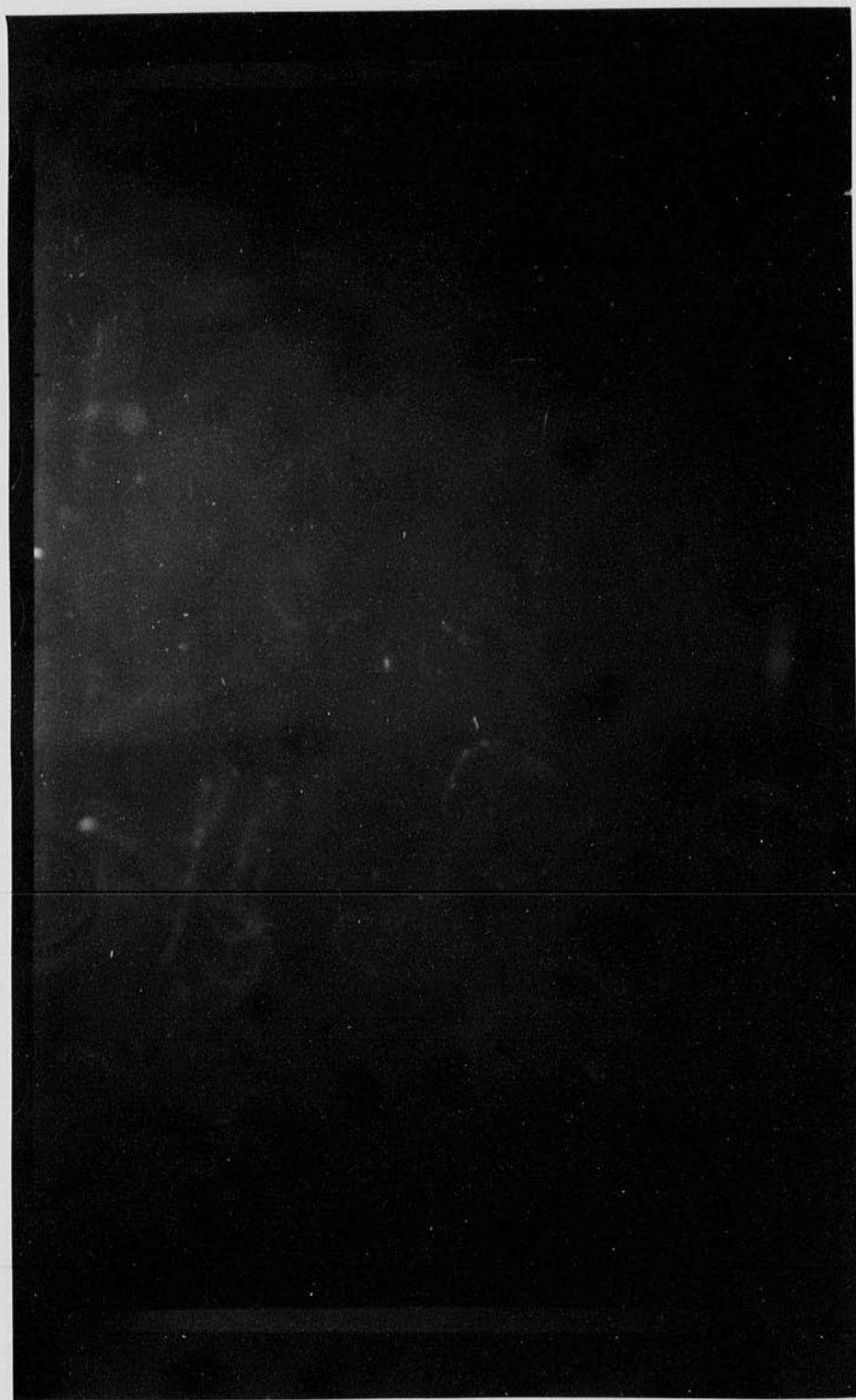
The device was lowered until the bottom  
was hit, then it was taken up about a  
meter and held while the ship rolled.



1. It would be very difficult to change batteries at sea. I was under the weather most of the time. Bob and Bill spent about all their time in the sacks.
2. A fast rigging method is needed for attaching the lamp and camera on the desk to the wish and to the weight.
3. A camera with a shutter is really needed so that daylight will not interfere with the photography.
4. An on-off switch is required for stand by son detection while on desk waiting for the inevitable delays that come up.
5. The back plate should not turn on the camera and trouble is bound to occur due to the twisting wires.
6. Low impedance circuits are really needed!
7. The mine connectors did not read 6V. but may have on 200 with 1 meg input. However they were ok when oiled and greased.
8. No trouble with O.Ring's.
9. Camera condensation was very bad when the camera was brought up from deeps and exposed to air. Some method should be devised to warm up camera. Also an effort should be made to reduce condensed water in camera on lenses and windows.

Position of photograph of scattering layer

$71^{\circ} 5'$  }  
 $38^{\circ} 50'$  }



August 7 1952.

15

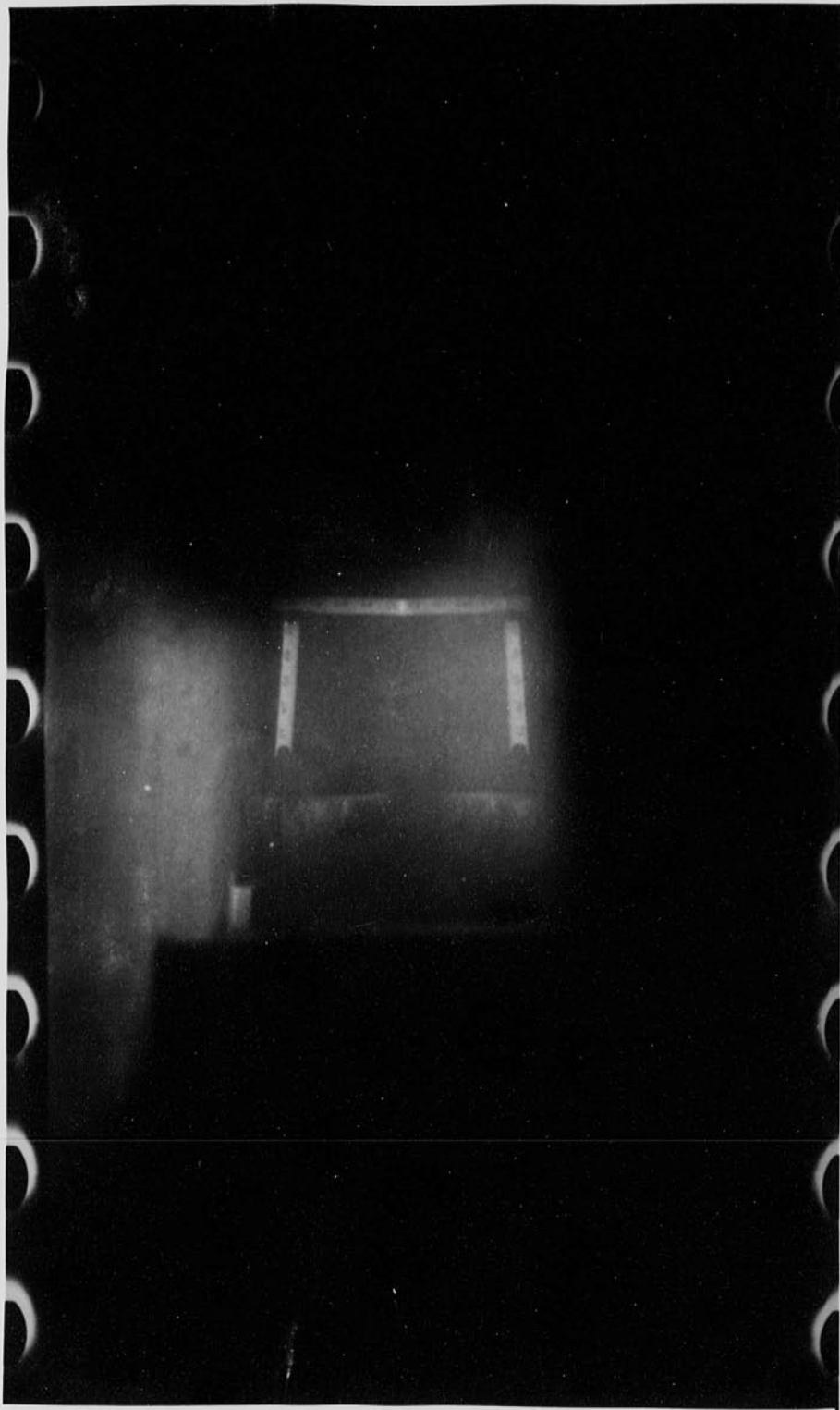
Harold S. Edgerton.

The Bear dodged about 5 pm yesterday.  
We had trouble getting our car started due  
to moisture and the long delay, while away.  
Whispering Willil and Dave Owen helped us to  
get the Plymouth started.

Today I had the negatives developed at  
the master motion picture plant in Boston.

The first negative showed an animal  
on the fourth frame, thus about 3 minutes  
after the camera was put in the water.  
See notes on Roll 1 page 9. Also many of the  
photos showed spots of light. Dave Owen  
had reported similar spots.






August 8 1952  
H. E. Eberhart.

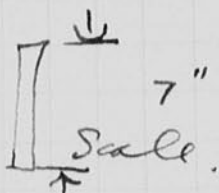
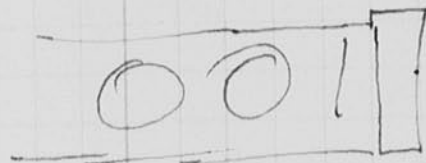
Bob Eberhart  
MIT 20 D 102

Under worst tests of conditions  
as used in Roll P on the Bear.

Camera set at ~~10m~~<sup>10M</sup> on scale. f 4.  
Actual distance is less than this  
since the lens is not set correctly  
at  $\infty$ .

  
Green flash.

Dark room seals.



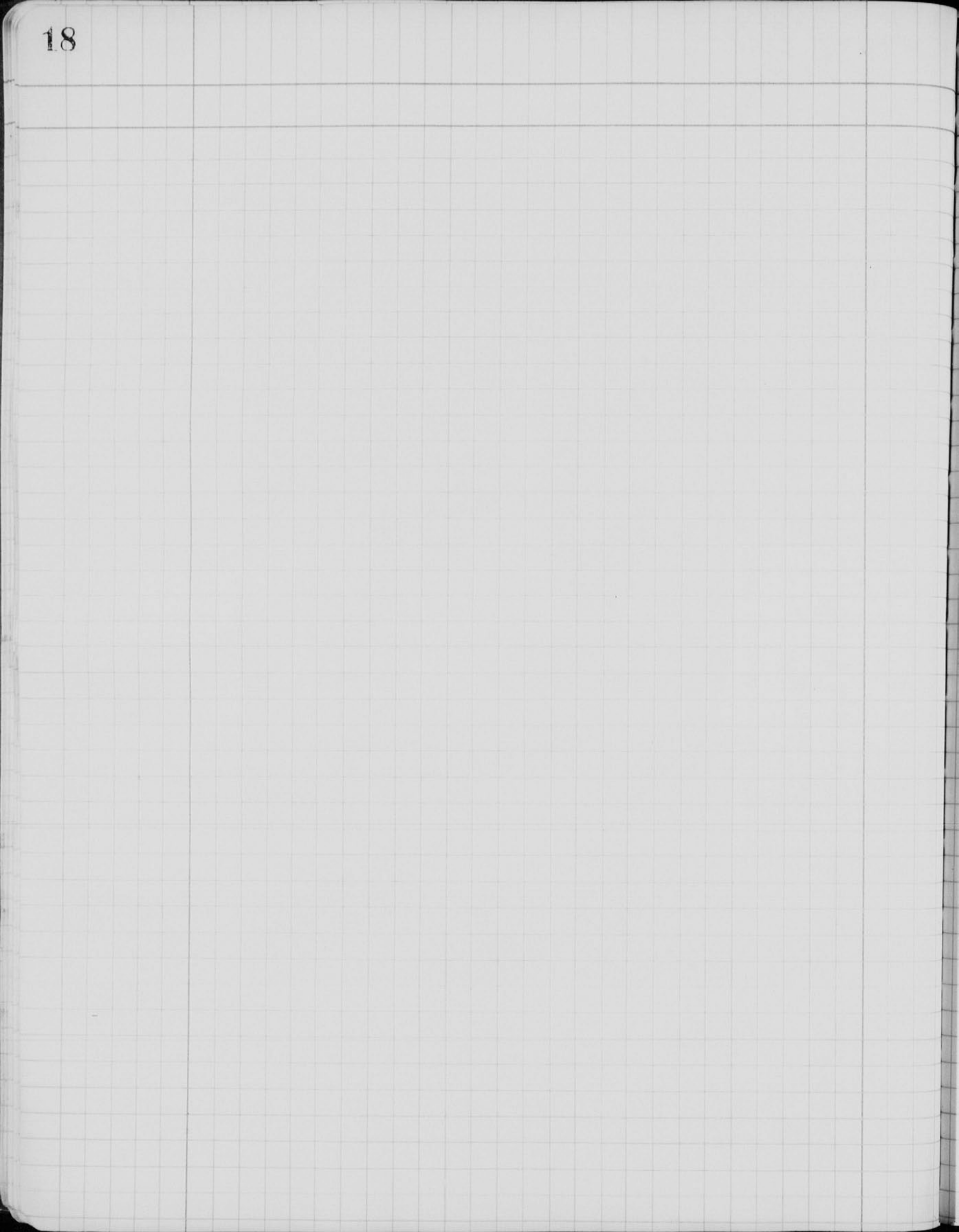
#1 Scale at 6" from front of glass plate.

- |     |     |  |
|-----|-----|--|
| # 2 | 6"  | all overexposed  |
| # 3 | 12" |  |
| # 4 | 18" | experiment repeated<br>with towel over lamp.<br><del># 2 eliminated.</del> |
| # 5 | 24" |  |
| # 6 | 30" |  |
| # 7 | 36" |  |

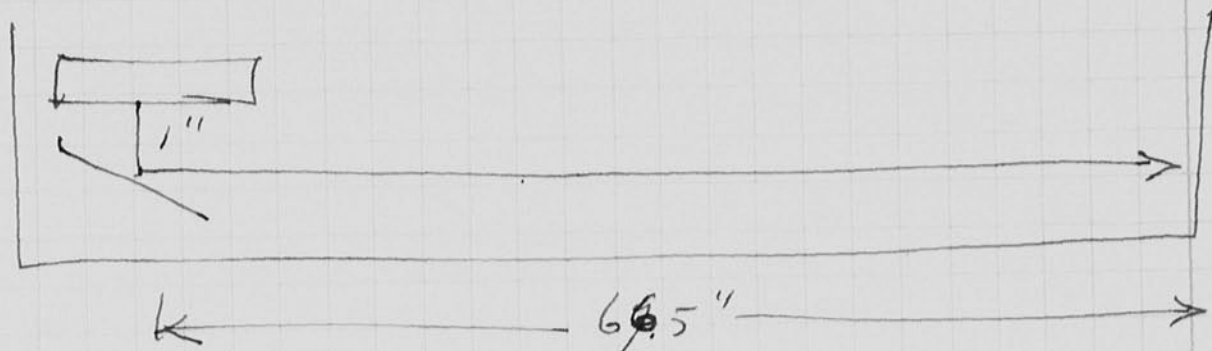
- 6"
- 3"
- 6"
- 9"
- 12"
- 18"
- 24
- 30
- 36.
- 42

The dial was set  
on 8 meters  
instead of 10

Note the last photo at 42" was  
just coming into focus.



A mirror was then put in the sink  
as shown.



42"	# 1	nothing sp.
54"	# 2	<del>42</del>
60"	# 3	#
66"	# 4	
66"	# 5	
60"	# 6	

67.5
25.5
42.0
13.5
54.0

67.5
42
25.5
6.
19.5
13.5
7.5
1.5

42"
48
54
60
66.

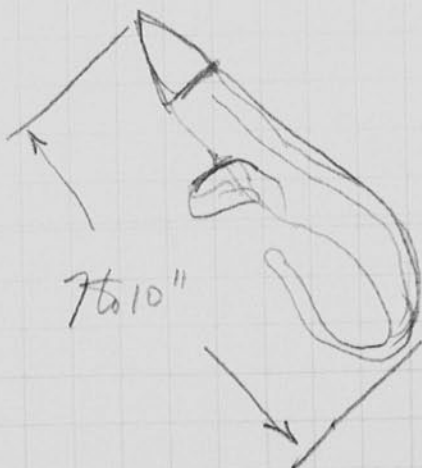
5# 1'  
5# 6"

Focus is sharp at max distance 5'6", or 5'.

A photo of a ruler was made to  
establish a scale.

The animal photographed was  
thus about 9 inches long, if in sharp  
focus.

Better estimate 7 to 10 inches in length.







Reference

21

Robt S. Dietz U.S. Navy Elect Lab San Diego 52 Calif.

Deep Scattering Layer in the Pacific and  
Antarctic Oceans.

Sears Foundation Journal of Marine Research  
Vol. VII No 3 Nov 15 1948 P 430-442 Fig 1-3

150 to 450 fathoms in Pacific  
700 2700 ft.

D.S.L. discovered in 1942

Diurnal cycle

zoo plankton

Copepods

Pelagic prawns

Euphausiids

Phytoplankton

nekton such as fish or squid

Syman (Squid). Sci Monthly 11 (4) 66 (1) 87-88

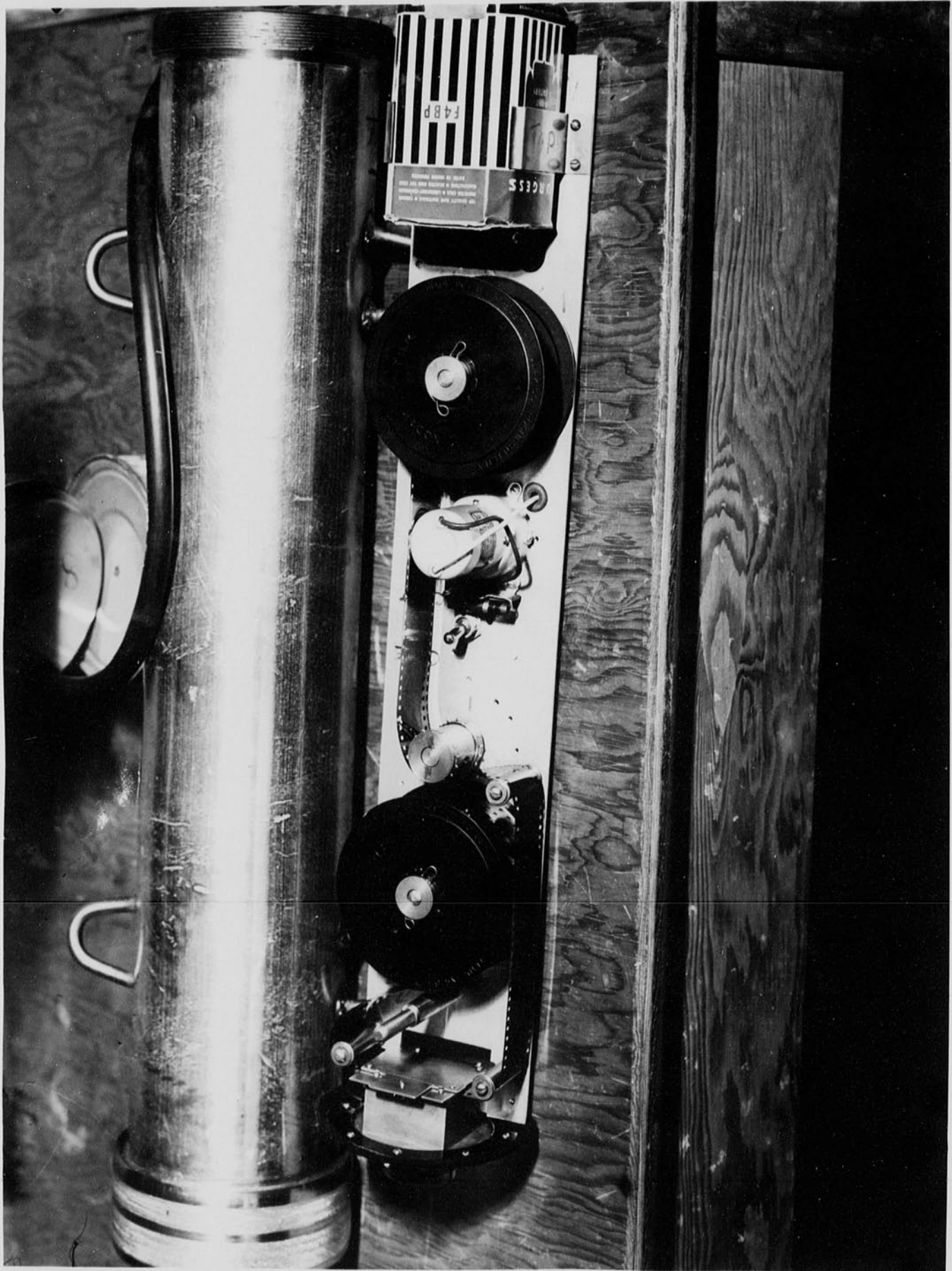
ECR

CF Eyring

RJ Christensen

RW ~~Hait~~ Raitt.

} Uni of Cal. Mar Research.





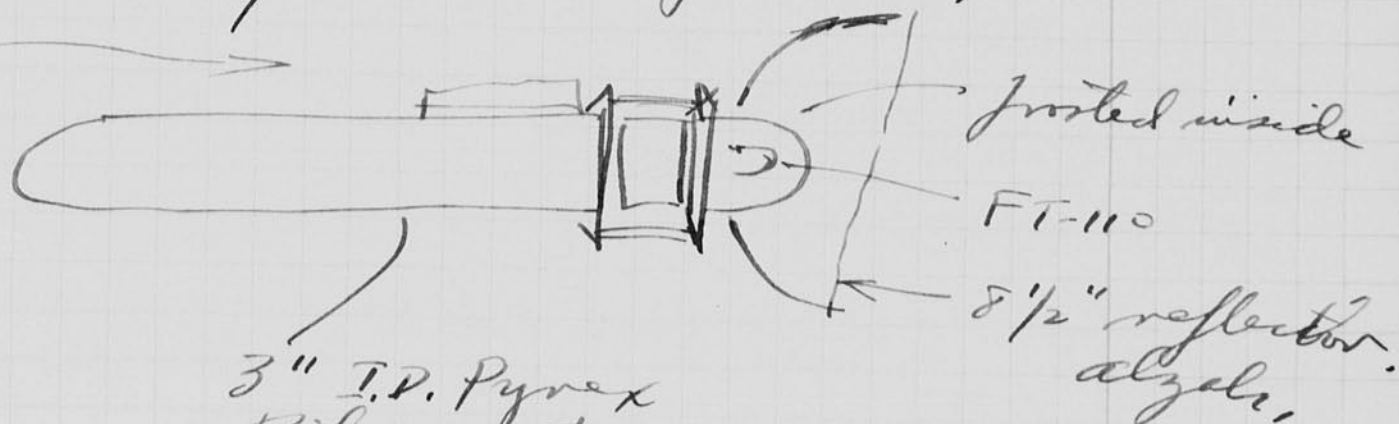


Sept 1, 1952.  
Hered Edgerton.

25

A camera and light system was tested yesterday in the ocean at Jolly Cove Rodeport Mass. Bill Westell and my son Bob helped.

The system is as follows.



3" I.D. Pyrex  
Pipe containing  
540 rolls B batteries  
and 100 watt sec of  
electrolytic batteries.

The water was rather Hazy. I could see about 10 ft. the water had a green appearance due to the ~~blue~~ rays.

Photos were taken on Kodachrome with the camera set for

$f\ 3.5$

$D = 1.25$  meters

A board 2' by 10" was used as a plane on the camera light. The equipment was made buoyant. Modifications are being made today to slide the plane forward and to cut away a wood cover that makes the rear end too buoyant.



Sept 1 cont

27

Tests were made last  
Thursday Aug 28 in the M.I.T. pool with  
the same equipment of page 26  
with the addition of a side light  
of 200 watt sec - photocell controlled.

I was helped by my sons Bob and Bill  
a friend of Bill's, Reels was there also.

I had the aperture set at  $f2$ .

Distance 1.5 meters or scale.

An entire roll of 20 Kodachrome,  
was shot in the pool of the  
aqualung equipment and the  
camera itself, etc. The last  
photos were taken in the M.I.T. pool  
with a lens through the window.  
The photocells on the under water  
lamps did the firing.





Sept 6 1952

29

H E Edy

MIT Pool tests.

Sept 4 Black and white tests

2" Lens at  $f 12.5$  Plus X film 100 watt sec unit,  
camera focused at 1.75 meters.

This film was over-exposed. developed?  
by an unknown amount. Overdeveloped  
is probably a good idea since it  
increases the contrast.

Exposure seems ok at 10 ft but  
begins to get thin, at this distance  
a person is about covered.

I note that I have difficulty  
in aiming the camera since I  
cannot see through the  
eye piece on the Visiola case.

On Sept 5 two Kodachrome day light were  
shot.

FILTER  
CC15

50mm  
Roll A 2" lens  $f 3.2$  1.5 meters,

FILTER  
CC15

B 35mm lens  $f 3.5$  1.5 meters.

The side light of 200 watt sec.  
was used on some of the  
photos. This equipment has  
been revised so that the  
photo electric cell is more  
effective.



Black and white

35 mm Summilux Lens at f11  
Plus x film.  
1.5 meters focus.

1. Daylight view (no flash) of lab.,  
Lightmeter at
2. Ditto but with flash
3. Lab view of pumps etc. □
4. " " " " " " □

at M.I.T. Pool.

3 ft.

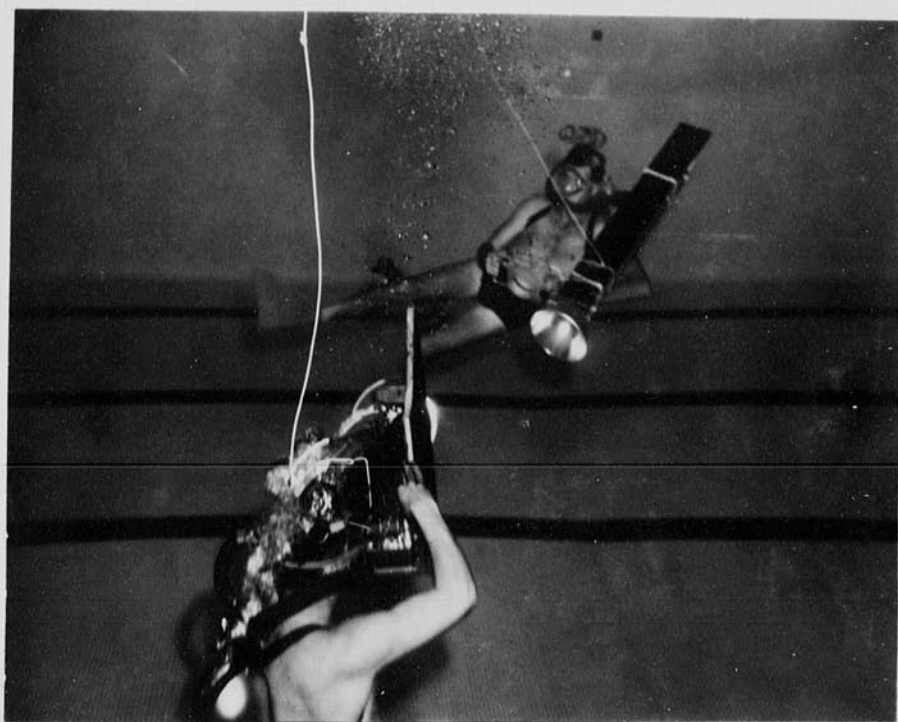
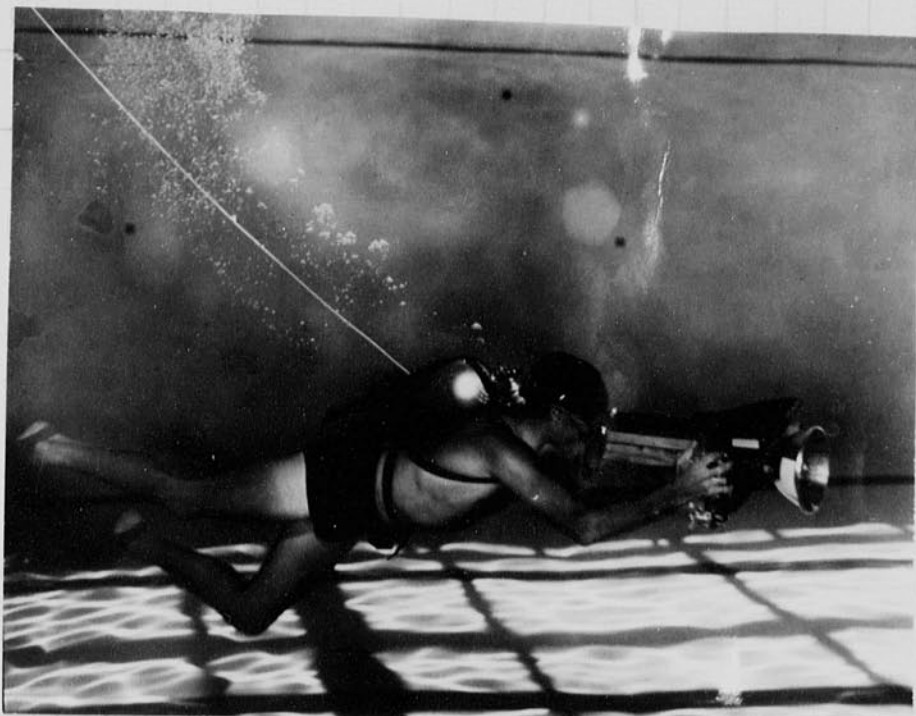
6 ft

9 ft

12 ft

15 ft.







Letter from O.E. Settle. Sept. 12. 1952

Sonic reflecting layer cannot be found at will. Good results at ~~the~~ divergent-convergence where plankton are richer than anywhere else.

Hugh M. Smith departs Honolulu Oct, return Nov 21.

Letter from Otis Barton

BENTHOSCOPE.

Aug 21 units from  
Pier C Long Beach  
Calif  
Pacific Tugboat &  
Salvage Co.

E.R. Fenimore Johnson.

Fen John 90 cricket ave Ardmore Pa.

Scientific Monthly - July 1952

K.O. Emery

Submersible Photographs with the  
Benthograph.

Historical Development in U.W. Photography  
Henry S. Moncrief.

PSA Journal vol 17 Nov 1951

The deep sea layer of life Lionel A. Walford  
Scientific American Vol 175 no 2  
August 1951

Aug 1948 Physics Today

C Iselin  
VI no 4





# Deep Sea Photography.

Ernest Herring & Edward R Boyler

Sears Foundation Journal of Marine Research  
 Vol VII No 1 Apr 13 1947 p 10-16.

# Photography of the Ocean Bottom

Maurice Ewing

Allyn Vine

J. L. Worzel

Journal of the Opt. Society

V 36 No 6 307-321 June 1946

# D.S.L in the Pacific and Eastern Oceans.

Robt S. Dietz

Sears Foundation J of M R

VII No 3 Nov 15 1945



Vernon Brodz T. Fish. Unit H.

Henry Kierstead N.E.L. Photo Lab.

Bob Dill

Ocean

Nov 15

Nov 20 to 25.  
Kwajalein & Fiji.  
500 miles.

Robert Dietz

"

A Scripts boat <sup>or two</sup> will be at Eni for a short time - say several weeks. Bob Dill will be aboard.



From Evelyn Sept 22, 1952.

41

Jap M. W. camera

Geo Pley

Univ. Tokyo.

Sept 24 1952

arrived in Honolulu last night by air, now at Halekulani Hotel on beach room 2110. Wyckoff and family were also on the plane a united travel line.

I went to the firm and Wild life service and met Harold Smithers (Gelle was out), W.F. Royce, Garth Murphy etc.

Arrangements were made to ship the M camera from Boston to be used on a cruise of the Hugh Smith

Bill Goslin came about 4pm and we went for a swim at Waikeiki beach. I took a roll of Kodachrome with the cork unit. More weight is needed to keep it down.

Roll 1. Daylight Kodachrome at f 3.5 1.5 meters.

The water was murky - yellow?  
Shots were made of Goslin  
Coral heads - small fish etc.  
Surf was good for me but Goslin  
said it was quiet.



Sept 26 Thursday,  
Haleka Lani Hotel  
Honolulu

43

Took rolls 2, 3, 4, at Hanalei Bay  
Koko Head yesterday

f 3.5 35mm lens,

2 meters ~~+~~ -

CC 15 f/11 (89)?

Daylight Kodachrome.

William Gosline } um Hau  
Dick Stroup } } Bur. Fish &  
Ike Ikehara } } Wild life.  
Dick Shomura } }





Friday Sept 27 1952

45

met Miller, Lt Donald, USN in morning - went to East man with film shot the day before.

Then went to Fish and Viel gift on Dole ave to fix Robot to lamp and sync. Tested in the swimming pool at Uni Hawaii for leaks - water and electrical - O.K.

Made a trip to Hanalei Bay in the late afternoon. Dick Stroup was there with two friends

Bill Monahan  
2843 Park St  
Calvin Brisk  
3860 Tentulus.

Several films were exposed on Kodachrome in the Leica as marked on the boxes. Used a cc 15 filter on all shots.

E. L. Hearne Hearne and wife at Hanalei Bay. in some photos



Sat Sept 28 1952  
27

47

ABElyer.

Took plane at 9am for ~~Kailua~~ Kona  
Kailua ~~Honolulu~~ Hawaii.

Vernon Brock met us with a truck  
to take our 400 lbs of apparatus to the  
Lihikai Hotel. Roy's place.

Jimmy Pa 2302 Hoonanea St  
George G. Gilbert 1307 N Vineyard St  
Yoshio Yamaguchi Bldg Agr and Foresty.

Leon Wollard

1553 W 52nd St Tel 62 cal AX 30297  
United pilot with plenty of cameras.

→ We went by car to Capt Cook's bay - then  
took a boat out. Lester's place. Sonny Boy  
Henry Lester Jr. was our pilot to see the  
monument. One of the boys knew where  
the tablet was located in the water where  
Cook had his trouble with the natives.  
I tried to take an under-water photo of it  
with the red flash.

Kealahou Bay.



28

Sunday Sept 29 1952.  
Harold E. Edgerton.

Kona Bay.

49

~~KEA~~ KEA HOLE point.

We took a boat at the Kona bay and went west by north. A large square light house was passed first. Then several miles further we saw another light house near a place where the lava rocks had ~~gone~~ gone down to the sea. At this light house point ~~we~~ the Brook crew layed out their 300 foot line for the fish survey.

Brook took the Leica with the 100 W5 unit using Black and white film. The focus was set a  $\frac{1}{2}$  meters (air) and the aperture at f 11. He endeavored to record the fish survey group, Dilbert and Yama guchi.

A second roll of film Kodachrome was exposed at 1 meter at f 8 CC15 filter. Brook reported many fishes.

He then ran a roll through the Robot camera using a guide factor of 20 to 30. no filter  $\frac{1}{100}$  sec.

A third roll of film Kodachrome was put in the Leica. I shot 5 or so exposures - then the film would not wind. I came up for lunch - freed the wind and re assembled the camera. Unfortunately I caught the chip under the edge of the plastic case. This made the camera leak. Sad! I flushed the camera with fresh water twice and let it dry.



Monday  
Sept 29 1952.

A.E. Edgerton

51

Lihikua Hotel. Kailua Kona Bay Hawaii.

We went by car today to the city of Refuge, Honauau south of Capt Cook's Monument.

Brook and Miller went down about 150 feet with the Aqualungs into a hole in the bay.

Brook used the Robot <sup>with flash</sup> while Miller used the Ten film camera movie.

I went down about 50 feet but my ears hurt some.

Brook shot some photos at 50 feet down of an eel that was speared by Gilbert.

Then the Robot failed to flash the tube. I changed batteries at the Hotel - the thing still did not fire. A coil is probably short in the flash tube.

I sent the camera to Oahu this morning via Wollford. (Wollard).

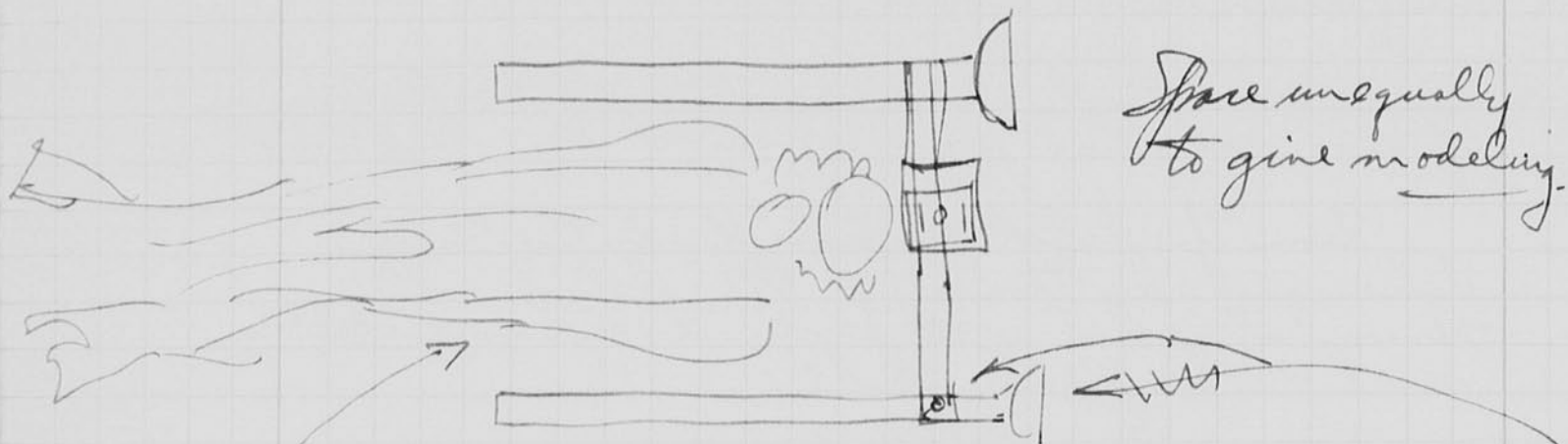
Sept 29, 1952  
Harold S. Edgerton, Kona.

Comments upon present design of U.W.  
Lamp and suggestions for new model.

Balance is very important - both total and forward aft., the square job seems to be about right.

More light could be used for Kodachrome and color film.

Two lights could be used on the same camera with a support between the two.



Provision for twisting lamps should be made.

a back ~~structure~~ spacer could be used for carrying the device in the air. This back brace could be taken off with a clamp when the device is put in the water.



Oct, 4, 1952,

53

The entire party at Kona left by truck and car for Hilo on the morning of Sept 30. Lt Miller and I took an army plane to Hickam field.

Returned apparatus to the Fish and Wildlife office for repair and adjustment. The Leica is in very poor condition due to flooding at point. Weather hot with rain.

On the Oct 2 I went with Miller to the sub base at Pearl Harbor. He took a sequence of photos of a diver leaving the escape hatch in the tower.

Then we went to the mine demobition base at Barber's Point where we met Lt Brooks of the U.S.N. Mine Disposal Unit 1.

Two rubber boats with six men were assigned to us for use at Nanakuli Beach.  
(or Maili Point)

My boat was flipped over by a large wave in about 6 ft of water. Nothing was damaged. It was exciting to have three men, two aqua lungs, and a camera with strobe plus fins, masks etc come down on top of me in the water. The water was not clear at this place due to the Kona (South) wind.

~~Oct 3~~ (Fri) Evening of Oct 2 Gorth Murphy tested the 200 ft camera in the Pool at Uni Hawaii. Although there was a slight leak the photos were ok. a series were taken on Super X at f5.6 at several distances to show depth of field.

Oct 3, tested flash equip, Robot, exposure meter, and Pen John for magnetic fields. The meter was the only device which had much effect in the field, all the others are safe a 4 ft away.

54 Oct. 4, 1952

R. P. Edgerton.

R.P.

(Kailua)  
62251

Lt Clark USAF pilot assigned to Hickam field invited us to work with him in his boat on the north side of the island. I called Lee Carr and he went with us. Clark lives at Kailua. From there we went to his landing on the west side of the Mas Kaneohe Bay, South.

We went north past coconut island to two islands that were covered with birds. Frigate and sooty terns.  
Moku Manu.  
(Island Bird)

There is a large cave in the north side of the largest island.

We anchored on the leeward side of the largest island and went under sea with the aqualungo. Don took movies of fishes and the still camera.

I shot quite a few photos of the propeller and the rudder of the boat.

Miller then took the still camera and shot some fish on the bottom at 30 ft deep.

At Edge  
Oct 5 1952

55

Took day off - went sunning in beach  
at Waikiki off Halekulani Hotel. Took tanks  
to Sub Base for refilling

Gave talk at Halekulani Hotel in  
evening. Showed some fish pictures.

Large white fish at Hawaii in schools.

Opelu Kala

*Naso hexacanthus*

Butterfly fish

Ki hi Ki hi

*Geniobius acuminatus*

Orange spot Surgeon fish

Pakui Kui

~~Geniobius~~ *acanthurus achilles*.

Notebook # Aug 4, 1952 - Oct. 19, 1952

### Filming and Separation Record

\_\_\_ unmounted photograph(s)

\_\_\_ negative strip(s)

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

was/were filmed where originally located between page 54 and 55.

Item(s) now housed in accompanying folder.

MIT Laboratory  
Hawaii  
1  
~~This meeting~~

Today I ~~wish~~ it is my pleasure  
to show you some pictures -  
in particular some pictures  
of underwater subjects. I am  
here in Hawaii to test out  
an experimental type of flash  
equipment that seems to have  
some uses for underwater  
still picture photography.

This effort is being sponsored by  
a small grant from the  
National Geo Society to M.I.T.,  
where considerable development  
effort has been expended upon  
electronic flash systems.

The underwater world is  
more vast than the above  
water, in fact more of the earth's  
surface is covered by water  
than not. Furthermore the deeps are  
deeper than the mountains are high.



## HALEKULANI

HONOLULU 15, HAWAII

2

Those who endeavor to learn of all mysteries of the sea have many methods - all of which are employed by oceanographers and geologists. One of the most powerful methods for visual observation is the camera. The object of my effort is to make this ~~medium~~ for research more powerful.

Every device is a compromise. I hope to get under water camera devices to be well designed and easy to use by a host of people who endeavor to learn of the under sea world.

One riding in a glass bottomed boat gets a preview of the under water world. However one who dives especially with the new aqua lung equipment actually becomes a part of the new world. He floats

with the greatest of ease. Everything is different. Above him is the flat top ceiling - the top of the water above which we live. To him it is a surface to avoid - a boundary.

As a diver goes down he notices that the red light fades very quickly with depth. At 30 or 50 feet down even in the clearest water - the reds are gone. As he goes below a hundred feet everything becomes dark. Now photography requires light - lots of light and this is where I come in.

For some years a group of us at N.P.I.T. have been developing stroboscopes and high speed flash devices for taking records of rapidly moving devices and subjects.



Probably many of you are familiar with the electronic flash system. I have a portable type here which has the ability to take many photographs. The speed of the flash can be very short, and as many pictures as desired can be taken.

This kind of lamp is what is needed for under water scenes.

Monday Oct. 6. 1952

St Miller and I left for Kailua (Kailua) with Brook at 9:30 am. Here we met

Kameke S.S.

Mealor Leonard

Daniels J.W.

Thomas L.P.

MacDonald R.H.

all above from the missile disposal unit no. 1. Barber's Point. This group brought two rubber boats, and a quantity of equipment from their station.

We went by navy boat to Bird Island. The swells on the ocean were very large and there was a strong current. I did not go in but Miller and Brook did for a while. Brook shot 40 color shots on the robot.

Upon return Miller packed his gear for departure to Washington on the mass tomorrow.

I am scheduled to go on Wed Oct. 8. via mats to Eirwelok.

Oct. 17 1952

Alice Bogalura Eniwetok atoll  
 Al Edgerton  
 Frank Strubala.

Teletronic checkout. #

The 160" Cassegrain teletronic # 8 was brought to this island on last Saturday by Whitney & Norton. It was installed on the south wall of the concrete photo house looking out the upper right hand port. (Looking at Bobulb site).

Checkout list.

Film holder with xxx film. (Papatrium type holder)

1. Check image and focus.
2. Take zero photo  $1/10$  sec.
3. Cross polaroids.
4. Close slow shutter and cock.
5. Open fast shutter.
6. Install fuse shutter.
7. Check plugs and cables.
8. Set switches "on".
  - Low voltage
  - High voltage
  - 10  $\mu$ s delay.
  - Set delay for 4 on scale (10  $\mu$ s).
9. Set 3KV variacs max (134. V)
10. Set 24KV to 110 volts.
11. Remove front cover.
12. Turn Tide marker on.
13. Install film holder and remove slide.
14. Check switches on but supply lower level.

Strabala returned to Perry Island at 3:30 pm by duck. I went as far as "Crane" Island where I lived up the Sun flash with Jack O'Donnell's help. We put the entire 10,000 watt sec into one lamp with out an extension cord. It was located at the fence about 200 ft from the building.

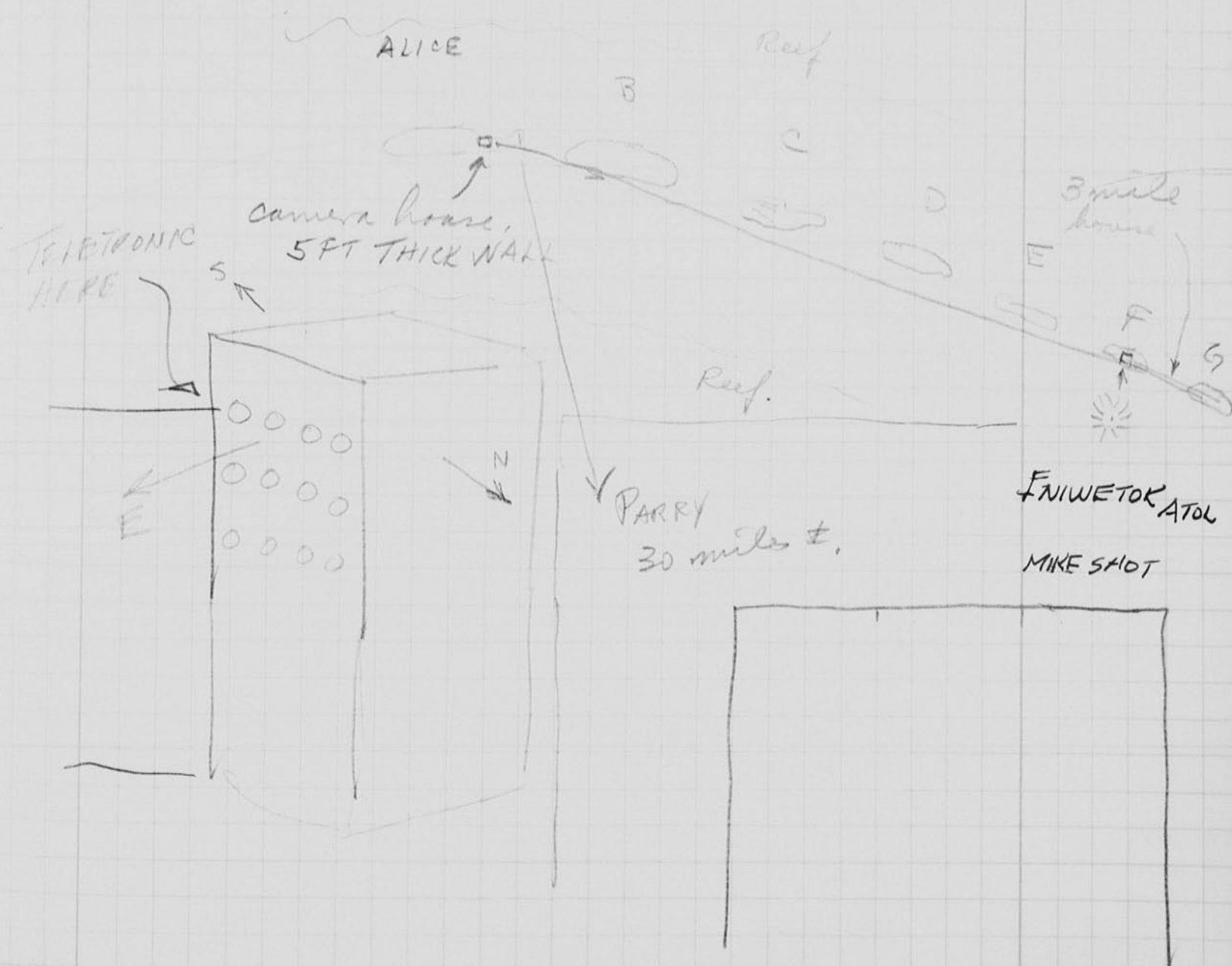
I have the 160" Cassegrain focused on the bomb house. The shutter will be open when the sun flash goes off. Aperture is about  $f/20$ . We crossed polaroid give about Density 1.8 to 1.5. Tri-X film.

Oct 19 1952  
H. S. Gentry,  
"Alice"

Wydroff came from Parry Island yesterday afternoon. We met at "Bent" island and came here by duck at 5:30 pm.

Photos were made of the ~~house~~ on microfilm film - 100 sec. ~~exposure~~. Wydroff reports this exposure thin but ok.

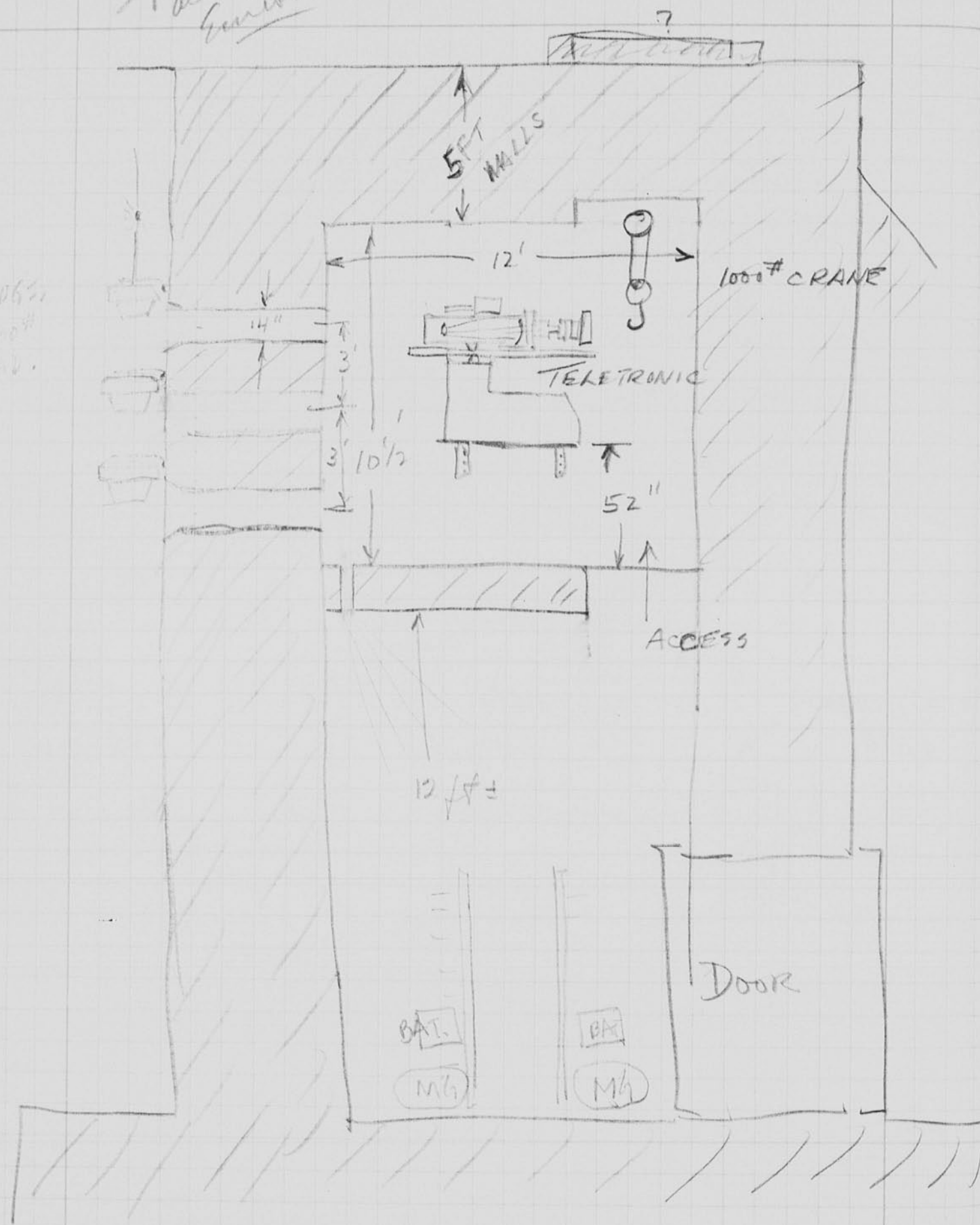
The sun flash is now set up for about 50 ft from the bomb. I hope to make an exposure tonight of the zero position. Tents and work trailers ought to be removed from the line of sight.



6/19/52  
30  
"Alice"  
Sawinlok

SOUTH WALL OF BLOCK HOUSE.

PLUGS  
1100#  
1500#





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