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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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SAN FRANCISCO, CALIFORNIA

15 February 1946

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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Ultra-Violet Communication Equipment.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Target X-03 of Fascicle X-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Major Wilhelm Jorgensen, AUS, with the assistance of Lt.(jg) J.R. Dannemiller, USNR.

C. G. GRIMES
Captain, USN

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X-03

JAPANESE ULTRA-VIOLET COMMUNICATION EQUIPMENT

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE X-1, TARGET X-03

FEBRUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

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SUMMARY

MISCELLANEOUS TARGETS

JAPANESE ULTRA-VIOLET COMMUNICATIONS EQUIPMENT

Considerable research had been conducted by the Japanese prior to the war on ultra violet communications equipment for the purpose of presenting photographic pictures on television screens. Reprints of the articles published on this work have been shipped to the Naval Research Laboratories through ATIS via NavTechJap Document Number ND50-5843. Specific application of ultra-violet light communications equipment to military uses was anticipated, although none but experimental models were produced. It was thought however, that two advantages could be found in such equipment. First, high intensity mercury lamp light sources could be modulated easily; second, filters could be designed to pass only the very short ultra-violet wave lengths not transmitted by normal ultra-violet light filters. Thus equipment with a high degree of security would be obtained.

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LIST OF ILLUSTRATIONS

REFERENCES

Location of Target:

Heat and Light Department, Second Naval Technical Institute, ZUSHI

Nippon Electric Company, KYOTO (Navy source of mercury tubes).

Tokyo Technical College, TOKYO (ultra violet filters).

Physics Department, Osaka Imperial University, OSAKA.

Mitsubishi Electric Company, ITAMI (near OSAKA).

Japanese Personnel Interviewed:

Captain K. AOKI, Second Naval Technical Institute, ZUSHI.

Professor V. HOSHINO, Tokyo Technical College.

Professor T. ASADA, Osaka Imperial University.

Mr. M. HORI, Director of the Mitsubishi Electric Company Laboratory at AMAGASAKI (near OSAKA).

Mr. T. ONAHA, Manager of Engineering, Itami Plant of the Mitsubishi Electric Company.

INTRODUCTION

The Japanese development of ultra-violet communications equipment paralleled that of infra-red light communications equipment. Though no actual use of the equipment was made, its state of development was advanced and showed definite possibilities worthy of further consideration.

The development of the equipment was carried out by the Heat and Light Department of the Second Naval Technical Institute in conjunction with the Physics Department of Osaka Imperial University and the Itami Plant of the Mitsubishi Manufacturing Company. The development of suitable ultra-violet filters was carried out by Professor Y. HOSHINO of the Tokyo Technical College.

THE REPORT

1. MERCURY TUBES FOR HIGH INTENSITY LIGHT SOURCES

The Nippon Electric Company, KYOTO, supplied the Navy with mercury vapor tubes of the types shown in Figure 1, part (a) to (e). Most of these tubes were used for searchlights but the Navy selected Type 1 for use in its ultra-violet light photophone. The Tokyo Shibaura Electric Company developed a low pressure mercury vapor tube shown in Figure 1, part (f), which was intended for use in an experimental photophone being developed by the Mitsubishi Electric Company at ITAMI. Professor ASADA of the Osaka Imperial University working with the Mitsubishi Electric Company developed the very high pressure mercury arc tubes, shown in Figure 1, part (g) to (i), for use in ultra-violet ray communications equipment. The wiring diagrams of the Mitsubishi photophone equipment were identical with those for the Navy Type 5 ultra-violet photophone developed by the Second Naval Technical Institute except for the type of tube used for the light source. Samples of each of these tubes have been shipped to the Naval Research Laboratories under NavTechJap Equipment No. JE50-5837. Table I gives physical data concerning the tubes.

TABLE I

LOW AND HIGH PRESSURE MERCURY VAPOR ULTRA-VIOLET LAMPS USED FOR TELEVISION AND ULTRA-VIOLET COMMUNICATIONS EQUIPMENT

Tube Figure	Power (W)	V	Pressure (Atms)	Shape	Cooling	Purpose	No. Mf'd	Mf'r
1 a	1000	65	20	8" long, 1½" bulb	None	Search-light*	5-6	N
1 b	2000	160	20	8" long, 1" bulb	Compressed Air	Search-light*	200-300	N
1 c	500	100	20	4" long, 1" bulb	none	Search-light*	500-600	N
1 d	100	100	10	4" long, ½" bulb	none	Photo-phone*	100	N
1 e	500	350	50	6" x ¼" tube	water	Search-light*	50	N
1 f			low	2 bulbs separated by ¼" tube	none	Experimental Army Photophone#		T
1 g	500	500	120-150	1.5mm tube	water	Navy Photophone@		M
1 h	500	500	120-150	1.5mm tube	water	Navy Photophone*		M
1 i	500	500	120-150	1.5mm tube	water	Navy Photophone*		M

* Used by the Navy
\# Photophone development by Mitsubishi Electric Co. ITAMI

@ Mercury Arc tubes
N Nippon Electric Co. KYOTO
T Tokyo Shibaura Electric Co. (TOKYO)
M Mitsubishi Electric Co. ITAMI

2. NAVY TYPE 5 ULTRA-VIOLET LIGHT PHOTOPHONE

The Navy Type 5 ultra-violet photophone was developed by the Heat and Light Section of the Second Naval Technical Institute in conjunction with the Physics Department of the Osaka Imperial University and the ITAMI plant of the Mitsubishi Electric Company. (Figure 2) A block diagram of the system, wiring diagrams of the transmitter and of the receiver are shown in Figures 3, 4, and 5. The equipment as used by the Second Naval Technical Institute utilized a 100 watt mercury vapor lamp (Figure 1, part (d)), but research was being conducted to utilize high pressure mercury arc lamps. (Figure 1, part (g) to (i)). The lamp was placed at the focus of a 60cm reflector for the transmitter. and a caesium cell was placed at the focus of another 60cm reflector for the receiver. The effective range of the equipment was placed at 10-15 km but it is believed that this was under ideal conditions. One prototype construction by the Mitsubishi Electric Company, but obtained at ZUSHI, was nearly completed and has been shipped to the Naval Research Laboratories under NavTechJap Equipment Numbers JE21-6324 to JE21-6329, inclusive. For the purpose of showing the relative importance placed on ultra violet equipment by the Japanese, an organization table of the Heat and Light Section of the Second Naval Technical Institute is attached as Enclosure (A). A summary of the research work conducted by Professor T. ASALA at the Osaka Imperial University is given in Enclosure (B).

3. EXPERIMENTAL ARMY PHOTOPHONE

Although Mitsubishi reported that they had developed an experimental model Army photophone some years ago but had stopped work on it and were not familiar with its details, they produced incomplete wiring diagrams of the transmitter and receiver and produced a low pressure mercury vapor tube which was used for the light source. (Figure 1, (f)) The tube was of standard design and had been manufactured by the Tokyo Shibaura Electric Company. There may be no significance to this ultra-violet light communications equipment other than that the spectra of low pressure mercury tubes favor the very short wave length ultra-violet light over visible and infra-red light. Photographs of Spectra vs gas pressure in the mercury tubes, (NavTechJap Document No. ND50-5843), show that the experimenters were aware of this fact. Further, Prof. HOSHINO, of the Tokyo Technical College, was working on a filter which he claimed would pass the mercury 2537 A°line, but cut out all longer wave lengths. He said that his work was considered "Top Secret" throughout the war. The plan was to use a low pressure mercury tube light source in conjunction with his filter to obtain a photophone which would be invisible through normal ultra-violet filters which do not pass light of wave length 2537 A°
No samples of this filter were available but the details of the filter are given in Prof. HOSHINO's report on filters entitled "Method of Producing Organic Dye Infra-Red Filters", which is Enclosure (O) of NavTechJap Report, "Japanese Infra-Red Devices, Article 3 - Research, Development, and Manufacture of Infra-Red Equipment", Index No. X-02-3.

4. GENERAL

As with infra-red equipment, the Japanese developed only laboratory models which in theory had merit but were not practical for field use. Navy equipment must, of necessity, work on rolling ships but very little effort was made to incorporate such ideas into the equipment. However, the ultra-violet photophone represents original thought and appears worthy of further consideration.

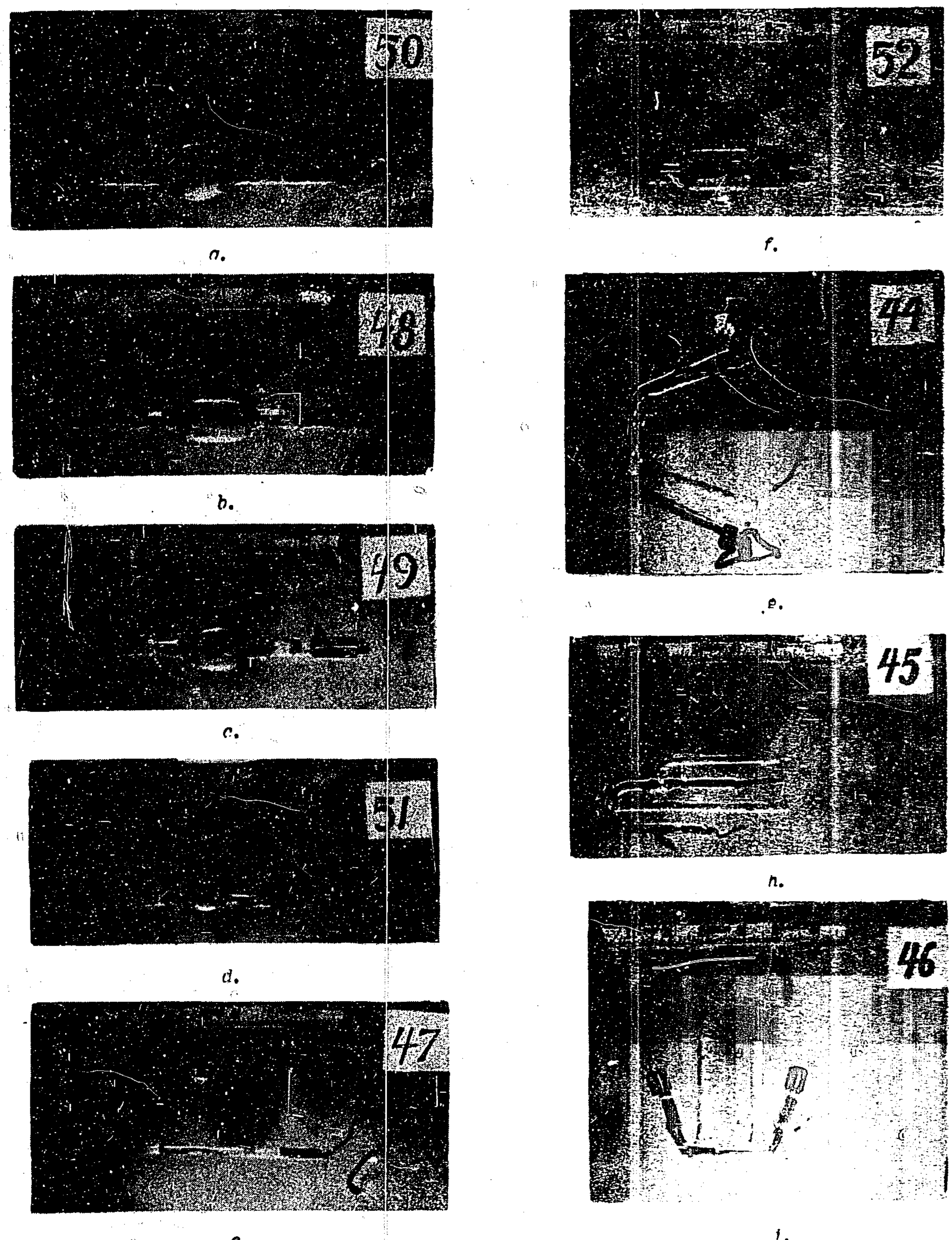
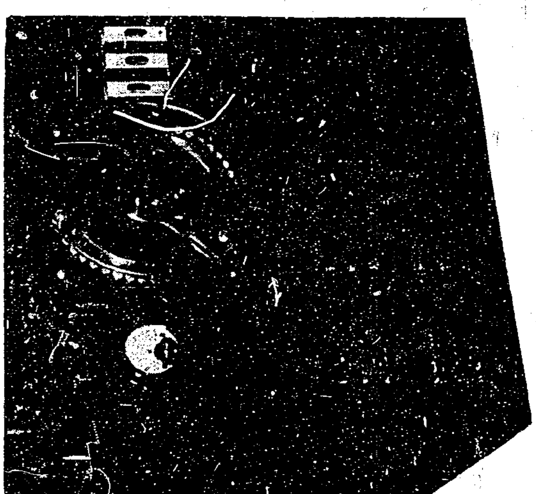
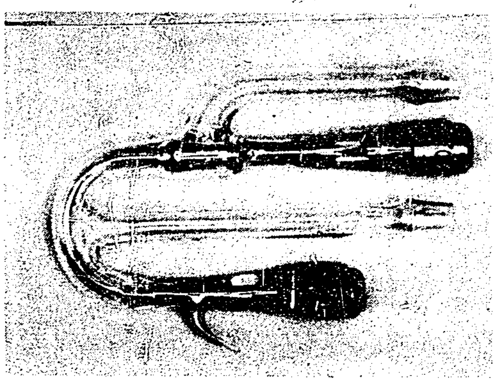


Figure 1

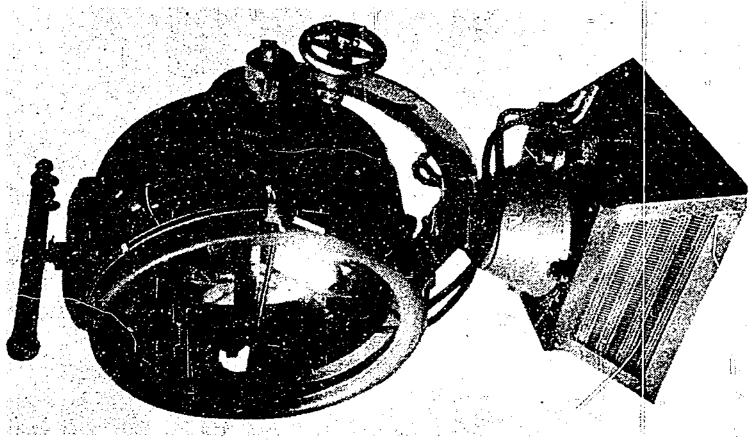
LOW AND HIGH PRESSURE MERCURY VAPOR ULTRA-VIOLET LAMPS USED FOR TELEVISION AND ULTRA-VIOLET COMMUNICATIONS EQUIPMENT



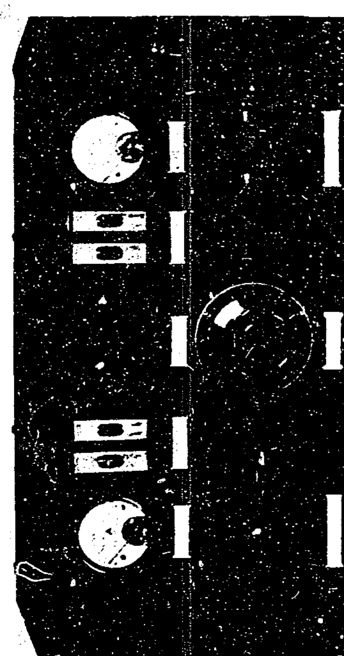
a. Power Supply for Hg Lamp



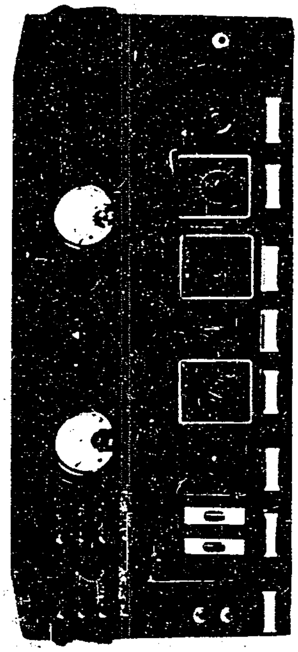
b. Water Cooled Hg Lamp



c. Projector



a. Transmitter



b. Receiver

Figure 2

ULTRA-VIOLET LIGHT COMMUNICATIONS EQUIPMENT (MITSUBISHI AT ITAMI)

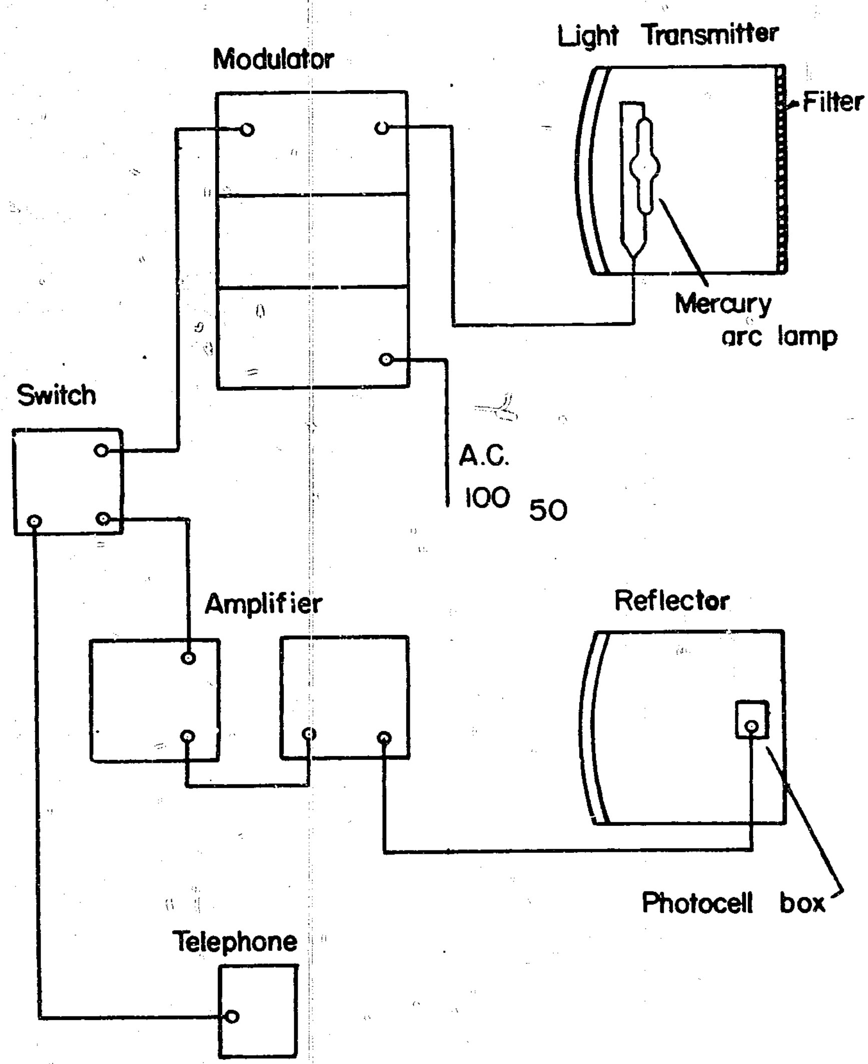
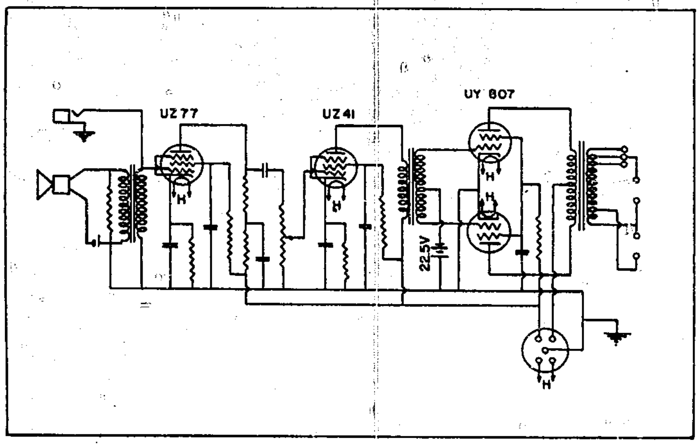


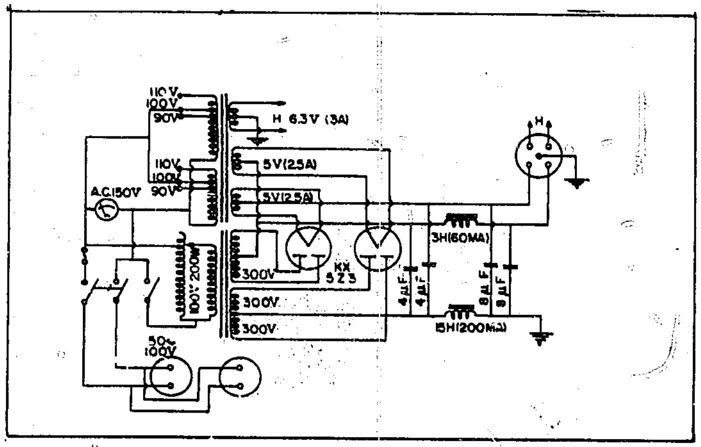
Figure 3
BLOCK DIAGRAM - NAVY TYPE 5 ULTRA-VIOLET PHOTOPHONE

Figure 4

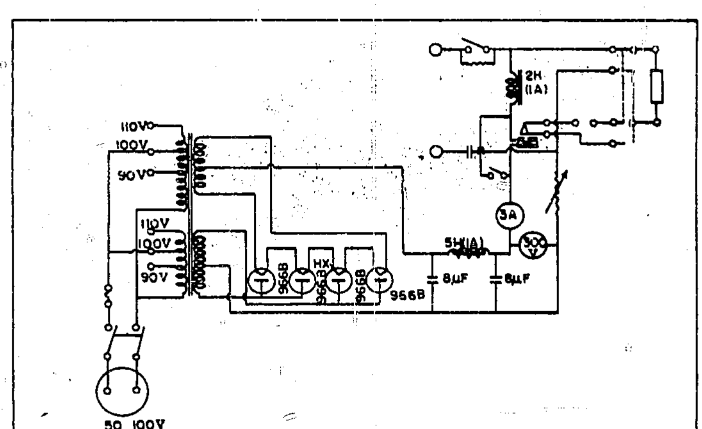
TRANSMITTER WIRING DIAGRAM - NAVY TYPE 5 ULTRA-VIOLET PHOTOPHONE



a. Transmitter (Modulation) Amplifier



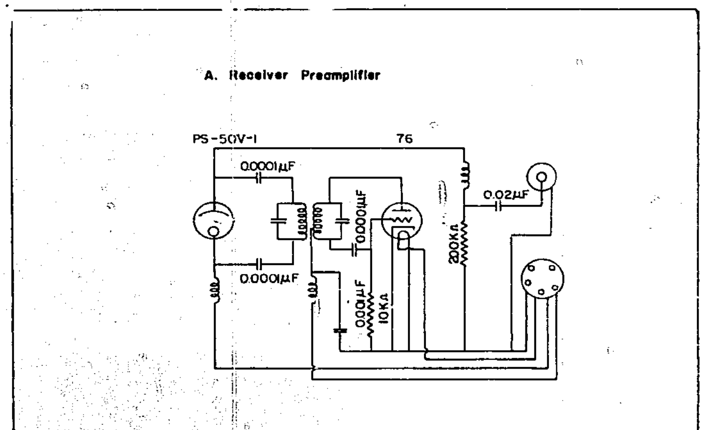
b. Transmitter (Modulation) Power Supply



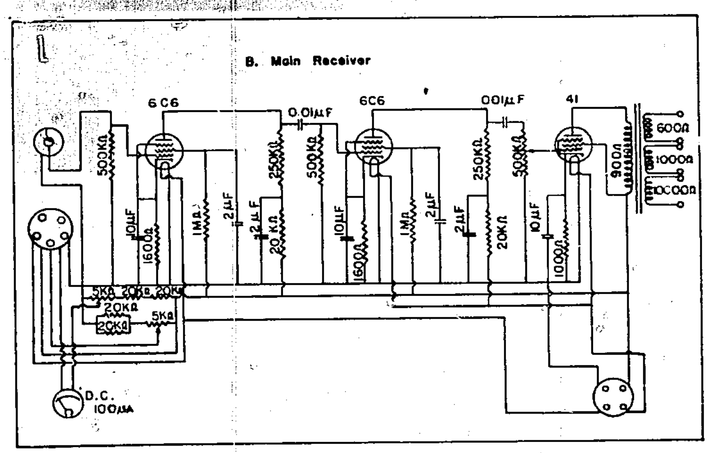
c. Mercury Lamp Power Supply (Transmitter), and Modulation Output Regulation

Figure 5

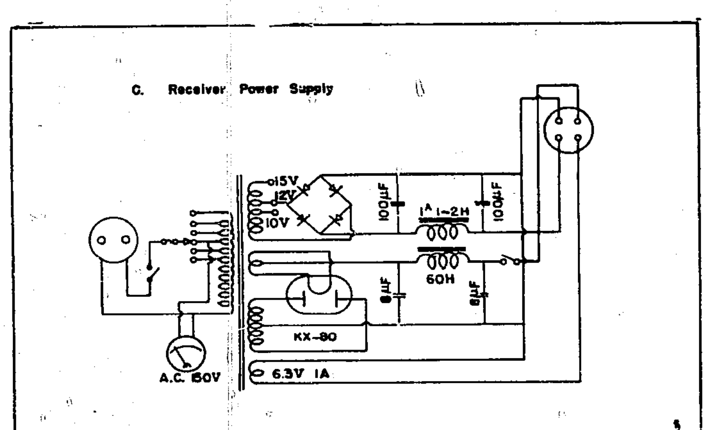
RECEIVER WIRING DIAGRAM - NAVY TYPE 5 ULTRA-VIOLET PHOTOPHONE



a. Receiver Preamplifier



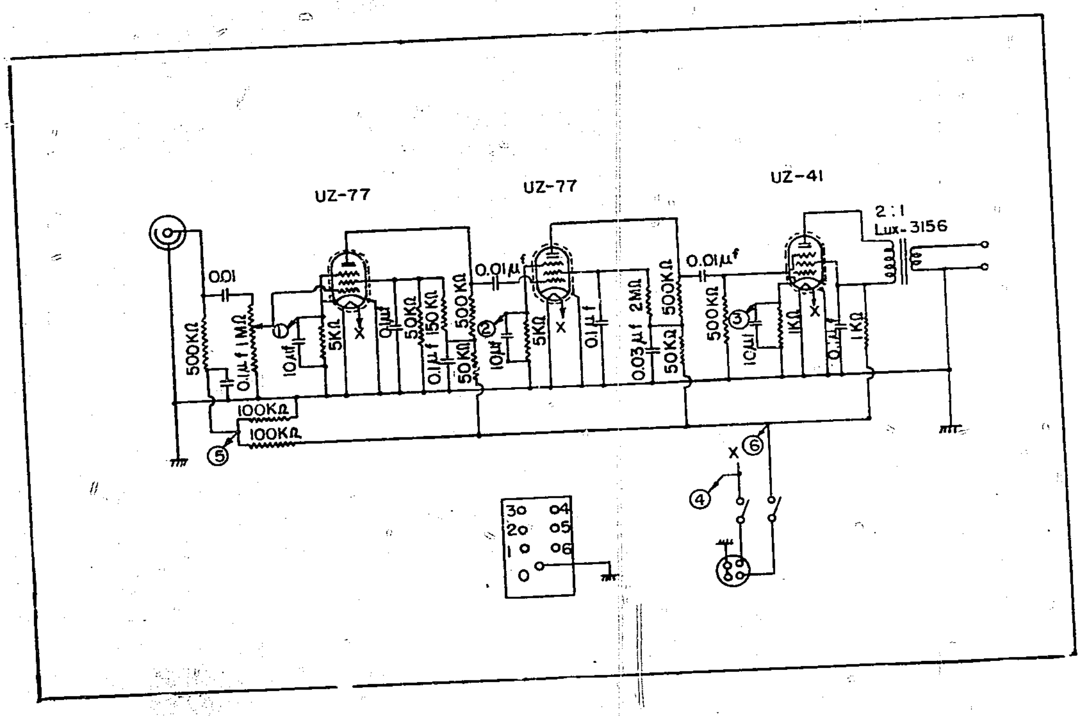
b. Main Receiver



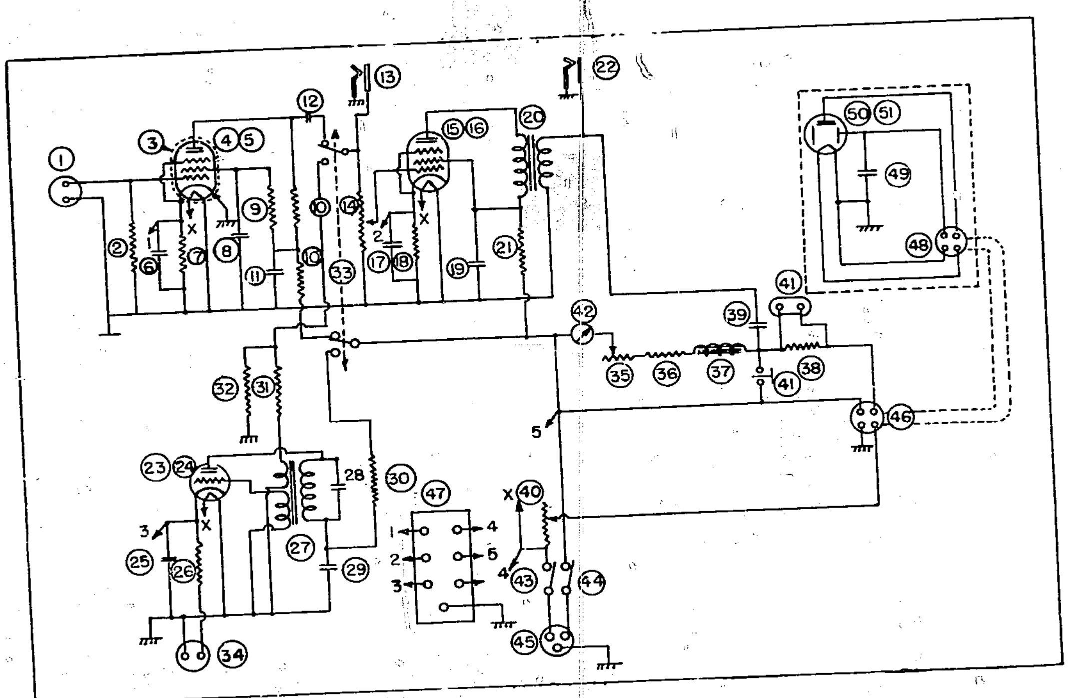
Receiver Power Supply

Figure 8

WIRING DIAGRAMS OF EXPERIMENTAL ARMY ULTRA-VIOLET LIGHT PHOTOPHONE
(Mitsubishi)



a. Transmitter and Light Source



b. Receiver

ENCLOSURE (A)

ORGANIZATION AND RESEARCH PROJECTS

OF THE LIGHT AND HEAT DEPARTMENT

SECOND NAVAL TECHINCAL INSTITUTE

10 September 1945

ENCLOSURE (A)

1. INTRODUCTION:

The Light and Heat Department was newly organized for the purpose of carrying out research and development on ultra-violet ray photophones, infra-red communication apparatus, and heat ray detectors.

a. Organiztion: The organiztion of the Light and Head Section is shown in Table I(A).

Table I(A)

ORGANIZATION OF THE LIGHT AND HEAT SECTION OF THE SECOND NAVAL TECHNICAL INSTITUTE

Head of the Department: Captain K. IZUISHI

Section	Duties	Location	Staff Members	Assistants
Office	General Office Work	ZUSHI and MEGURO	7	21
Design	Design and Drafting	ZUSHI	4	7
First	Study of Fundamentals and Caesium Photocells	ZUSHI and MEGURO	1	9
Second	Heat Detector and Noctovision	ZUSHI	5	31
Third	Photophone	ZUSHI	4	35
Fourth	Infra-Red Ray Apparatus	AJIRO	6	39
Total			27	142

b. Research Projects: The research projects undertaken are listed, with contemplated uses and pertinent remarks, in Table II(A). Additional details can be found in the "Report on Scientific Intelligence Survey in Japan", by the USAFPAC Scientific and Technical Advisory Section, dated 1 November 1945.

ENCLOSURE (A), continued

Table II(A)

RESEARCH PROJECTS CONDUCTED BY THE LIGHT AND HEAT SECTION OF THE SECOND NAVAL TECHNICAL INSTITUTE

Symbol	Item	Use	Remarks
D-1	Infra-Red Ray Communication Equip., Type 2.	Installation on ships of large size.	Utilizes 1 kw tungsten lamp, interrupted beam with infra-red filter for transmitter and caesium photocells with amplifiers for receivers. One receiver with wide angle aperture is used to alert the operator and the second receiver with narrow aperture is used for communications. Accurate wave lengths of 8,000 to 12,000 A°. Effective range 15 km. Approximately 100 manufactured.
D-2	Infra-Red Ray Communication, Equip., Type 3.	Installation on ships of small size.	Utilizes 30 watt tungsten lamp interrupted beam with infra-red filter for transmitter and a small noctovision tube for receiver. Effective range: 50 km. Approximately 100 manufactured.
D-3	Infra-Red Ray Communication Equip.. Type 5	Between fixed land stations.	Same as Type 3 but with optical parts enlarged. Effective range: 30 km. Two protosets made.
D-4	Ultra-Violet Photophone, Type 5.	Station to Station telephone	Utilizes modulated 100 watt mercury lamp with 60 cm mirror as transmitter and photocell with 60 cm mirror as receiver. Effective range: 10-15 km. One prototype nearly completed.
D-5	Heat Ray Dectector, Type 5.	Installed in aircraft to locate ships or aircraft.	Utilizes a thermopile and a 20 cm mirror on a revolving base. Effective range: 10 km against airplane engines and ship funnels. Experimental apparatus only. Not in production.
D-6	Infra-Red Ray, IFF.	On aircraft to identify each other.	Utilizes 80 cp tungsten lamp with an infra-red filter for transmitter and a noctovision tube for receiver Effective range: 5 km. Eight sets were made. (System using 750 watt lamp to increase range to 10 km was under trial manufacture.
D-7	Infra-Red Ray Beacon and Detector.	On boats for night navigation in harbors	Utilizes 40 watt tungsten lamp and a 20 cm reflector with infra-red filter for transmitter and caesium-type noctovision tube for receiver. Effective angle: 6 degrees, effective range: 7 km.

ENCLOSURE (B)

DESCRIPTION AND APPLICATIONS OF HIGH PRESSURE MERCURY LAMPS
(Edited Summary of Information Contained In NavTechJap Document Nos. ND50-5843.1 to ND50-5843.5, by Prof. T. ASADA, Osaka Imperial University)

1. In recent years studies of super high pressure mercury lamps have been carried out in several laboratories throughout the world. Our lamps, made of fuzed quartz, are of both air and water-cooled types, using mercury pools for the positive and negative electrodes. The current for the lamp is supplied from a 600 volt, D.C. source with the ripple voltage as low as possible. The specifications and operating conditions of the water-cooled type are as follows:

Inner diameter of tube at arc	1.5mm
Arc length	10mm
Plate current	1 amp.
Terminal voltage	500 V
Pressure of mercury vapor	120 atm
Light intensity	3000 cp
Maximum Brightness	50,000 stilb
Life	1000 hr
Cooling (water).......................	1.5 l min.

2. To start the lamp, high frequency shocks are applied to the lamp while the D.C. voltage of 600 volts is supplied to the terminals.

3. In the case of the water-cooled lamp, if the running water stops, the lamp is easily destroyed. To prevent this damage, a water switch is used. The two electrodes of the switch are connected to the current circuit of the lamp, and the circuit is closed as long as the cooling water is running but breaks when the flow stops. An additional precaution must be taken if the cooling water contains a trace of iron ions. A film of iron hydroxide is easily formed on the quartz tube at the arc part, as a result of heat or the intense ultra-violet rays, and reduces the transparency of the lamp. This defect can be prevented easily if a small quanity of oxalic acid is added to the cooling water. When the lamp is used in aircraft, a circulation pump is used and about three liters of water are circulated at the rate of one liter per minute.

4. The merits of the water-cooled super high pressure Hg lamp are:

a. The brilliancy is probably 30 to 50 thousand stilb and is higher than ordinary carbon arcs.

b. Although the candle power is less than that of a carbon arc of great intensity, it is greater than that of a tungsten filament lamp.

c. The efficiency is as high as about 7 candle power per watt.

d. The light gives off very little heat, specially in case of a water-cooled type, and can be used continuously without over-heating the equipment.

e. The light can be modulated to practically 100%.

f. The lamp emits high intensities of both ultra-violet and infra-red light, permitting a dual purpose use.

g. Using a process photographic plate with a green filter, the lamp can be used as a very intense monochromatic light source of the green line whose wave length is 5461 A°.

h. The arc is stable and is easy to handle.

5. The applications of the lamp are as follows:

a. Light source for searchlight of comparatively small size. The lamp is a light source of a point form and it does not change its relative location during operation. The optical advantages of such a light source are self-evident.

b. Light source for movie-projector. The screen appearance is very white and since the light emits but a small quantity of heat compared to a carbon arc or a filament lamp, it minimizes the danger of igniting the film. If the lamp is modulated or flush synchronized with the speed of the film, the brightness of the screen can be further greatly increased. This lamp has actually been used in movie-theaters.

c. Light source for printing photographs on zinc plates. This lamp has also been used practically in printing work by the Asahi Newspaper Publishing Co.

d. Light source of an electromagnetic oscillograph of the Duddel type. As the brilliancy is high, this lamp is suitable for recording high frequency phenomena, and is much better than tungsten lamps.

e. Light source for a demonstrating microscope in a lecture hall.

6. Light source for a light-telephone (photophone).

a. The frequency response of the lamp has been studied and light can be modulated from 60 to 15,000 cycles. For higher frequencies the light modulation decreases, even though the current responds to the modulation. However, for the light-telephone, a frequency response of 60 to 10,000 cycles is sufficient. At lower frequencies (below 1000 cycles) the light flux from the lamp is proportional to the current through it raised to 1.5 power. At frequencies higher than 1000 cycles, the degree of modulation of the light flux decreases and is less than that of the current. The phase angle of the light is retarded compared with that of the electric current and at 1000 cycles,this phase difference is about 120 degrees, but this time lag is so short that in a light-telephone we can not detect this phase lag with our ears. The terminal voltage remains constant even though the current is modulated.

b. The light source was placed at the focus of a 120cm reflector and as the brilliancy was very great, it was possible to communicate over a great distance. (20km at night). The receiver consisted of a caesium photoelectric tube placed at the focus of a 30cm reflector with a gain of about 100 db in the amplifier. The distance was doubled by supplying a 10cm high frequency potential to the photoelectric tube to increase the sensitivity and to increase the signal to noise ratio.

ENCLOSURE (B), continued

c. In cases where the degree of modulation of the current exceeded 100% the light went out. However, with the use of a set of relays and high frequency current, the arc will relight automatically in less than one second.

d. The light source contains much ultra-violet and infra-red light and can be made invisible by adapting a suitable filter.

7. The method of communication by means of a modulated light beam can be applied to the ordinary picture transmission, (i.e., the wires connecting the transmitting station with the receiver station of the picture transmission can be replaced by this modulated light). However, since the light intensity varies in proportion to the 1.5 power of the current, the contrast in the received picture is greater than that of the original picture and a special amplifier must be constructed to compensate for this defect.

8. Light source of "Schattenmethode" (shadow method) and "Schlierenmethode" (knife-edge method). This light source can be used as if it were a very intense source of monochromatic light, (wave length of which is 5461 A^{o}), by using a suitable filter such as an aqueous solution of potassium bichromate and as such is valuable for viewing objects by the shadow method or by the knife-edge method.

ENCLOSURE (C)

LIST OF DOCUMENTS FORWARDED TO WDC THROUGH ATIS
(ATIS No. 4630)

NavTechJap No.	
ND50-5843.1	"Photo Transmission by Light Beams" (Reprint of article by T. ASADA and H. YOSHINAGA, 1940).
ND50-5843.2	"Modulation of the Luminosity and Application of Super High Pressure Mercury Lamps" (Reprint of article by T. ASADA and H. YOSHINAGA, 1940).
ND50-5843.3	"Modulation of Luminosity and the Application of Super High Pressure Mercury Lamps" (Reprint of article by T. ASADA and H. YOSHINAGA, 1942).
ND50-5843.4	"The Modulation of Luminosity of Super High Pressure Mercury Lamps" (Reprint of article by H. YOSHINAGA, 1942).
ND50-5843.5	"Light Spectra of Super High Pressure Mercury Arcs" (Reprint of article by T. ASADA and H. YOSHINAGA).

ENCLOSURE (D)

LIST OF EQUIPMENT SHIPPED TO THE
NAVAL RESEARCH LABORATORY
Washington, D.C.

NavTechJap No.	
JE 50-5837	Mercury Tubes
JE 21-6324	Miscellaneous Filters
JE 21-6325	Mirrors (4 ea)
JE 21-6326	Loud Speakers (2 ea)
JE 21-6327	Amplifier (1 ea)
JE 21-6328	Translator, Photocell (1 ea)
JE 21-6329	Modulator, Photophone Type 5 (boxes 1 to 6 incl.)