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U. S. NAVY UNDERWATER SOUND LABORATORY
FORT TRUMBULL, NEW LONDON, CONNECTICUT

LONG DISTANCE SOUND RANGING EQUIPMENT (SOFAR) - INSTALLATION AND OPERATING NOTES

USL REPORT NO. 55

by

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Encl: (HW)
1. Subject Report

ABSTRACT

After a brief statement of the general theory, the equipment for receiving, recording, and timing the arrival of ultra-long-distance (SOFAR) signals is described. Directions are given for unpacking this equipment, for setting it up, and for preparing it for operation. The routine operating procedure is described in detail and instructions are given for receiving and recording deep channel signals. In conclusion, a procedure is presented for using both channels of the equipment simultaneously during special tests.

AUTHORIZATION

U. S. Navy Underwater Sound Laboratory Project D74, authorized under BuShips Problem P-17.1.

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LONG DISTANCE SOUND RANGING EQUIPMENT (SOFAR) - INSTALLATION AND OPERATING NOTES

THEORY OF LONG DISTANCE SOUND RANGING

1. The intensity of sound spreading in all directions from a source in a spherical wave falls off as the square of the distance from the source. This familiar "inverse square law" is easily evident as a consequence of the principles of energy conservation. On the other hand, according to these same principles of energy conservation, the intensity of a sound which is prevented from spreading - by some channeling effect - is conserved.

2. In an ideal sound channel the only intensity loss is due to attenuation, which is a direct linear function of the distance travelled by the sound. At very low frequencies, in a relatively incompressible medium like water, this attenuation is slight.

3. The ultra-long distance sound ranging system is based on the fact that sounds originating at a depth beneath the main thermocline (about 4000 feet for the North Atlantic Ocean) are effectively channeled by natural conditions. This channeling is so effective that the explosion of one pound of TNT has been detected at distances as great as 2000 miles.

4. The time interval between an explosion in the sound channel and the arrival of the sound at a distant monitoring station is proportional to the distance travelled. Thus, an explosion can be located by geometrical methods if the time of arrival of the sound at three separate stations can be accurately measured. This report describes the method for installing and operating the equipment which has been developed in experimental form for receiving and timing the arrival of such signals.

EXPLANATION OF THE SOUND CHANNELING EFFECT

5. The velocity of sound in water is affected by various oceanographic conditions, of which temperature and pressure are the most important. Velocity increases with increasing temperature or with increasing pressure.

6. The direction in which a sound wave is travelling is changed, by refraction effects, when the sound goes from a medium of one velocity into a medium of a different velocity. This refraction, or bending of the sound beam, accounts for the channeling effect which makes long-distance signaling possible.

7. Normally the temperature in the ocean decreases rather steadily down to a certain depth (about 4000 feet in the North Atlantic) and below this depth it remains constant. Hydrostatic pressure, on the other hand, naturally

increases with depth. Above this critical depth, the temperature change has a greater effect than pressure change on sound velocity. The pressure change has a greater effect below this depth: As a consequence, a sound originating at a depth of about 4000 feet is bent downward by the layers of water above it and upward by the layers of water below.

8. Sound is therefore channeled horizontally at a depth which actually varies in different parts of the ocean, but is sufficiently constant to make the SOFAR system possible. It spreads horizontally in all directions, but many of the sound rays which tend at first to go up or down are bent back into the horizontal channel.

9. When an explosion at a distance of several hundred miles or more is received at a SOFAR monitoring station, the signal sounds like the roll of a kettle drum building up to a crescendo and ceasing abruptly. This peculiar quality of the received signal is explained on the hypothesis that the sound travelling by the direct route from exploding bomb to hydrophone is also travelling by the slowest route. The sound waves which are refracted from above or below cross and re-cross the axis of the sound channel, actually reaching the hydrophone before the direct sound because they travel through layers of water in which the velocity is greater. The time interval between the first sound reaching the hydrophone and the subsequent sharp cut-off is about one second for every thousand miles.

DESCRIPTION OF THE EQUIPMENT

10. The receiving, recording, and timing equipment for one complete station consists of:

(a) A 5-foot cabinet-type panel rack (Rack 1), containing dual amplifiers, power supplies, attenuators, and a monitor power amplifier.

(b) A 4-foot cabinet-type panel rack (Rack 2), containing the automatic switching device, the "slow-speed" PL Recorder, and a Magnetic Tape Recorder (number 2).

(c) A 4-foot cabinet type panel rack (Rack 3), containing the break circuit chronometer, the "high-speed" PL Recorder, and a Magnetic Tape Recorder (number1).

(d) A monitor speaker mounted in a bass reflex cabinet.

(e) A General Electric voltage stabilizer.

(f) Connecting cables, spare parts, and a supply of waxed-paper tape for the PL graphic level recorders.

[illegible]

[illegible] installing the material in this [illegible] made for [illegible] place the thr[illegible] of the [illegible] shown in Fig. 1. Each [illegible] in the correct position; Fig. [illegible] should be in the top [illegible] must be to the right [illegible] to the [illegible] in Fig. 1.

[illegible] be placed at least [illegible] from the wall to allow [illegible] eight inches. [illegible] together [illegible] space is half [illegible] sides [illegible] through the [illegible] will cover a [illegible] that the [illegible] are level.

[illegible] should be placed [illegible]

[illegible]

[illegible] the top and middle [illegible] in the middle panel of [illegible] cabinet [illegible] When [illegible] the cabinet. [illegible] can be pulled out to [illegible] sliding [illegible] the front of the

[illegible]

[illegible] the top panel of Fig. [illegible] recorders when [illegible] the same time [illegible] of the unit. [illegible] connected [illegible] the operator. This alarm [illegible] the cabinet [illegible] in the top pan[illegible]

Connecting the Power Supply

16. All units operate from 60 cycle AC at voltages from 105 to 125 volts. If the power line voltage varies beyond these limits or fluctuates considerably, a line voltage regulator must be installed to maintain the voltage within operating limits. A General Electric Voltage Stabilizer (catalogue No. 7470609) is supplied with each complete station for this purpose. Its characteristics are:

Input voltage: 95-130 volts, 60 cps.

Output voltage: 113-115-117 volts.

Frequency range: 57-63 cps.

Rating: 780KVA at .80 power factor.

17. The AC power supply for the three racks is distributed as follows:

Rack 1: Power cable from Rack 1 plugs into AC source, 60 cps, 105-125 volt main, or into voltage stabilizer.

Racks 2 and 3: Power cables from Racks 2 and 3 plug into female Hubbell twist-lock receptacles located on either side of Rack 1.

18. When the MAIN switch on the front panel of Rack 1 is turned on power is applied to all three racks and their component units. The power consumption of a complete monitor station with all components turned on and operating is approximately 750 watts.

Connecting the Hydrophones

19. Five hydrophones can be connected into the monitoring and recording equipment. Heavy cables from the deep submerged hydrophones probably will terminate in a cable box at the station. From this box two-conductor shielded cables should be brought to the terminal strip on the right side of the top panel of Rack 1. After they have been connected, the metal shield provided with the equipment should be screwed in place over the terminal strip.

20. The five pairs of terminals on the terminal strip are permanently wired to five male Cannon receptacles located at the top of Rack 1. On the top panel of Rack 1, just below these five receptacles, there are two female Cannon receptacles marked CHANNEL NO. 1 and CHANNEL NO. 2. These receptacles connect to the inputs of each channel. Two jumper cables are furnished with the equipment, making it possible to connect any one of the five hydrophones to either channel.

21. Two lever-action switches (one for each channel) are also located on this panel. These switches are spring-loaded and return auto-

matically to their central positions when released. When on the central position, each switch connects one of the female Cannon receptacles to its channel; when pushed up, it replaces the hydrophone by 600-ohm terminating resistors; and when pushed down it connects a terminal strip provided for connecting a signal generator to the channel in place of the hydrophone. This strip is located between the two switches and is labeled SIG. GEN. IN.

Connecting the Cables

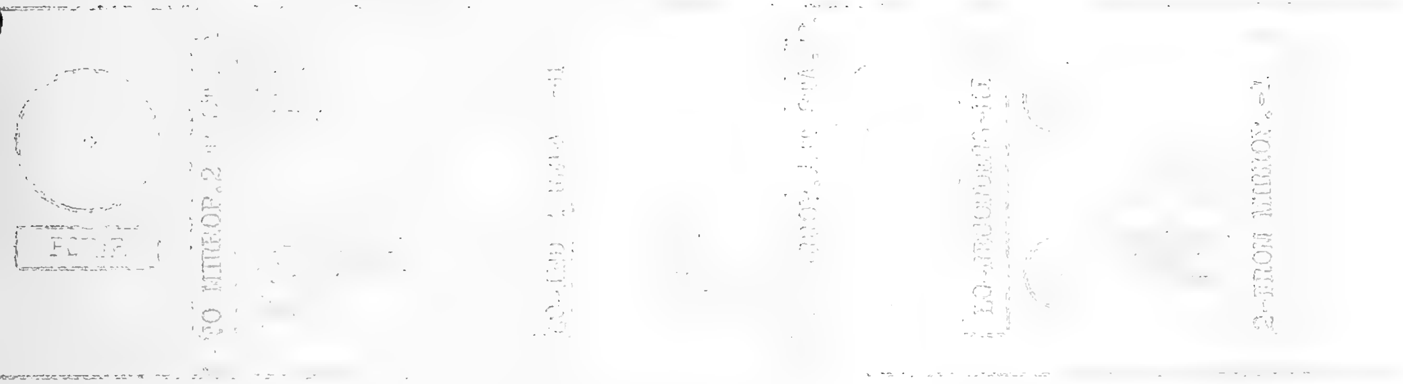
22. The [illegible] wiring within each rack is already complete. Before operations can be begun, however, the cables which run from one rack to another must be installed. These cables are supplied with each station and are numbered. They should be installed according to the following table ("Microphone" in this table means "Magnetic Tape Recorder"):

CABLES REQUIRED FOR INTERCONNECTING RACKS

Cable No.	Description	From	To
# 1	To Break-Circuit Chronometer	Rack 1	Rack 3
# 2	Output from Microphone #1 (Female Cannon to open end)	Rack 1	Rack 3
# 3	Output from Microphone #2 (Female Cannon to open end)	Rack 1	Rack 2
# 4	Power Cable for [illegible] Amplifier	In Rack 1	
# 5	Input to [illegible] First Stage (Male [illegible] phone plug)	Rack 1	Rack 3 (Front)
# 6	Input to Microphone #2 First Stage (Male Cannon to phone plug)	Rack 1	Rack 2 (Front)
# 7	To So[illegible] "High[illegible] (Male [illegible])	Rack 1	Rack 3
# 8	To S[illegible] "Low[illegible] (Male [illegible])	Rack 1	Rack 2
# 9	Signal [illegible] (Female [illegible] Volume Control)	In Rack 1	

Cable No.	Description	From	To
#10	To Index Relay – "High-speed" Recorder (Male Cannon to open end)	Rack 1	Rack 3
#11	To Microphone #1 Second Stage 3 kc signal (Male Cannon to open end)	Rack 1	Rack 3
#12	To Microphone #2 Second Stage 3 kc signal (Male Cannon to open end)	Rack 1	Rack 2
#13	To Index Relay "Low-speed" Recorder (Male Cannon to open end)	Rack 1	Rack 2
#14	To Mon Amp (124-1) (Male Cannon to Female Cannon)	In Rack 1	
#15	Power Cable for Automatic Operation of Graphic Level Recorder Switch	Rack 2	Rack 3
#16	Main Power Cable	Into Rack 1	
#17	Power Cable to Rack 2	Rack 1	Rack 2
#18	Power Cable to Rack 3	Rack 1	Rack 3
#19	Monitor Amp. (124ME) Output to Speaker (Male Cannon to Female Cannon)	Rack 1 to Speaker	
	Hydrophone Jumper Cable (2)	Male Cannon Hydrophone Input on Front panel Rack #1	Channel #1 and #2 Input front panel Rack #1 Cannon Female

23. The diagram below shows the location of each numbered cable on the rear of the Chronometer Time Control and Phone Monitor (Time Tone Amplifier), third panel from the top of Rack 1.



24. [illegible] Cannon plugs:

Pin 1 - High side, white wire

Pin 2 - [illegible]

Pin 3 - [illegible], black wire

25. [illegible] the cables reference should be made to the block [illegible] 2, which shows cables [illegible] except that the power cable to the [illegible] Amplifier, [illegible], is not shown. Bushings are located at the [illegible] both sides and at the rear of Racks 2 and 3. Cables should be [illegible] through these bushings to allow closing of the rack doors.

[illegible]

26. [illegible] recording equipment will operate reliably a number [illegible] tests must be made. Detailed directions for these tests [illegible] maintenance manual for the equipment. The operation [illegible] will operate normally [illegible] installation [illegible] have been com- [illegible] and carefully [illegible]

27. [illegible]

[illegible]	Location
a. [illegible] 1	Rack 1
b. [illegible] 2	Rack 1
c. [illegible]	Rack 1
d. Monitor [illegible]	Rack 1, Cabinet Speaker

e.	Automatic Switching Unit	Rack 2
f.	"Low-speed" (5mm/sec.) PL Sound Level Recorder	Rack 2
g.	Magnetic Tape Recorder 1	Rack 3
h.	"High-speed" (10mm/sec.) PL Sound Level Recorder	Rack 3
i.	Magnetic Tape Recorder 2	Rack 2
j.	Chronometer and code switch	Rack 3

OPERATING THE SOFAR EQUIPMENT BEFORE A SIGNAL IS RECEIVED

28. Turn on all AC power switches. These are the master switch on the front of Rack 1; a switch on each of the 7-volt power supplies in the back of Rack 1 on the second and third shelves from the bottom; a switch on the automatic switching device on the top shelf of Rack 2; a switch on each PL sound level recorder on the second shelf from the top of Rack 2 and 3; and a switch on each magnetic tape recorder on the second shelf from the bottom of racks two and three.

29. To prolong the useful life of the selenium rectifiers in the amplifier channels, the channel which is not in use should be turned off by means of the switch at the rear of the 7-volt DC supply for this particular channel (the supply for channel one is on the right side of the third shelf from the bottom of Rack 1, and the supply for channel two is on the right side of the second shelf from the bottom).

30. Similarly, to prevent wear and consequent dulling of the pole pieces, the stand-by magnetic recorder should be turned off. The Western Electric Mirrophone magnetic tape recorder is turned off by rotating its 3KC. V.C. completely counterclockwise, and the Geltron magnetic tape recorder is turned off by rotating its SIG. V.C. completely counterclockwise. Normally, the magnetic tape and Power Level recorders in Rack 3 are kept on stand-by. However, the Power Level recorder in Rack 3, which is identified as the "high-speed" recorder, may be used to transcribe the sound record from either of the magnetic tape recorders. This recorder operates at a paper-tape speed of 10mm/sec, which will double the time indexing space and give an accurate check on the arrival time evaluation.

31. Under normal continuous long-term operation the operator should establish a rotation cycle so that the duty load can be divided among the duplicate parts of the equipment. This rotation will prolong the efficient operation of both types of recording equipment and of the power supplies and amplifier channels.

32. When the AC power has been turned on as described above, all units except those in stand-by and the motors on the PL sound level recorders should be operating. The PL recorder motors will be actuated by the automatic switching unit unless their motor control has been switched to MANUAL and their amplifier control switch is off.

33. A 15-minute warm-up period should be allowed for the amplifier channel and the automatic switching unit to become stable. During this period the sensitivity of the automatic switching unit will change considerably and it will not operate properly.

34. Rack 1: Set the CHANNEL NO. 1 VOLUME or CHANNEL NO. 2 VOLUME, according to which channel is being used, at approximately 10 and the BUS VOLUME at approximately 6 db. These settings will vary depending upon background noise conditions. To prevent the line amplifier from being overloaded, the channel volume control, which follows the preamplifier and governs the input to the following line amplifier, should be set somewhat higher than 10 when high background noise prevails. The BUS VOLUME control governs the voltage applied to the system bus controlling the minimum writing level of the PL sound level recorder; it should be set lower than 6 db when high background noise prevails to prevent the PL recorder from writing too high on the paper, thereby reducing the writing range available.

35. Turn the TO RECORDER switch S-101 on the left side of the front panel of the Time Tone Amplifier (Rack 1, shelf three from the top) to the BUS position. In BUS position, S-101 connects the "High-speed" PL recorder to the system bus and throws the "High-speed" indexing relay under chronometer control. Turn the MICROPHONE S-102 switch (to the right of the TO RECORDER switch) to whichever of the two magnetic tape recorders is in use. Recorder #1 is in Rack 3; Recorder #2 is in Rack 2. Turn the third switch on this panel (to the right of the "Microphone" switch) to the BUS position. This is switch S-103, marked MONITOR. Plug 600-ohm Permoflux earphones into the monitor jack at the right of the time tone amplifier panel. The volume control labeled MONITOR R-122 for these earphones is just to the left of the earphone jack. The station operator should listen to the signal on the bus through these earphones.

36. On the bottom panel of rack one there is a volume control for the monitor speaker which reproduces the signal on the bus which is being fed to the recorders.

37. Rack 2: Turn the VOLUME control of the automatic switching unit at the left of the top panel to the full "on" position. Turn the SENSITIVITY control at the right of the top panel clockwise to the point where the background noise just fails to fire the automatic switching unit. This adjustment may require attention off and on throughout the day, and some false alarms may be caused by sudden changes in background noise. When the automatic switching unit fires it places the PL graphic level recorders in operation. After a false alarm has occurred the automatic switching unit must be reset manually by operating the reset switch located just to the left

of the SENSITIVITY control and labelled PUSH TO RESET. To reset, hold the reset switch down for about ten seconds. If the automatic switching unit fails to reset, reduce the SENSITIVITY control very slightly (counter-clockwise) and repeat the resetting.

38. For routine operation, pull the sliding drawers in racks two and three out to the stop. Turn the SPEEDS clutch adjustment marked WRITING on the PL recorder in the second panel from the top of Rack 2 to the FAST position, and turn the PAPER MM/SEC. clutch adjustment beside it to the 5/1 position. These adjustments will give a paper tape speed of 5mm/sec.

39. Turn the "Mirrophone" magnetic tape recorder SELECTOR switch on the upper right of the bottom panel of rack two to the RECORD position. Turn the SIG. V. C. switch just to the left of the magnetic tape recorder switch about two thirds maximum clockwise. Turn the 3KC V.C. switch just below the magnetic tape recorder switch as far as it will go clockwise.

40. Rack 3: It is assumed that the chronometer has already been placed in operation. Adjust the WRITING clutch on the PL graphic level recorder to the SLOW position and the PAPER MM/SEC. clutch to the 50/10 position. These adjustments will provide a paper speed of 10 mm/sec.

41. Even though the magnetic tape recorder in Rack 3 may be in stand-by operation and not running, adjustments should be made to ready it for operation the moment it is needed. Turn the SELECTOR switch on Mirrophone #1 in Rack 3 to the RECORD position. If it is a Caltron recorder turn the 3KC V.C. completely clockwise; if it is a Western Electric Mirrophone, adjust the SIG. V. C. to about two-thirds maximum (clockwise). The Caltron recorder is then placed in operation by turning its SIG. V. C. to about two-thirds maximum, and the Mirrophone is started by turning its 3KC V.C. completely clockwise.

42. The station is now ready to receive, record, and time the arrival of a signal.

OPERATING THE SOFAR EQUIPMENT WHEN A SIGNAL IS RECEIVED

43. All volume controls and variable pads have numbered dials. It is very important that a complete log of all settings be kept for each signal that is received, together with the name of the operator in charge at the time. This information is necessary for the evaluation of SOFAR data and will facilitate the making of circuit adjustments. Fig. III gives the headings which should be used. Data sheets drawn up according to the pattern of Fig. III should be on hand at all times.

44. As soon as the signal strength on the arrival of a sound channel signal rises above the background noise the automatic switching unit will fire.

Normally, the firing will turn on the motors of both the low and high speed PL graphic level recorders, start the time indexing, and alert the operator. However, if the "high speed" recorder amplifier switch is off and its motor control switch is set on MANUAL, then the "high speed" recorder will not be started by the firing of the automatic switching unit.

45. The time interruptions of the break-circuit chronometer, which breaks the time-tick circuit once each second except the 59th in each minute, will be recorded along the right-hand edge of the waxed paper tape of the PL graphic level recorders and keyed as a 3-KC tone on the magnetic tape recorder.

46. Immediately after the peak of the signal has passed the arrival time must be coded onto all recorders. This is done by pressing firmly but momentarily (for less than one second) on the code switch located just in front of the chronometer in the top sliding drawer of rack three. Pressing this switch will cause a secondary mark to be made on the time index of the PL recorder paper tape and a secondary 3-KC tone signal to be impressed on the magnetic tape recorder. At the moment of pressing the coding switch the operator must note the exact position of the chronometer second hand. The hour and minute should then be recorded. The exact time of coding should be written on the paper tape for future reference.

47. After coding the signal the operator must immediately turn the magnetic tape recorder switch on the bottom of Rack 2 or 3 (depending on which recorder is in use) to the HOLD position. This switches the tape recorder off the erase position and keeps the signal on the tape until the operator is ready to play it onto the "high-speed" graphic level recorder. This switching must be done before 2 minutes and 15 seconds have elapsed after the beginning of the signal, or the signal will be erased. One revolution of the magnetic tape recorder clock hand represents 2½ minutes. Note that the entire shot signal is recorded on the magnetic tape and that normally this unit is continuously recording and erasing. Note also that the early part of the signal up to the firing time of the automatic switching unit will not be on the PL recorder tape.

48. Immediately after putting the magnetic tape recorder on the HOLD position return the station to normal operation by starting the stand-by magnetic tape recorder. Push the reset button on the automatic switching unit so that any incoming signal can be recorded by the "slow-speed" PL graphic level recorder.

49. Process the signal already received by playing the magnetic tape recording back onto the "high-speed" graphic level recorder. To do this turn on the motor of the "high-speed" recorder by turning the motor switch in the front right corner of the chassis to the MANUAL position and switching on the adjacent amplifier control switch. Turn switch S-101 at the left of the third panel from the top of Rack 1 marked TO RECORDER to the MIRROR position. This will switch the magnetic tape recorder whose record is being held to the "high-speed" PL recorder. Turn the 3-KC volume control

on this magnetic tape recorder to the OFF position and switch the selector to PLAYBACK. The magnetic tape recording will then be played onto the "high-speed" graphic level recorder.

50. As soon as the signal from the magnetic tape recorder starts to appear on the "high-speed" PL recorder the time indexes along the right-hand paper margin should be carefully examined. [illegible] If they appear weak or an index is occasionally skipped the following adjustments should be made immediately:

(a) The signal volume control on the panel of the magnetic tape recorder, which also controls the play-back volume, should be adjusted until clear indexes appear with no skipping.

(b) If satisfactory results are not achieved by adjustment (a), the indexing should be strengthened by turning up the TIME TONE VOLUME at the rear of rack one in the right top corner of the time tone amplifier chassis.

51. If the signal is recorded on the magnetic tape recorder at too high a level it may override the 3-KC time tick at the peak of the signal. This will eliminate the indexing at that point during playback. If the signal volume control on the magnetic tape recorder is set at not more than ½ to 2/3 maximum when recording, however, this overriding should not occur.

52. After the signal on the magnetic tape recorder has been played back and recorded on the "high-speed" PL recorder the waxed-paper tapes should be carefully removed from both PL recorders and preserved for evaluation. The operator will be given detailed instruction in data evaluation by the scientific personnel who are responsible for this phase of the work.

OPERATING BOTH CHANNELS SIMULTANEOUSLY

53. It is sometimes necessary to operate both channels of the SOFAR equipment during experimental work or for hydrophone testing. During such operations one input channel is connected to the bus as usual and the magnetic tape recorder number 2 and the "low-speed" PL recorder operate off the bus.

54. On the rear of the top shelf of Rack 1 a special connector plate is located just below the 121A line amplifier. This plate is provided with two 3-contact Cannon female receptacles and is labeled: TO BE USED FOR DUAL CHANNEL OPERATION ONLY. A short cable leading from the back of this plate and terminating in a 3-prong Cannon male plug connects the plate to whichever of the 121A amplifier channels is not feeding the bus.

55. To make use of the second channel turn on both amplifiers and make sure that the output of one is connected to the bus and the output of the

other to the Dual Channel plate as described above. Disconnect cables 5 and 7 from the back of the Time Tone amplifier chassis in Rack 1 and plug both cables into the two receptacles of the Dual Channel plate.

56. This change in the normal cable connections provides two independent receiving channels, one making use of the normal duty channel with its recording equipment located in Rack 2, and the other, feeding directly into the recording equipment in Rack 3. Time indexing and PL graphic level recorder motor control from the automatic switching unit are obtained in the normal way for both channels.

57. The normal "duty" channel can be monitored from the jack on the right side of the third panel from the top of Rack 1 just as in conventional single channel operation. If crystal headphones are used to avoid loading the 600-ohm bus, it can also be monitored from the jack marked BUS MONITOR on the "slow-speed" PL recorder in Rack 2. The other channel can only be monitored on crystal headphones plugged into the BUS MONITOR jack on the "high-speed" PL recorder in Rack 3.

58. To obtain a comparable output level from both channels turn the BUS VOLUME dial on the right side of the second panel from the top of Rack 1 to 0. Then control each channel independently by adjusting the CHANNEL NO. 1 VOLUME and the CHANNEL NO. 2 VOLUME controls on the left side of the top and second panels of Rack 1.

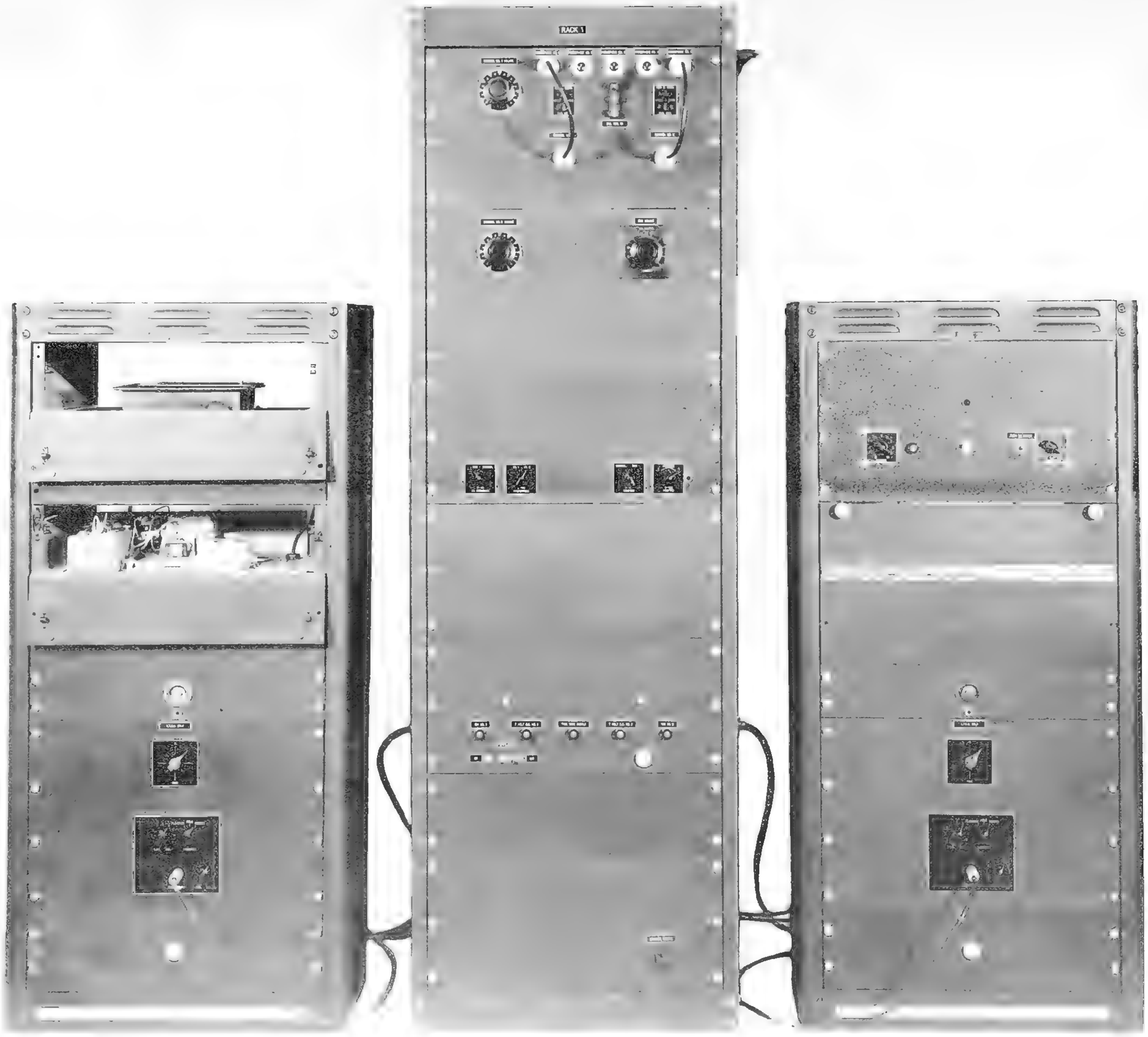


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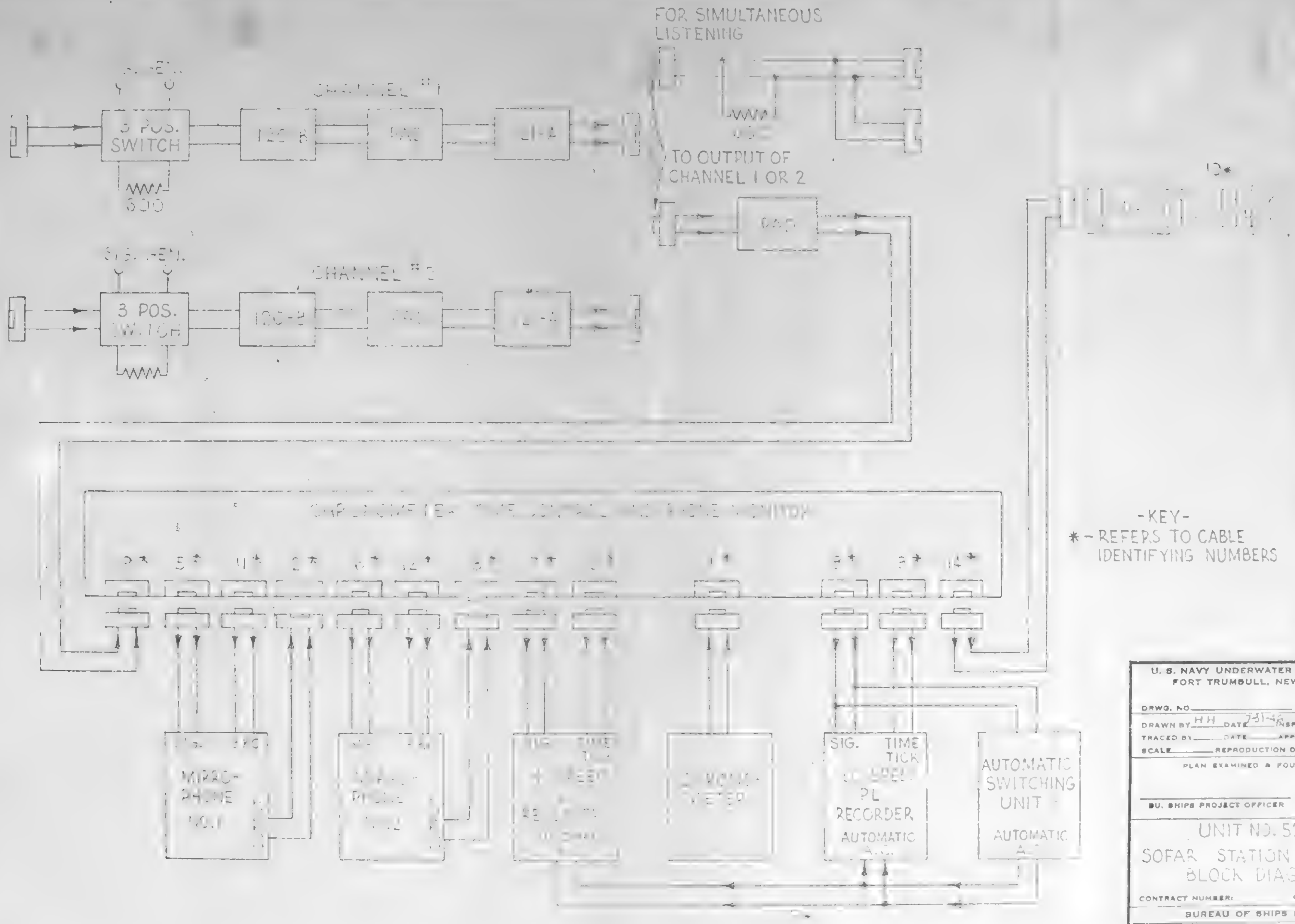
Figure 1 The Three Racks of a Completed Station



-KEY-
* - REFERS TO CABLE IDENTIFYING NUMBERS

ISSUE NO.	DATE	APP.
1:	7-31-46	

U. S. NAVY UNDERWATER SOUND LABORATORY
FORT TRUMBULL, NEW LONDON, CONN.

DRWG. NO.______ SHEET__OF__SHEETS
DRAWN BY HH DATE 7-31-46 INSPECTED BY ______ DATE ______
TRACED BY ______ DATE ______ APPROVED BY ______ DATE ______
SCALE ______ REPRODUCTION OF FINAL PLANS MADE ______

PLAN EXAMINED & FOUND SATISFACTORY

BU. SHIPS PROJECT OFFICER COMMANDING OFFICER

UNIT NO. 5214
SOFAR STATION ASSEMBLY
BLOCK DIAGRAM

CONTRACT NUMBER: CONTRACT DATE:

BUREAU OF SHIPS PLAN NUMBER

U.S.L. REPORT NO. 55

FIG. 2

SHEET E-24281-AA

"SOFAR" STATION LOG SHEET

Recording Data

Station Located At______________________________ Sheet No.__________

Operator	Date	Chrono. Time	Channel Vol. Control Settings		Bus Vol. Control Setting	Magnetic Tape Rec. Settings			Auto. Switching Unit Settings	
			Channel I	Channel II		Rec. No.	Sig. Vol. Control	3 kc Vol. Control	Vol. Control	Sensitivity

Figure 3