RS 3A 534

COMMUNICATION FACILITY INSTRUCTION BOOK

for

U. S. NAVAL RADIO STATION (TRANSMITTING)

BUSKIN LAKE

a component of the

U. S. Naval Communication Station, Kodiak, Alaska

Assistant Industrial Manager, USN, Seattle
2400 11th Avenue S. W.
Seattle 4, Washington

Submitted by

R. H. McAfee, Jr
Lieutenant Commander, USN

Approved by

W. B. Cole
Captain, USN

PREFACE

The aim of this book is to provide between one set of covers a complete statement of what the radio transmitting installation at Buskin Lake was designed to do and the reasons which determined the various features of installation and design. This book contains an analysis of the communications control and antenna switching systems, illustrated with block diagrams and photographs, and also includes a brief discussion of employment limitations, operation and maintenance concepts, an inventory of installed equipment, and a reference to significant documents and plans.

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PHOTOGRAPHS, CHARTS AND SUNDRY DATA

U. S. NAVAL COMMUNICATION STATION
Navy No. 127 (Box 9)
c/o Postmaster
Seattle, Washington (COPY)

NR84/4:rb
A23
Serial: 726
3 Oct 1955

From: Commanding Officer
To: Assistant Industrial Manager, USN, Seattle

Subj: Electronics Acceptance Inspection, U. S. NavRadSta (T), Buskin Lake

1. A joint inspection of subject activity was made this date by the Commanding Officer, U. S. Naval Communication Station, Kodiak; the Officer-in-Charge, U. S. Naval Radio Station (T), Buskin Lake; the Electronics Officer, Industrial Manager, USN, Seventeenth Naval District; and the Electronics Officer, Assistant Industrial Manager, USN, Seattle.

2. The following Electronic Installation is hereby accepted:

(a) Transmitters installed:

Type	Number
AN/FRT-4	1
AN/FRT-19	1
AN/FRT-18	16
AN/FRT-5	5
TDN-3	3
TDO	3
TAB-7	4
TDH	4

(b) Antenna loading apparatus:

AN/FRT-4 Antenna Tower Helix
TAB-7 Antenna Helix and Control

(c) CCL Equipment:

AN/TRC and Antennas
CF1B Carrier Terminals
AN/FCC-8 Telegraph Terminals
Model UG Telegraph Terminals

(d) Modified TAB-7 Transmitters for FSK operations.

Modified AN/FRT-18 for oscillator monitoring signal pick-up.

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(e) Transmitter control and monitoring bays and console.

(f) Antenna TL switching and designation plates for HF Transmitters.

(g) Power distribution panels for heater and monitor-keyer circuits.

(h) Modification of four (4) TDN radio frequency channels LF to MF and HF.

Field changes 1, 2, and 3 on FCC-8 at NAVRADSTA(T), Buskin Lake and NAVRADSTA(R), Cape Chiniak.

Modification antenna coupling units on TDO and TDH transmitters.

Modified AN/FRT-4 helix loading per BUSHIPS instructions.

3. The following are uncompleted items to be accomplished by Assistant Industrial Manager, USN, Seattle, prior to final acceptance:

(a) Complete insulation (Y) insulators on AN/FRT-4 TL.

(b) Install TDO to come.

(c) Accomplish tuning or stubbing of the following antennas pending frequency assignments:

Antenna Designator

DV-5
DP-12
DH-38
DV-9
DH-34
DH-35
DH-30
DH-29
DV-23
DV-24
DV-20
DV-19

(d) Check on construction of antennas and transmission lines.

(e) Make recommended field checks on certain types of antennas, and stubb for proper VSWR.

(f) Prepare station brochure as required by BUSHIPS.

NR84/4:rb
A23

4. Unsatisfactory conditions:

(a) Beverage Antennas on 109.7 KCS used with AN/FRT-19 are not satisfactory.

(b) 600 foot radiator on 53 KCS with AN/FRT-4 limited to 15 KW into Helixhouse due to corona.

(c) Transmission line coupling transformers T-801 in TAB tuning huts, secondaries burn up.

/s/ Robt. M. Petty

ROBT. M. PETTY

Copy to:
BUSHIPS(Code 925)
INDMAN 17
INDMAN 12

SECTION 1

GENERAL

1-1. BACKGROUND INFORMATION

The new U. S. Naval Radio Transmitting Station near Buskin Lake was completed in April 1955, superseding an older facility built during World War II. Expanding operational requirements had overcrowded the older building with radio transmitters and overloaded the existing antenna facilities. The construction of a new and larger radio transmitter building with increased equipment capacity and with a larger antenna field was therefore included in a shore development program sponsored by the Chief of Naval Operations (OPNAV) and authorized in 1948.

Construction of the new transmitter building with its associated utilities and antenna field was undertaken during the calendar years 1952 and 1953 under Bureau of Yards and Docks contract NOy-26646.

Plans were developed by the Assistant Industrial Manager, USN, Seattle during 1953 for the installation of electronic equipment including five transmitters relocated from the old building, six transmitters rehabilitated under the SERAD program, and twenty-seven new production transmitters. Installation work in the new building under the technical supervision of the Assistant Industrial Manager, USN, Seattle was started by Puget Sound Naval Shipyard in July 1954 using funds authorized under Allotment 14648, Appropriation 17X1205 PWN. The progress chart denotes the progress throughout the installation period.

Adjustment of antennas for their assigned operating frequencies and performance tests of radio transmitters and associated control equipments were conducted by Assistant Industrial Manager engineers concurrently with the equipment installation by Puget Sound Naval Shipyard forces. The final tests and calibration of all units were completed during the period from April to July 1955.

1-2. OPERATIONAL REQUIREMENTS

Facilities in the new transmitter building were provided to meet the communications operational requirements of OPNAV INSTRUCTION 0201.1 of 10 April 1951 as amended by OPNAV letter serial 419P20 of 2 July 1952. Transmitters and transmitting antennas are provided for the following circuits:

Primary ship/shore	Manual CW
Secondary ship/shore	Simplex voice
Secondary ship/shore	Manual CW
Pacific Fleet	CW, RATT
Kodiak facsimile broadcast	Radio photo
Kodiak weather broadcast	CW, RATT
General warning	CW, voice
Kodiak-Seattle	RATT
Kodiak-Adak	RATT
Kodiak-Ketchikan (USCG)	Manual CW
Kodiak-Ft. Richardson	RATT, voice
Pacific emergency net	Manual CW
Pacific HF/DF net	Manual CW
Distress	Manual CW
Merchant ships	Manual CW

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Pacific emergency net	Manual CW
Pacific HF/DF net	Manual CW
Distress	Manual CW
Merchant ships	Manual CW

Fleet Air Wing	CW, voice
Navy universal air/ground	CW, voice
Search and Rescue	CW, voice
Western Sea Frontier	Manual CW
Seventeenth Naval District	CW, voice
VHF communication control link	CW, RATT, voice

Transmitting facilities were not provided at the new transmitter building, Buskin Lake, for communication circuits, UHF ship/shore RATT, and Navy air traffic control tower, although control circuits from the control tower to the new transmitter building are available to make use of Buskin Lake transmitters on an emergency basis.

1-3 EQUIPMENT INVENTORY AT COMMISSIONING

At the commissioning of the new radio transmitting station, U. S. Naval Radio Station (T) Buskin Lake, the following radio transmitters had been installed, performance tested, and placed in operation:

Quantity	Model	Frequency Range	Emissions
1	AN/FRT-4	50-150 kc	CW, RATT
5	AN/FRT-5B	4-26 mc	CW, RATT, photo
16	AN/FRT-18	2-30 mc	CW, RATT, photo
1	AN/FRT-19	30-600 kc	CW, RATT
4	TAB-7(FC#1)	100-550 kc	CW, RATT
4	TDH-4	2-18 mc	CW, RATT, voice
2	TDN-3	2-20 mc	CW, RATT
1	TDN-4	2-20 mc	CW, RATT, voice
3	TDO	2-18 mc	CW, voice

Fleet Air Wing	CW, voice
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2	TDN-3	2-20 mc	CW, RATT
1	TDN-4	2-20 mc	CW, RATT, voice
3	TDO	2-18 mc	CW, voice

One model TDO transmitter, No. 23, scheduled to carry the high-frequency portion of circuit P41 to Fort Richardson, was not available from the Bureau of Ships SERAD program during the 1954-55 installation period, but was subsequently delivered and installed in February 1956.

To standardize the keying input circuits of all transmitters to accept a normal 90 volts positive keying signal, special "isolation keyer" units designed and manufactured under contract for the Assistant Industrial Manager, USN, Seattle were installed in transmitters as follows:

Quantity	Model	Description	Used with
1	RS 6E 1471	Isolation keyer	TAB-7 #9 (KY-43)
4	RS 6E 1471	Isolation keyer	TDH-4 transmitters
3	RS 6E 1471	Isolation keyer	TDO transmitters
12	RS 6E 1471	Isolation keyer	TDN-3 transmitters

Communication control links, using AN/TRC-1 radio equipment with CF-1B (voice) and UG (telegraph) terminals, were installed to connect the new transmitter building to existing links at the air traffic control tower and U. S. Naval Radio Station (Receiving) at Buskin Beach. Equipment for these links was relocated from the old transmitter building. A communication control link was established to U. S. Naval Radio Station (Receiving) at Cape Chiniak using new AN/TRC-1 radio equipment, CF-1B voice terminals, and AN/FCC-8 telegraph terminals. Two teletype repeaters, designed by the Assistant Industrial Manager and manufactured under contract, were provided to operate between the AN/FCC-8 full duplex terminals and half-duplex local or landline teletype loops.

The following electronic equipment was installed, performance tested, and placed in operation in the communication control link room:

Quantity	Model	Description
14	CY-597/G	Electronic equipment rack
3	T-14/TRC-1	VHF(FM) radio transmitter
4	R-19/TRC-1	VHF(FM) radio receiver
3	CF-1B	Voice terminal
11	UG	Telegraph terminal
1	AN/FCC-8	8NB send, 8NB receive, telegraph terminals
1	TA-182/U	Signal converter (voice frequency ringer)
8	NT-491394	AF jack strip
22	J-242/G	AF terminal strip
2	RS 23E 545	Teletype repeater (2w/4w)

Installed on the transmitter building roof:

7	AS-20/TRC-1	VHF antenna

A Bureau of Ships designed control and monitoring system, AN/FRQ-3, consisting of a transmitter control console, five bays of transmitter monitoring equipment and related units of electronic test equipment, was installed in the radio transmitter room. Two additional CY-597/G electronic equipment cabinets were installed adjacent to the AN/FRQ-3 monitoring bays, to house frequency-shift keyers, photo keyer adapters, and keyer patching. The following units are included in this control/monitor/keying system:

Quantity	Model	Description
1	AN/FRQ-3	Transmitter control console
1	OA-498/FRQ-3	Transmitter monitoring equipment
2	CY-597/G	Electronic equipment rack

Quantity	Model	Description
3	RCH	Radio receiver
2	CU-168/FRR	Antenna multicoupler
2	CV-60/URR	Frequency shift converter
1	LR	Frequency meter
3	OBL-3A	Oscilloscope
2	LAJ	Audio oscillator
1	OBQ-4	VT multimeter
1	TS-629/U	Audio level meter
4	FSA	Frequency shift keyer, HF
2	FSH	Frequency shift keyer, MF
4	KY-44C/FX	Photo keyer adapter
2	RS 6E 1471	Isolation keyer (used with FSH)

Installed on the transmitter building roof:

2	NT-66053	Whip antenna (cut to 15 feet for monitoring)

Stowage facilities for electronic maintenance parts and electron tubes using Bureau of Ships designed standard units were provided as follows: (Refer to Fig. 1-Z)

Quantity	Model	Description
4	RE 6F 2249	Type "A" stowage unit
2	RE 6F 2249	Type "B" stowage unit
24	RE 6F 2249	Type "C" stowage unit
50	RE 6F 2249	Type "D" stowage unit
1	G54-F-2325 (h)	Chaindex filing cabinet

The following auxiliary electronic units were installed to provide a complete transmitting facility:

Quantity	Model	Description
1	KY-43/URT	Frequency shift keyer (TAB-7 #9)
51	RM 24F 255	Antenna transmission on line switch
4	RS 10B 999	RF meter panel (for TDO's)
4	NT-50153	Antenna coupling unit (for TDO's)
1	RS 10B 979	Relay panel (in console C-5)
1	TF-11/FRT-19	Antenna coupling transformer

SECTION 2

DESIGN

2-1. SITE SELECTION AND DEVELOPMENT

A site in the vicinity of Buskin Lake was approved by the Chief of Naval Operations for construction of the new transmitting station (OPNAV INSTRUCTION 0201.1 of 10 April 1951). Design architects under the Bureau of Yards and Docks contract NOy 23786, placed the transmitter building near the center of the area most useful for antenna construction between Bear Creek and the Buskin River. Figures 2-1 and 2-1A show the building location in relation to the principal roads, streams and hills in the area.

In addition to the transmitter building, other facilities planned under contract NOy 23786 and constructed by contract NOy 26646, include the emergency power building, the 600-foot vertical radiator and helix house, four 300-foot steel towers supporting MF antennas, four MF antenna tuning huts, 63 antennas of wood pole construction, and two Beverage wave antennas. Antennas were so located that their construction could be completed without disturbing the operation of existing antennas in use at the old transmitter building, and followed the design criteria specified by Bureau of Ships letter serial 925-259 of 2 August 1951 and subsequent amendments thereto. The 70 antennas were arranged as shown in Figure 2-1A. Space near the old transmitter building was reserved for the future construction of San Francisco rhombics and an area east of the new transmitter building along Bear Creek was similarly reserved for future construction of Honolulu rhombic antennas.

The construction height for antenna towers at the new station was originally limited to 300 feet by restrictions expressed in Bureau of Aeronautics letter AER-SE-41 serial 99400 of 15 December 1950 to Bureau of Ships. OPNAV INSTRUCTION 0201.1 of 10 April 1951 requested the Bureau of Aeronautics to grant a clearance for 600-foot tower construction at Buskin Lake for erection of the low-frequency vertical radiator. The 600-foot vertical radiator, as constructed, is therefore a compromise from the 800-foot tower height recommended for 50 to 150 kilocycle operation of the AN/FRT-4 50-kilowatt transmitter. Excessive voltage at the tower base and on the antenna tuning components within the helix house may be expected at frequencies below 85 kc., because of the high reactance of the short antenna tower. (Refer to antenna tower data, Appendix I)

Bureau of Ships design criteria requires a minimum separation of 1000 feet between radio transmitting antennas and overhead power lines. Power connections for the new transmitter building were therefore made by underground cable entering the area from the south along Buskin Lake road. An existing 2400 volt aerial power line to the Lake Buskin pump house was removed and the service placed underground.

Two 26-pair underground cables were installed in the duct connecting the new transmitter building with existing cable facilities terminating at the old transmitter building No. 37.

2-2. TYPES OF ANTENNAS AND INDOOR SWITCHING SYSTEM

The selection of transmitting antenna types to meet the operational requirements of OPNAV INSTRUCTION 0201.1 from design criteria prepared by the Bureau of Ships resulted in antennas as follows:

Service	Circuits	Antenna Type	Quantity
LF Point-to-Point	P2, P19	Beverage	2
LF General coverage	Future B12, B22	Vertical tower	1
MF Point-to-point	P21, P41	Vertical flat top	2
MF General coverage	L2, L5	Vertical flat top	2
HF Point-to-point	P2, P19	Rhombic	4
HF Point-to-area	A1, A5, P40	Doublet array	12
HF General coverage	A2, B12.3, B22, C5, P30, E10, E11, E12, E19.1, Q1	Doublet, 2-wire	41
HF General coverage	Standby	wide-band doublet	6
			70

By far the largest number of antennas are simple 2-wire folded stub-tuned doublets for omni-directional use at a single frequency. For the higher frequencies (above five megacycles) these doublets are supported vertically on one wood pole. At lower frequencies, where pole heights for vertically supported doublets become impractical, tilted or horizontal doublets with two supporting poles are specified.

Twelve doublet antenna arrays, for single-frequency operation, were specified for circuits A1, A5, and P40 to provide long range communication to general areas of the earth's surface. Each of these arrays consists of a stubtuned 2-wire vertical folded doublet with a second doublet placed one-quarter wave length away in the "back" direction and tuned to act as a parasitic reflector. A signal gain of about 3 decibels, over a sector 90 degrees wide, may be obtained by properly tuning the parasitic reflector.

Each doublet and doublet array is designed for operation at a single assigned frequency. The radiation efficiency of one of these single-frequency antennas will fall off very rapidly when excited at a frequency different than that for which it is tuned. Use of any of the 53 doublets or doublet arrays at other than its assigned frequency is therefore not recommended. Restubbing and possibly reconstruction will be required whenever operational frequencies are changed.

To provide for any emergency requirement for transmitting at other than the assigned frequencies, six wide-band doublet antennas were specified. Each of these antennas consists of a tilted two-wire folded doublet with a termination resistor (15 kw stainless steel termination line) inserted to give broad frequency acceptance. These are compromise antennas whose efficiency and standing-wave-ratio varies with frequency, but which should have considerable practical use as interim antennas during casualty to a doublet or doublet array or when a tuned antenna for the required frequency is not available.

Sixty-eight of the seventy antennas, including MF and LF verticals are fed with two-wire transmission lines of 600 ohms nominal characteristic impedance. The exceptions are the two Beverage antennas which are fed with three-wire transmission lines of 350 ohms nominal characteristic impedance.

In arranging the antennas in the field, the point-to-point rhombics and phased arrays were given favored locations to provide a minimum of terrain interference from hills and mountains in the direction of transmission. Single frequency omni-directional doublets were arranged in groups by circuit use, as assigned by OPNAV INSTRUCTION 0201.1.

A switching system within the transmitter building was designed to allow operating personnel to select the antenna required for use with each transmitter and to allow interchange of transmitters or of antennas during repair or routine maintenance to antennas or equipments. Electronics drawing RS 66E 1317C shows by diagram the switching provided.

2-3. BUILDING, EQUIPMENT ARRANGEMENT AND CABLING

The transmitter building is built of reinforced concrete without windows and with a main transmitter room 220 feet long by 50 feet wide. An office wing 35 feet by 85 feet in size houses the communication control link equipment, main power switchboards, electronics shop and storage, as well as office spaces (Figs. 2-2 and 2-3). Transmitters are arranged in four rows in the main room with an operator's control console and frequency monitoring bays centrally located. Basement space carries overhead cable trays beneath the equipment rows on the main floor. Access to cabling is by means of three inch pipe sleeves through the main floor slab spaced on 24 inch centers above the cable trays. The basement space is also used for the stowage of electronic maintenance parts and electron tubes.

The walls of the main transmitter room are pierced with antenna entrance ports at a height of 15 feet above the floor. Bowl insulators are arranged in pairs for the entrance of two-wire balanced transmission lines. Switches to interconnect the transmitters and transmission lines are bulkhead mounted at an average convenient height of eight feet above the floor (Refer to Figs. 3-21 and 3-23). Switching is accomplished by the use of hardwood insulated switch poles, stored in hangers at convenient locations along the main transmitter room wall.

Power for the transmitting equipment is transmitted over lead covered electric cables laid in the lower level of the basement cable trays. Control wiring consists of RG-108/U twin-conductor shielded cable for balanced circuits and RG-59/U coaxial cables for unbalanced circuits, all laid in the upper level of the cable trays. Cables are identified by markers attached at each end and at the center of each cable run. Figure 2-4 of this instruction book provides a schematic diagram of the general cabling plan. Complete cabling details may be obtained from the electronic installation drawings, particularly sheets 25 through 30, RS 6E 1465 through RS 6E 1470.

2-4. CONTROL AND MONITORING SYSTEMS

The majority of control circuits entering the transmitter building carry teletype or manually keyed signals and voice or radio-photo modulations for the control of transmitters. Control circuits reach the transmitter building by land line cable or by VHF radio link from the communication center, radio receiving station, radio photo facility and the Cape Chiniak direction finder station. All incoming control channels terminate in the CCL room for patching at bays L-3 (Fig. 3-10) and L-9 (Fig. 3-11) before reaching the operator's control console in the main transmitter room, where they appear at the "CHAN OUT" jacks. Local keying lines and voice input lines to the transmitters also terminate in the control console at jacks labeled "XMTR IN".

Selection of a transmitter to be controlled by a particular channel is made at the operator's control console by patching from "CHAN OUT" to "XMTR IN" jacks in the control line jack field or by depressing a push key switch below the desired channel designation, and opposite the desired transmitter label, in the associated push key panel. (A connection made by patch cord takes precedence and disconnects any circuits made by push key to the same channel or transmitter carried by the patch cord.) The push key switch opposite several transmitters may be depressed under the same channel for simultaneous keying of the required number of transmitters, or patch cords may be used via paralleling jacks. Reference is made to the electronic installation drawings, RS 6E 1460 and RS 6E 1461, sheets 20 and 21, for channel and transmitter assignments at the control console as originally set up. These assignments may be varied by patching or cross-connecting in the CCL room to suit operational requirements.

Incoming keying signals by landline cable are normally received as DC pulses with approximately 120 volts of "battery" supplied at the distant end of the line. Such lines are known as "wet" lines. Other keying lines enter the transmitter building "dry", without battery, and the keying voltage must be supplied at the transmitter building. For this purpose, a rectifier supply has been provided in the CCL room, bay L-3, to convert incoming dry lines to wet lines at the control console. Keying lines at the control console "CHAN OUT" jacks carry approximately 90 volts of keying voltage, positive above ground, for transmitter keying. A neon lamp, type NE-2, is installed as a channel indicator across each console "CHAN OUT" circuit to indicate which channels are active and being keyed.

Incoming keying signals by VHF link arrive at the transmitter building as on-off keyed tones at the output terminals of each VHF link receiver (AN/TRC-1). Model UG and AN/FCC-8 tone telegraph terminals, installed in the CCL room (Fig. 3-11) convert these tones to DC keying voltages before delivery to the control console "CHAN OUT" jacks. The keying signal at the "CHAN OUT" jacks is therefore identical whether received via wet line, dry line, or VHF link, and may be interchangeably connected to any transmitter.

Radio-photo modulations are normally received over the VHF radio link as an amplitude modulated tone which is converted to a varying DC voltage by the KY-44C/FX keyer adaptors installed in bay M-13. The DC output voltage from the KY-44C/FX keyers appears at jacks in the operator's control console for patching to the desired transmitters. Reference is made to drawing RS 6E 1462, sheet 22 of the set of electronic installation drawings.

Voice modulation is received over the VHF radio link or over cable pairs via CF-1B voice terminals (Fig. 3-10) whose output channels are made available at jacks in the operator's control console for patching to TDO, TDH, or TDN-4 voice modulated transmitters.

Monitoring facilities, Model OA-489/FRQ-3 (Fig. 3-8) as designed by the Bureau of Ships, are provided for sampling the radio-frequency output of individual transmitters to measure (1) the transmitted frequency, (2) the spread and mark/space frequencies for radio teletype keying and (3) the degree of modulation of voice transmitters. Radio receivers with frequency shift converters are installed in the monitoring bays for aural monitoring of manually keyed or voice modulated transmitters and for use with teletype printers for monitoring RATT transmissions. Details of the monitoring system are shown by electronic installation drawings RS 6E 1462 through 1464, sheets 22 to 24.

2-5. COMMUNICATION CONTROL LINKS

In planning the communication control links to connect the new transmitter building with existing Naval Communication Station facilities, the Bureau of Ships directed the continued use of AN/TRC-1 VHF (FM) radio equipment, as presently installed, supplemented by additional AN/TRC-1, CF-1B and AN/FCC-8 units for the new link to Cape Chiniak.

Operating frequencies assigned for the AN/TRC-1 VHF links were limited to the frequency band from 76.1 to 98.6 megacycles to comply with a Federal Communications Commission recommendation requesting that the Navy vacate its use in Alaska of frequencies between 70 to 76 megacycles because of possible interference with television reception.

Links planned and subsequently installed at the new transmitter building provide the following channels:

Link Designation	Channels Teleg.	Voice	VF Ringing	Radiophoto
G to NAVSTA tower	6(UG)	1(CF-1)	0	0
H from NAVSTA tower	6(UG)	1(CF-1)	0	0
I from NAVSTA tower	0	0	0	1(AN/TRC-1)
J to NRS(R) Buskin Lake	8(UG)	2(CF-1)	0	0
K from NRS(R) Buskin Beach	6(UG)	2(CF-1)	0	0
L from NRS(R) Chiniak	8*(FCC-8)	2(CF-1)	1(TA-182)	0
M to NRS(R) Chiniak	8*(FCC-8)	2(CF-1)	1(TA-182)	0

* The AN/FCC-8 telegraph terminal equipment assigned to the Cape Chiniak link is intended to be divided, during the future installation program at Holiday Beach, to provide four channels between Chiniak and Buskin Lake and four channels between Chiniak and Holiday Beach. At that time four channels from the AN/FCC-8 terminals now installed in

the transmitter building will be relocated to the new receiver building at Holiday Beach.

All model AN/FCC-8 receiver telegraph channels for the Cape Chiniak link were modified in accordance with Assistant Industrial Manager, USN, Seattle drawing RS 43A 1226C to provide a positive output voltage for keying radio transmitters.

Two teletype repeaters, manufactured from Assistant Industrial Manager, USN, Seattle drawing RS 23E 545C, were provided for the combined use of a "send" and a "receive" channel of the AN/FCC-8 terminal equipment into a half-duplex teletype DC loop. Instructions for the operation and maintenance of the RS 23E 545 repeater will be found in Section four of this instruction book.

2-6. POWER DISTRIBUTION AND EMERGENCY POWER

Design of the emergency power plant and power distribution system for the new transmitter building was provided by the architect-engineer contractor, following Bureau of Yards and Docks design criteria, under contract NOy-23786. The power distribution to radio transmitters and electronic components from Main power panels P1 and P2 was designed by the Assistant Industrial Manager, USN, Seattle. Additional distribution panels "F" and "G" were included in the electronics planning to distribute 120 volt AC power to master oscillators and keyers of the AN/FRT-5B and AN/FRT-18 transmitters providing a separate disconnect point for the thermostatically controlled ovens so these will not be turned off when the main power breaker to a transmitter is opened.

2-7. ELECTRONIC GROUND SYSTEMS

As a part of the transmitter building construction, under contract

NOy-26646, a buried radial ground wire system was provided through which radio transmitters and electronic equipments are grounded. Details of the ground system are specified by Bureau of Yards and Docks drawing No. 504190. The radial copper wires are #6 AWG, each 500 foot long, and spaced every two degrees for a total of 180 wires around the perimeter of the transmitter building. Two number 1/0 copper perimeter cables, around the building wall, pick up the radial wires and connect at frequent intervals to number 1/0 copper cables through the building wall to a grid of 1/4" x 2" copper bus bars above the cable trays in the basement. All reinforcing and structural steel as well as metal flashings, piping and ducts are bonded electrically to the radial ground system.

Each of the four 300-foot steel antenna towers (Fig. 2-5) is grounded by means of two number 2/0 copper cables bonded to two tower legs and brazed to a minimum of eight underground radial wires. (Specification: ASTINDMAN Seattle sketch 22568-44)

The ground return at each of the TAB-7 antenna tuning huts (Fig. 3-16) is made by means of two number 2/0 copper cables brazed to a minimum of eight of the underground radial wires. (Specification: ASTINDMAN Seattle drawing RS 66D 1293B))

At the 600-foot vertical radiator for the AN/FRT-4 transmitter, a separate ground system designed for low resistance at low radio frequencies was specified by Bureau of Yards and Docks drawing number 504201. The radial copper wires are #6 AWG, each 1000 feet long, and spaced every 1.5 degrees for a total of 240 wires around the helix house and tower base.

Separate radial ground systems, each consisting of 24 buried radial wires of #6 AWG soft copper 300 feet long, or equivalent, were specified for the end poles of the two Beverage wave antennas. (Reference: BUDOCKS drawings 504230, 504232, 504233 and 504236)

The electronics installation drawings prepared by the Assistant Industrial Manager, USN, Seattle specify a #6 AWG armored copper wire connecting each radio transmitter and equipment frame to the copper ground bus in the basement. This ground is for protection of personnel to prevent the metal frame of any transmitter or equipment from accidentally carrying a dangerously high potential above ground. Radio frequency grounds, when required, are carried by other means, for example the antenna return, unbalanced, for the AN/FRT-19 antenna transformer is carried by three inch copper strip to the main electronic ground bus of the radial ground system.

2-8. LIST OF APPLICABLE PLANS AND SPECIFICATIONS

a. Bureau of Yards and Docks construction drawings:

Drawing No.	Subject
Y&D 504161-504165 (sheets 1-5)	Title sheet and site plans
Y&D 504166-504190 (sheets 6-30)	Transmitter building
Y&D 504191-504197 (sheets 31-37)	Emergency power building
Y&D 504198-504201 (sheets 38-41)	Helix house
Y&D 504202-504204 (sheets 42-44)	Antennas
Y&D 504205-504206 (sheets 45-46)	Transmission-line details
Y&D 504207-504218 (sheets 47-58)	Antenna towers
Y&D 504219-504236 (sheets 59-76)	Antenna details

b. Electronics installation drawings:

ASTINDMAN, Seattle drawing No.	Subject
RS 6E 1441 - RS 6E 1442	Title sheet and material list
RS 6E 1443 - RS 6E 1446	Equipment arrangements
RS 6E 1447 - RS 6E 1449	AN/FRT-4 arrangement and wiring
RS 6E 1450 - RS 6E 1455	Transmitter wiring diagrams
RS 6E 1456 - RS 6E 1459	Antenna T/L switching
RS 6E 1460 - RS 6E 1464	Control & monitoring equipment
RS 6E 1465 - RS 6E 1470	Cabling plans
RS 6E 1471	Isolation keyer
RS 6E 1472	AN/FRT-18 wiring
RS 6E 1473 - RS 6E 1475	CCL installation
RS 6E 1476 - RS 6E 1478	Cable running lists

c. Antennas and antenna switching:

RS 66E 1317C, sheet 1	Antenna plot plan, as built
RS 66E 1317C, sheet 2	Antenna switching chart

d. Electronic components built or modified by the Assistant Industrial Manager, USN, Seattle:

RS 6E 1471	Isolation keyer
RS 23E 545	2W/4W teletype repeater
RS 10B 979	Keying relay panel (for TDN-4 PTT)
RS 10B 999	RF meter panel (for TDO)
RS 43A 1226	AN/FCC-8 tone telegraph receivers, modification for keying voltage output

e. Specifications for Bureau of Yards and Docks construction:

NAVDOCKS specification No. 28687

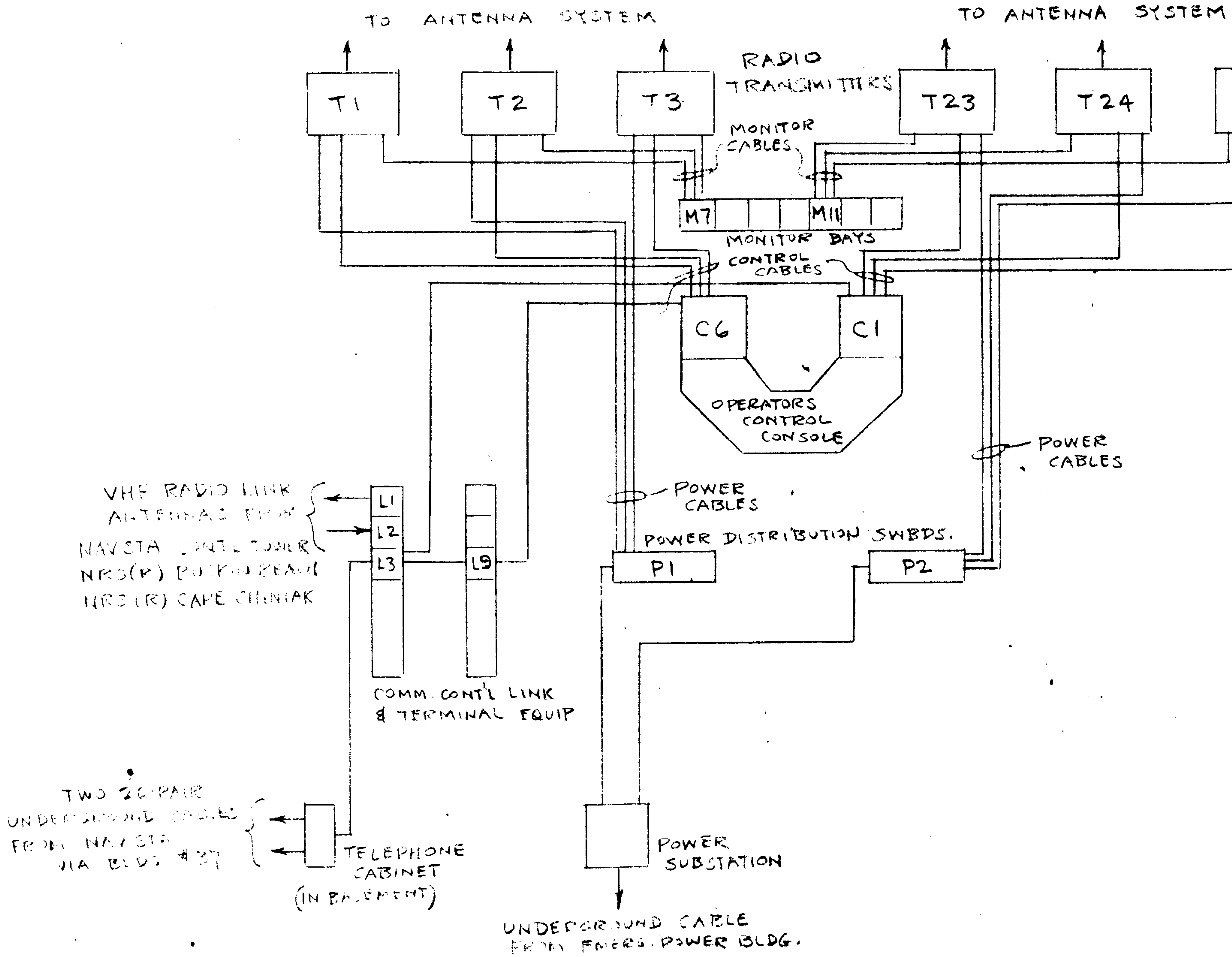
f. Specifications for grounding of 300-foot antenna towers and TAB-7 antenna returns:

ASTINDMAN, Seattle sketch 2256B-44

ASTINDMAN, Seattle drawing RS 66D 1293

g. Instructions for special electronic units built by the Assistant Industrial Manager, USN, Seattle:

2-wire/4-wire teletype repeater for use with AN/FCC-3 carrier telegraph terminals, of 1 December 1954.



TRANSMITTER BUILDING
CABLING SCHEMATIC

FIG. 2-4

SECTION 3

EQUIPMENT INSTALLATION AND OPERATION

3-1. TRANSMITTER INSTALLATION

The transmitters were located and installed in the transmitter building in accordance with Figs. 3-1, 3-1A, 3-2, 3-2A and the installation specifications. A copy of the "Specification for the Installation of Electronics Equipment in the New Transmitter Building" is included in the appendix. The transmitters, being of various physical sizes and ranging in power outputs from 50,000 watts to 500 watts with a frequency coverage of 30 kilocycles to 30 megacycles, are provided with a system of antenna switching arranged to facilitate operational requirements for antennas and to provide for a spare transmitter on all primary circuits. In order to provide for frequency shift keying operation and for frequency monitoring and adjustments, many of the transmitters were modified in a manner described in paragraph 3-2 of this section. Each transmitter has been provided with keying and monitoring circuits which terminate in the centrally located CONTROL CONSOLE and MONITOR bays. Interunit wiring is installed in wiring troughs suspended from the ceiling of the basement below the transmitter room floor (Fig. 3.3). Bonded copper strap buses connect unit chassis directly to the main station ground bus and the buried ground system surrounding the transmitter building.

The keying control and frequency monitoring of each transmitter is accomplished through keying and monitoring circuits from the control console and monitor group bays. In order to minimize the number of keying and monitoring lines between each transmitter and the control console, a circuit selector switch has been provided in the base compartment of each transmitter unit except the Model AN/FRT-19, the Model TDO and the Model TDN equipments. Through the CIRCUIT SELECTOR switch, the keying control line may be switched into either the CW or the FSK-PHOTO input to the transmitter. Also a sample of the radio frequency output voltage may be selected from the oscillator output or the final output stage of the transmitter for frequency measurements. Power is supplied to the transmitters through two main breaker power cubicles containing individual branch circuit breakers for each transmitter. Separate circuits from auxiliary power panels supply power for oven temperature control on all units equipped with oven heaters.

A standard keying voltage of 135 volts positive is supplied through the keying lines for keying all transmitters. Some of the older type transmitters such as the Model TDN, require a keyer adapter unit known as an ISOLATION KEYER to transform the standard keying voltage to the proper voltage for keying these transmitters. (Refer to Section I, paragraph 1-3 and installation drawing RS 6E 1450J) A simple type RF detector unit is mounted on the top of each transmitter to sample and rectify the radio frequency output to operate the monitor glow lamps in the control console. In this way, monitoring the operation of each transmitter may be done at the control console unit.

3-2. TRANSMITTER MODIFICATIONS

Model TAB-7 transmitters were installed in positions, Nos. 8, 9, 30 and 33 of the floor plan drawings (Figs. 3-1A and 3-2A) and were modified for frequency shift keying. The frequency shift keying of the Model TAB-7 transmitters in positions, Nos. 8, 30 and 33 is obtained from the output of a Model FSH frequency shift keyer in monitor bays 12 and 13. The keyer output is cabled into a selector switch in the right hand bottom compartment of the transmitters for selection of FSK or CW keying. With the selector switch in the CW position, the transmitter functions in a normal way through excitation from its own master oscillator. In the FSK position, the output of a Model FSH excites the grid of the master oscillator tube V-101 through grid condenser C-106. A .03 microfarad capacitor was added between capacitor C-106 and the switch S-108 and capacitor C-102 circuit to remove plate voltage from the keyer selector circuit. (Refer to Model TAB-7 transmitter schematic diagram, Fig. 3-4) The push button switch S-504 in the land line control unit was replaced with a single pole single throw toggle switch to bridge the contacts of the land line relay K-501-B when switch S-505 is in the relay keying position to lock key the transmitter during FSK excitation by the FSH keyer unit. The TAB-7 in position nine was additionally equipped with a type KY-43/URT frequency shift keyer mounted within the transmitter.

Sampling the radio frequency output from the master oscillator unit on the Model AN/FRT-18 transmitters for frequency measuring purposes was accomplished through a voltage divider network installed in the MASTER OSCILLATOR output. As indicated in Fig. 3-5 and installation drawing RS 6E 1472J, the divider network consists of a 3300 ohm in series with a 10 ohm resistor connected to ground from jack plug J-803. The sample voltage is obtained across the 10 ohm resistor. A SELECTOR SWITCH provides a means of selecting the oscillator output or the transmitter output for frequency measuring purposes. From the SELECTOR SWITCH the chosen signal is transmitted to the Model LR frequency meter in the MONITOR group.

3-3. MONITOR AND KEYER BAYS

The monitor and keyer bays designated as type OA-489/FRQ-3, monitor group equipment, consists of seven cabinets or bays numbered as bay M-7 through M-13. The monitor group contains apparatus for monitoring, testing and operating the station transmitters. Included are monitoring receivers, frequency measuring and comparison standards, RF and AF switch selector panels and jack plug fields, receiver antenna couplers for monitor receivers, line level meters and frequency shift keyers for FSK operation of some types of transmitters. A descriptive outline of the monitor group is shown in Fig. 3-6 and installation drawing RS 6E 1462. The monitor bay assembly is located near the center of the equipment area. The monitor bays contain the following specific equipments:

Bay M-7 contains:

1 Type OBL-3a oscilloscope
1 Model TE 200K audio oscillator
1 Audio jack field group
1 RF jack field group, monitor

Bay M-8 contains:

2 Monitor receiver speakers
1 Antenna coupler CU-168/FRR
1 Monitor receiver, Type RCH
1 Teletype converter unit, CV-60/URR

Bay M-9 contains:

1 Audio selector switch, SA-135/G
1 Jack panel, J-265/G (RF)
1 Frequency meter, Model LR
1 Switch panel, RF, Type SA-138/G

Bay M-10 contains:

1 Speaker assembly, LS-139/G
1 Antenna coupler, Type CU-168/FRR
1 Monitor receiver, Type RCH
1 Teletype converter, Type CV-60/URR
1 Model OBQ-4 test set

Bay M-11 contains:

1 Model OBL-3a oscilloscope
1 Type TE 200K audio oscillator
1 Audio panel jack field group
1 RF antenna jack field group

Bay M-12 contains:

1 Model FSH frequency shift keyer MLF
1 Patch panel, RF, FS keyer outputs
2 Model FSA frequency shift keyers HF
2 Isolation keyers for FS keyers

Bay M-13 contains:

1 Model FSH frequency shift keyer MLF
2 Model FSA frequency shift keyers HF
4 Facsimile keyers

The use and purpose of monitoring facilities are for checking the operation of equipment in the following ways:

By means of the monitoring receivers, local transmitters may be monitored and reception of standard frequency broadcasts from the Bureau of Standards, Station WWV and WWVH may be obtained for checking frequency standards such as the Model LR frequency meter.

For measuring and checking frequency shift of transmitters operating FSK, the following procedure is generally used. The transmitter output frequency is adjusted for zero beat with the desired frequency output of the Model LR frequency standard, and fed into the horizontal plates of the Model OBL-3a oscilloscope where it is compared with the output frequency of a type TE 200 k audio oscillator connected to the vertical plates of the Model OBL-3a oscilloscope. When the transmitter frequency is shifted to "Mark" or "Space", the amount of frequency shift may be measured directly by the calibrated dial of the audio oscillator.

For measuring voltages, resistance values or continuity of keying and control circuits, the Model OBQ-4 test set may be used as a general purpose testing device. Both ac tone and dc control and keying voltages may be measured merely by plugging the input of the test set into the line or trunk that is to be measured. Voltages across a line however, should be measured with the load connected to the line.

Various switches and jack panels are provided for monitoring the keying and radio frequency output circuits of transmitters and for cross patching circuits for emergency or operational requirements. Antenna coupler units, type CU-168/FRR are provided for multiple operation of monitoring receivers on a single antenna.

The Model CV-60/URR teletype converters are provided in monitor bays M-8 and M-10 to monitor FSK transmissions from local transmitters through local monitor receivers. (See photograph, Fig. 3-8)

3-4. CONTROL CONSOLE

The Model AN/FRQ-3 control console is a type OA-490/FRQ-3 control monitor consisting of six panel bays mounted in a desk type console cabinet. The physical arrangement is shown on transmitter installation drawing, RS 6E 1460, and Fig. 3-7. The panel bays are designated as bay C-1 through C-6. They mount jack fields and test equipment for monitoring and controlling the operation of radio transmitters.

The panel bays contain the following equipments:

Bay C-1 contains jack field and plugs for transmitter control lines including CCL output and monitor jacks and lamps, land line output and monitor jacks and lamps, and transmitter keyer inputs and monitoring lamps.

Bay C-2 contains push key selector line switches that parallel the jack connections in the jack field of bay C-1. The incoming control lines are connected to the vertical rows and the transmitter keyer inputs to the horizontal rows of the push key switches.

Bay C-3 contains an audio level test meter Model TS 629/U with bridging and terminating circuits and one audio oscillator Model 200 ABR, range 20 to 200 cycles.

Bay C-4 contains a cathode ray oscilloscope Model OBL-3a and one Model RCH radio receiver for monitoring.

Bay C-5 contains push key selector line switches that parallel the jack field in bay C-6. The incoming control lines are connected to the vertical rows and the transmitter keyer inputs to the horizontal rows of push key switches.

Bay C-6 contains a jack field with plugs and retractable cords and monitoring jacks and lamps for monitoring control line inputs, also transmitter keying line inputs similar to bay C-1.

A hand telephone set operated on the station dial system is mounted on an auxiliary panel between bays C-1 and C-2. A monitoring loudspeaker with volume control is mounted in each of two auxiliary panels between bays C-2 and C-3 and between bays C-4 and C-5.

A local battery magneto ringer hand telephone set is mounted on auxiliary panel between bays C-5 and C-6 for communication over the CCL radio link to U.S. Naval Radio Station (R) Cape Chiniak and the Direction Finder Station, Cape Chiniak.

The control console is located at the center of the equipment area in front of the monitor bay unit and is the terminus for all incoming trunk lines from the carrier control link equipment and the control cables terminating in the transmitter building. From it, control lines radiate to each transmitter and to the monitoring bays for the purpose of cross-patching and testing (see photograph Fig. 3-8).

3-5. CARRIER CONTROL LINK AND TERMINAL EQUIPMENT

Use of the Model AN/TRC very high frequency radio transmitters and receivers in the Navy system standardizes all communication link equipment between the Naval facilities, the Signal Corps, Alaska Communication System and the Civil Aeronautics Administration on Woody Island. A review of Fig. 3-9 indicates the various paths of the CCL circuits in the vicinity of the Kodiak area. At the Buskin Lake transmitter station, three transmitters and four receivers are installed to handle station remote control and operational circuits. Two transmitters and receivers handle circuits to the receiver site at Buskin Beach and to the terminal facilities at the control tower location. One transmitter and receiver handles the circuit to the Cape Chiniak receiving station. A fourth receiver is employed for facsimile and photo reception originating from the Weather Central. Medium gain reflector-director doublet antennas mounted on the roof of the transmitter building are connected to the AN/TRC equipment through 50 ohm coaxial line of low loss characteristics. Operating frequencies lie within the 76 to 95 megacycle spectrum.

The CCL terminal equipment (see plates Figs. 3-10 and 3-11), comprises three type CF-(1B) four channel telegraph carrier equipments, eleven Model UG telegraph terminal equipments, eight channels of Model AN/FCC-8 telegraph terminal equipment together with two 2-wire/4-wire type RS 23E 545 teletype repeaters, test boards and local and trunk circuit jacks for incoming and outgoing circuits. The Model UG telegraph terminal equipment is used on all telegraph circuits except those between Cape Chiniak receiver station for which the Model AN/FCC-8 is used. Full control of circuits for routing and cross-patching can be maintained through the patch panels and monitoring boards. Signals from both incoming radio circuits and land lines may be selected, cross-patched or routed to the transmitter control console for keying any one or several transmitters simultaneously. In the equipment arrangement, the incoming circuits from telephone lines and radio carrier units terminate in bay No. 3 patch and test panel. From there they are trunked over to bay No. 9 and thence to the control console. Descriptive literature and operating instructions for the type RS 23E 545 2-wire/4-wire teletype repeater are included in Section 4-5.

3-6. POWER DISTRIBUTION SYSTEM

Three-phase power is supplied to the transmitter building substation through a 13.6 kilovolt underground cable from the Kodiak Naval Base power system by way of the standby engine-generator plant. The substation, located adjacent to the front of the transmitter building, transforms the power to 230 volts three-phase for the transmitter building load. Within the building, power is distributed to the various transmitters and building loads through two Westinghouse power cubicles rated at 240 volts, 2000 amperes each and containing one main breaker and a suitably rated branch breaker for each of the transmitter loads. The transmitter building lighting load is obtained from a 208/120 volt four-wire three-phase transformer bank connected through circuit breaker No. 22 on the east power cubicle. For arrangement of the load on the cubicles refer to Assistant Industrial Manager, USN, Seattle drawing RS 6E 1465 and 1466; and for branch circuit breaker designations and locations refer to Figs. 3-12A and 3-13A and to photographs, Figs 3-12 and 3-13. The numbered transmitters are arranged on the branch circuit breakers as follows:

East Power Cubicle, Fig. 3-12A		West Power Cubicle, Fig. 3-13A	
CB Number	Trans. Number	CB Number	Trans. Number
1	15	1	2
2	16	2	5
3	25	3	0
4	34	4	0
5	20	5	0
6	19	6	14
7	38	7	4
8	23	8	3
9	17	9	6
10	29	10	0
11	35	11	0
12	21	12	8
13	26	13	13
14	0	14	11
15	36	15	0
16	18	16	7
17	31	17	0
18	30	18	0
19	22	19	9
20	27	20	0
21	0	21	12
22	Building load	22	1
23	37	23	0
24	24	24	10
25	32	25	0
26	33	26	0
27	28	27	0
28	0	28	0
29	0	29	0
30	0	30	0

With all of the present number of transmitters installed, there remains 15 vacant circuit breakers on the West power cubicle and five vacant circuit breakers on the East power cubicle, providing a total expansion of 20 additional transmitters which may be accommodated.

3-7. STANDBY EMERGENCY POWER PLANT

The standby emergency power plant is housed in a re-enforced concrete building in the vicinity of the radio transmitter building. The plant consists of an 800 kilowatt, 13.8 kilovolt three-phase alternator driven by a diesel engine prime mover. It contains switching, metering and synchronizing apparatus and has sufficient capacity to supply full load requirements to the transmitter facility during station power failures. It may be synchronized with the Naval Base power system to supply power to the system during peak power demands.

3-8. ANTENNAS AND TUNING HOUSES

High frequency antennas are designed to operate from an open wire, 600 ohm impedance transmission line. The overall frequency spectrum ranges from 3 megacycles to 30 megacycles. The majority of the high frequency antennas are half wave tuned folded doublets having a terminal input impedance of 300 ohms. The 600 ohm transmission lines are matched to the antennas by tuned stub lines (see Figs. 3-14, 4-1, 4-2 and 4-3). Other high frequency antennas include rhombics and terminated broadband folded doublets. The rhombics are designed for high gain point to point service while the terminated folded doublets are aperiodic antennas designed primarily to cover frequencies for which tuned antennas are not available. The 600 ohm impedance transmission lines are constructed of two number 6 wires spaced 12 inches apart and are normally matched to the terminal impedance of the rhombic antennas.

Medium low frequency antennas operating within the 100 to 500 kilocycle range are of the flat top vertical and the Beverage types.

The Beverage antennas, one of which bears toward Seattle, Washington and the other toward Adak, Alaska, are designed for operation in the 100 to 300 kilocycle band with the Model AN/FRT-19 transmitter (refer to Figs. 3-15 and 3-19). The terminal impedance of the Beverages is in the order of 350 ohms and fed from the transmitter through a 3-wire 350 ohm transmission line. Other low frequency antennas are constructed as flat top loaded vertical radiators supported by 300 foot self supported steel towers (Fig. 2-5), and are normally used on short distance non-directive circuits on two kilowatt Model TAB-7 transmitters. The TAB-7 transmitters (Fig. 3-20) excite the vertical flat top-loaded antennas through a 600 ohm balanced radio transmission line terminated by the antenna coupler device situated in a tuning house (Fig. 3-16) at the base of the antenna. Although all vertical top-loaded antennas at this station are electrically short and require inductive loading for resonance, a series capacitor is also provided in the tuning house for operation as an electrically long antenna. Another low frequency antenna in use at this station is the vertical insulated guyed 600 foot tower operating in the 50 to 150 kilocycle range from the Model AN/FRT-4 fifty kilowatt radio transmitter (Fig. 3-22). Like the smaller vertical top loaded antennas, this antenna is excited through a balanced 600 ohm transmission line coupled into the tower antenna by means of an antenna coupling device in the helix house at the base of the tower (Fig. 3-17). The antenna coupling device contains the antenna loading helix, the antenna tuning variometer and the transmission line terminating and coupling transformer. Fine tuning of the antenna variometer is remotely controlled by the ANTENNA TUNING dial on the front panel of the Model AN/FRT-4 transmitter. The tower base insulator is designed to withstand a 200 kilovolt peak amplitude radio frequency voltage. A tower lighting transformer located between the tower base and the helix house isolates the 60 cycle lighting circuit from the radio frequency voltage impressed at the base of the tower. Electronic heaters are installed in the helix house in the vicinity of each of the litz wound coils and helices. Their purpose is to maintain the temperature of the air in the helix house above the dew point for keeping the tuning equipment dry and free from mildew and damage due to electrical arc-overs. It is imperative during the maintenance of the AN/FRT-4 helix house equipment that the operation of these heaters be checked and kept in proper working order at all times.

The tuning houses for the Model TAB-7 top loaded vertical antennas are small wood frame buildings which shelter an enclosed metal cabinet containing the antenna loading and tuning equipment. Small strip heaters within the cabinets prevent condensation of moisture on the radio components. Operation of these heaters should be checked periodically. The Model AN/FRT-4 helix house is a reinforced concrete structure near the base of the tower radiator. It is completely shielded with copper sheet on the walls, ceiling and floor to prevent radio frequency losses in the structural steel and reinforcement bars in the concrete. The tower radiator is a triangular cross section steel tower mounted on a single base insulator and supported with six insulated guy wires. An extensive buried radial ground system emanates from the base of the antenna. It consists of 240 radial wires spaced one and one-half degrees apart. Each radial is a number six copper wire 600 feet long. Being electrically short over the range of operating frequencies, the reactance of the tower antenna is entirely capacitative. At frequencies below 60 kilocycles, the antenna resistance tends to increase due to ground system losses. Above this frequency, the resistive losses of the antenna predominate and increase with frequency. The complete electrical characteristics of the tower antenna, with information on loading, tuning and termination of the transmission line, is tabulated in the appendix.

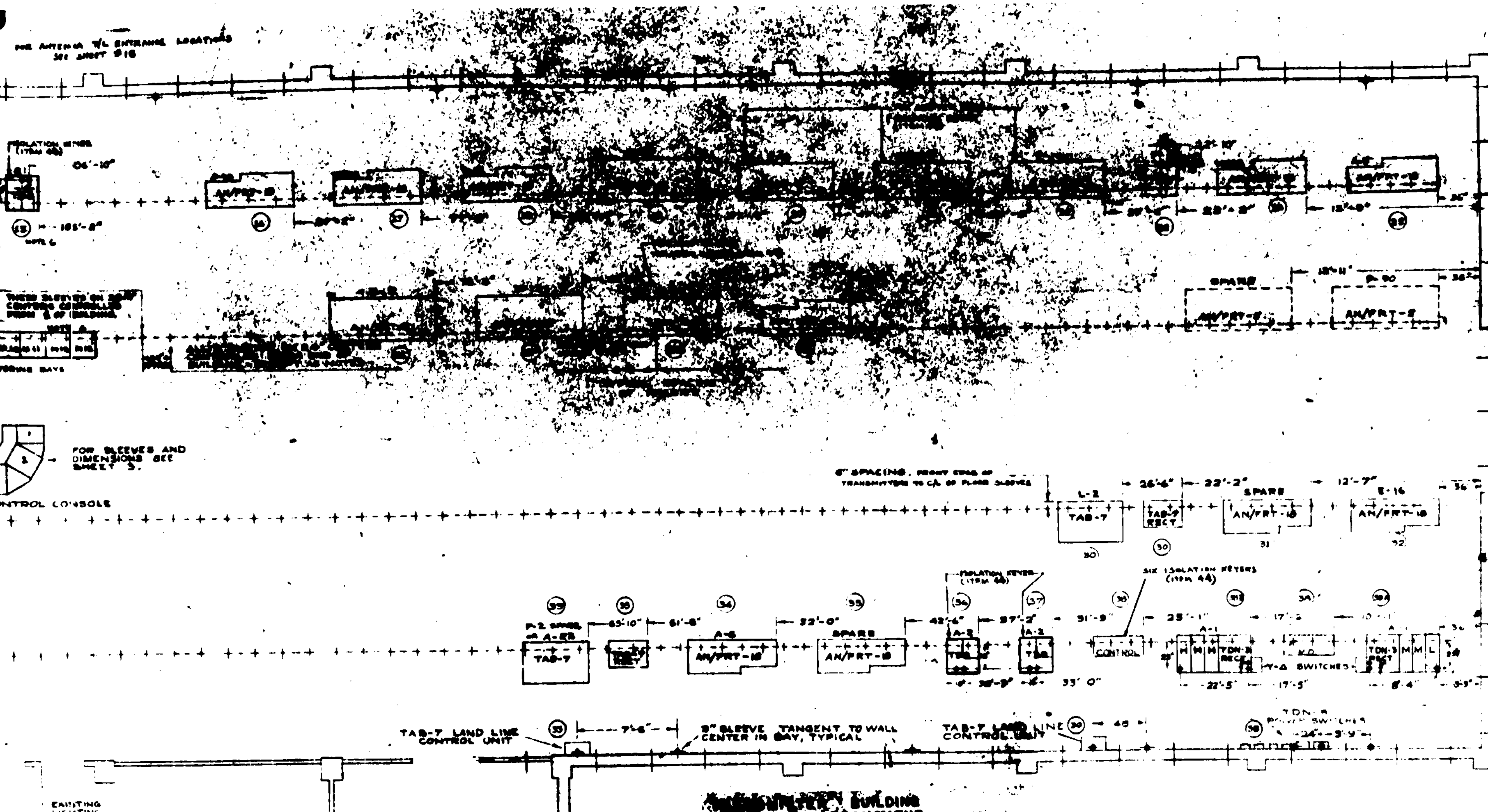

FOR SLEEVES AND DIMENSIONS SEE SHEET 5.
SPARE
AN/FRT-18
TAB-7
CONTROL
Y-Δ SWITCHES
TAB-7 LAND LINE CONTROL UNIT
8" SLEEVE TANGENT TO WALL CENTER IN BAY, TYPICAL
SWITCHBOARD ROOM

Fig. 3-1A

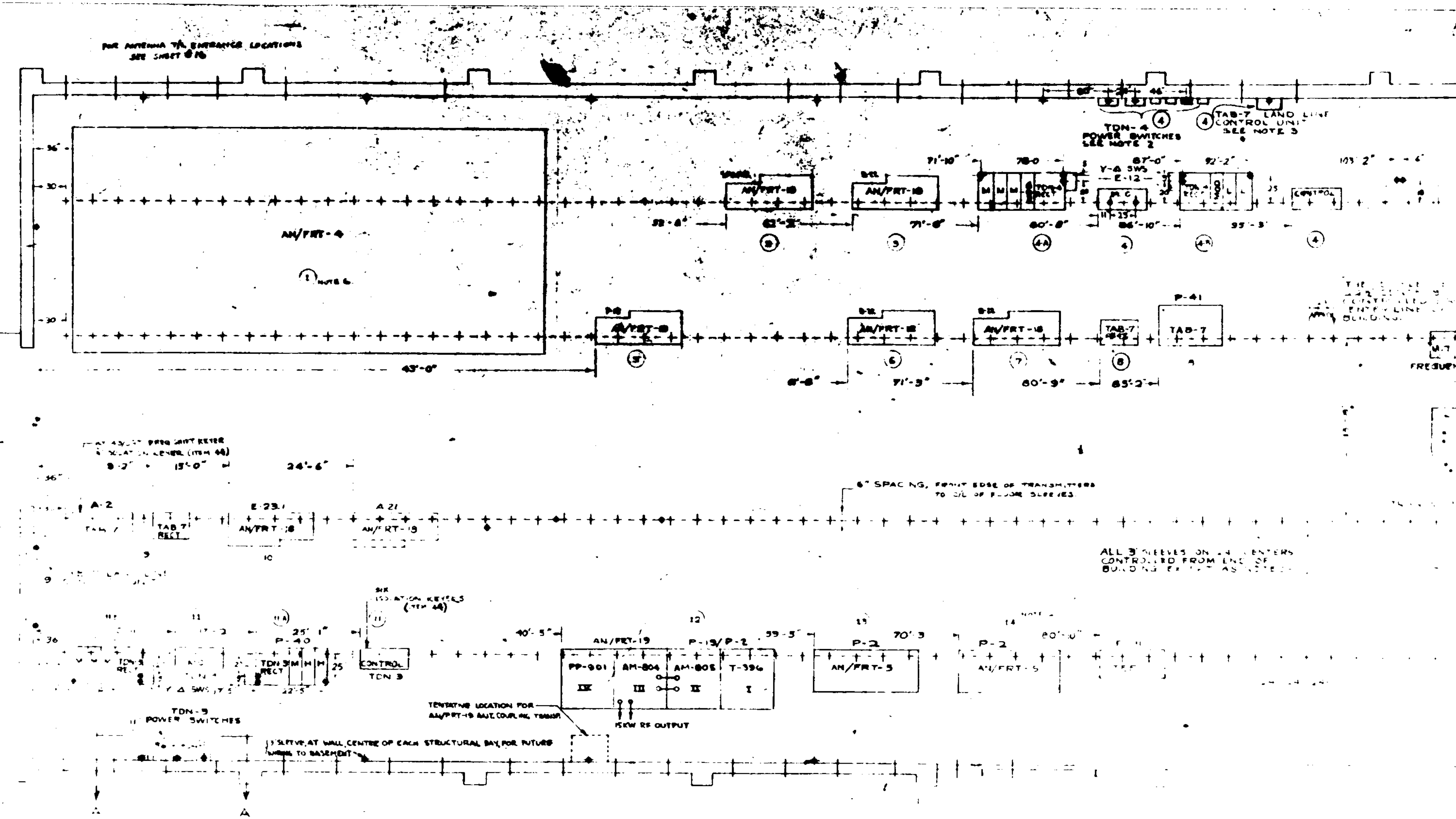


Fig. 3-2A

TRANSMITTER BUILDING
EQUIPMENT ARRANGMENT
FIRST FLOOR WEST SIDE

SCALE ¼" = 1'-0"

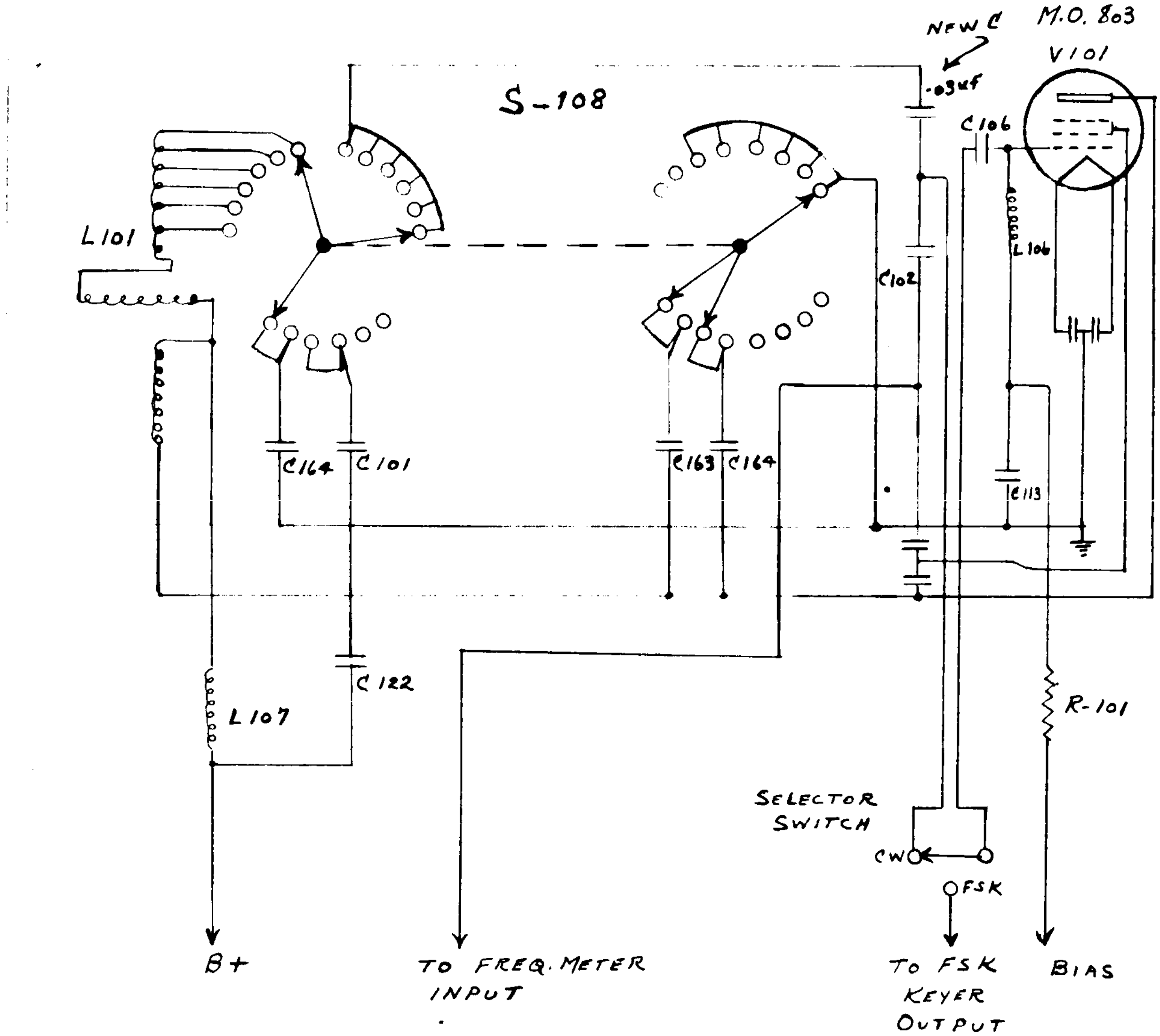


Fig. 3-4 MODEL TAB-7 MODIFICATION OF MASTER OSCILLATOR FOR FSK OPERATION.
REFER TAB-7 INSTRUCTION BOOK (DWG. 7300558)

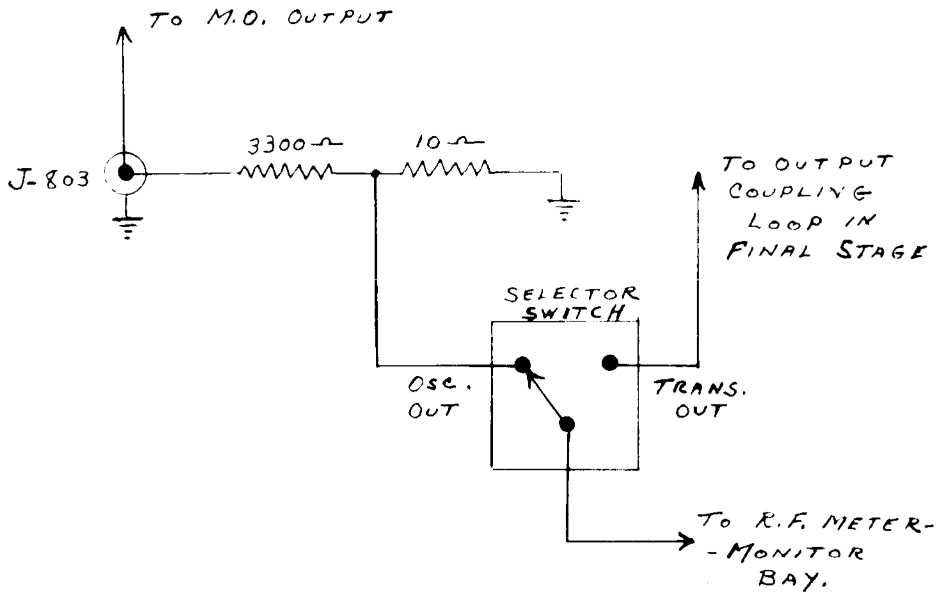
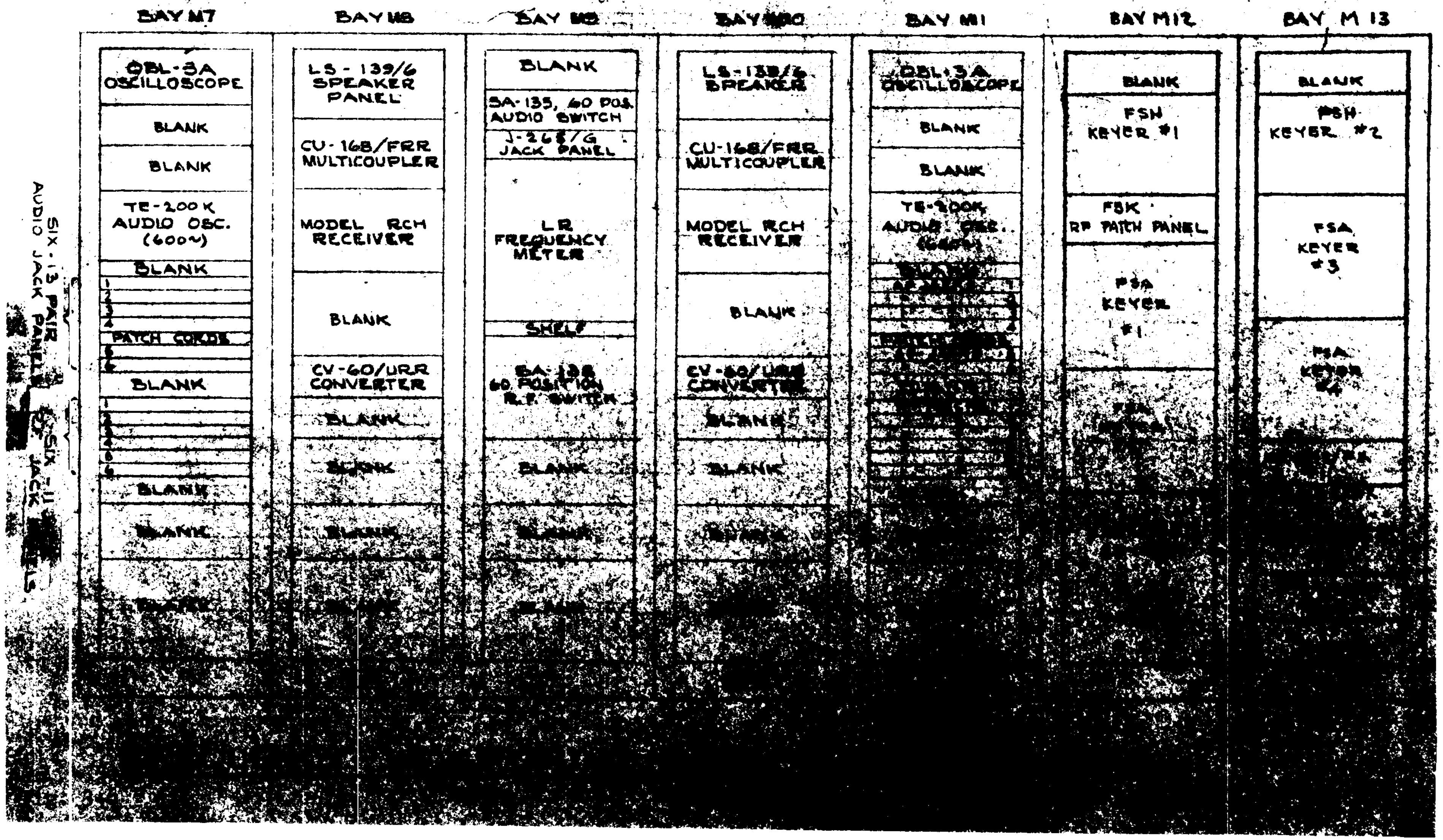
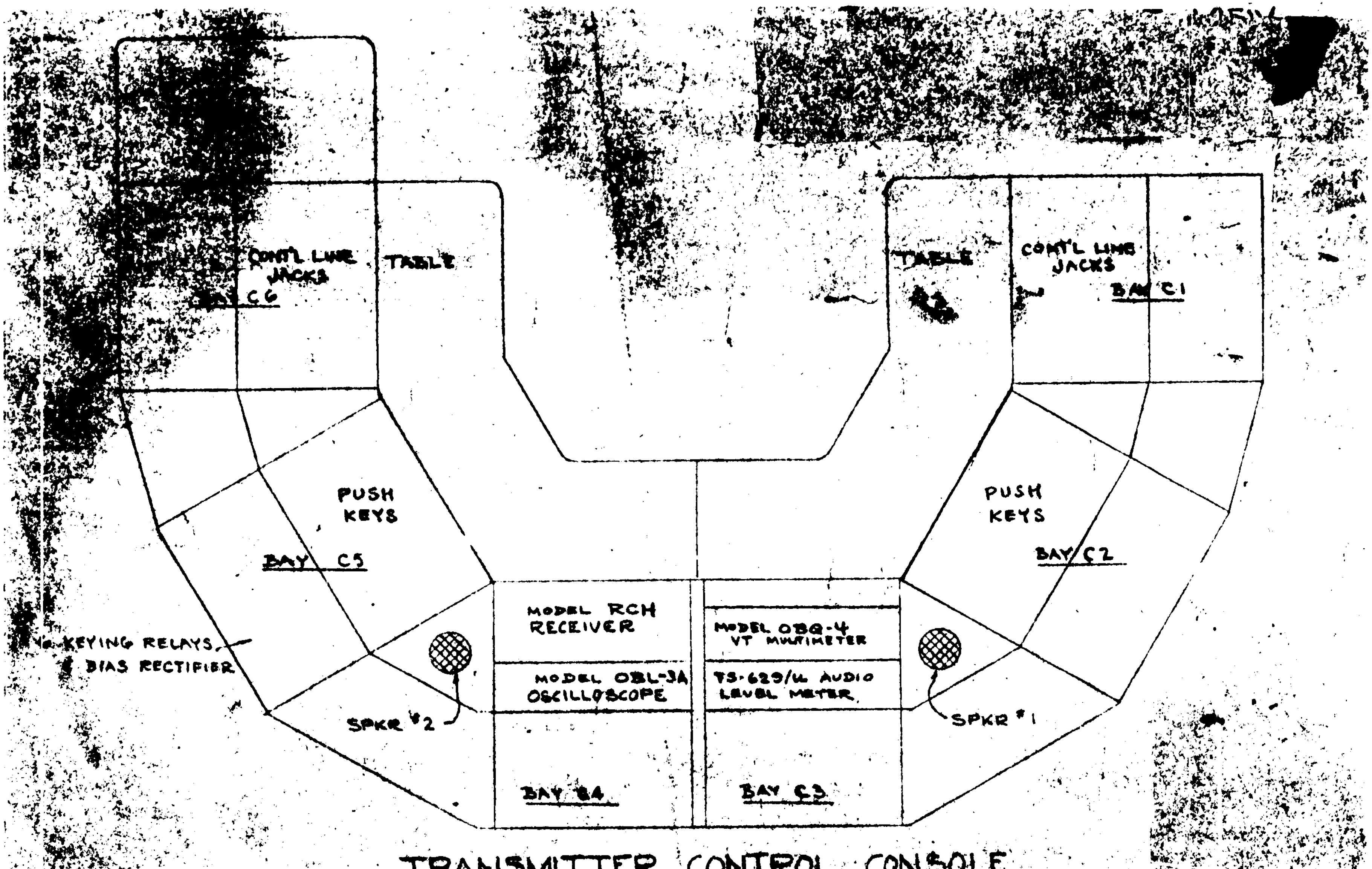


Fig. 3-5 MODIFICATION OF MODEL AN/FRT-18 FOR R.F. VOLTAGE DIVIDER NETWORK TO MONITOR BAY.

REFER TO DWG. RS6E1472 SHEET 32.


BAY M7
OBL-3A OSCILLOSCOPE
BLANK
BLANK
TE-200K AUDIO OSC. (600~)
BLANK
PATCH CORDS
BLANK
BLANK
BLANK
BAY M8
LS-139/G SPEAKER PANEL
CU-168/FRR MULTICOUPLER
MODEL RCH RECEIVER
BLANK
CV-60/URR CONVERTER
BLANK
BLANK
BLANK
BLANK
SA-135, 60 POS. AUDIO SWITCH
J-268/G JACK PANEL
LR FREQUENCY METER
SHELF
SA-138 60 POSITION R.F. SWITCH
BLANK
LS-139/G SPEAKER
CU-168/FRR MULTICOUPLER
MODEL RCH RECEIVER
BLANK
CV-60/URR CONVERTER
BLANK
BLANK
BAY M1
OBL-3A OSCILLOSCOPE
BLANK
BLANK
TE-200K AUDIO OSC.
BAY M12
BLANK
FSH KEYER #1
FSK RF PATCH PANEL
FSA KEYER #1
BAY M13
BLANK
FSH KEYER #2
FSA KEYER #3
SIX-13 PAIR AUDIO JACK PANELS
SIX-11 RF JACK PANELS



TRANSMITTER CONTROL CONSOLE
NO SCALE

Fig. 3-7.

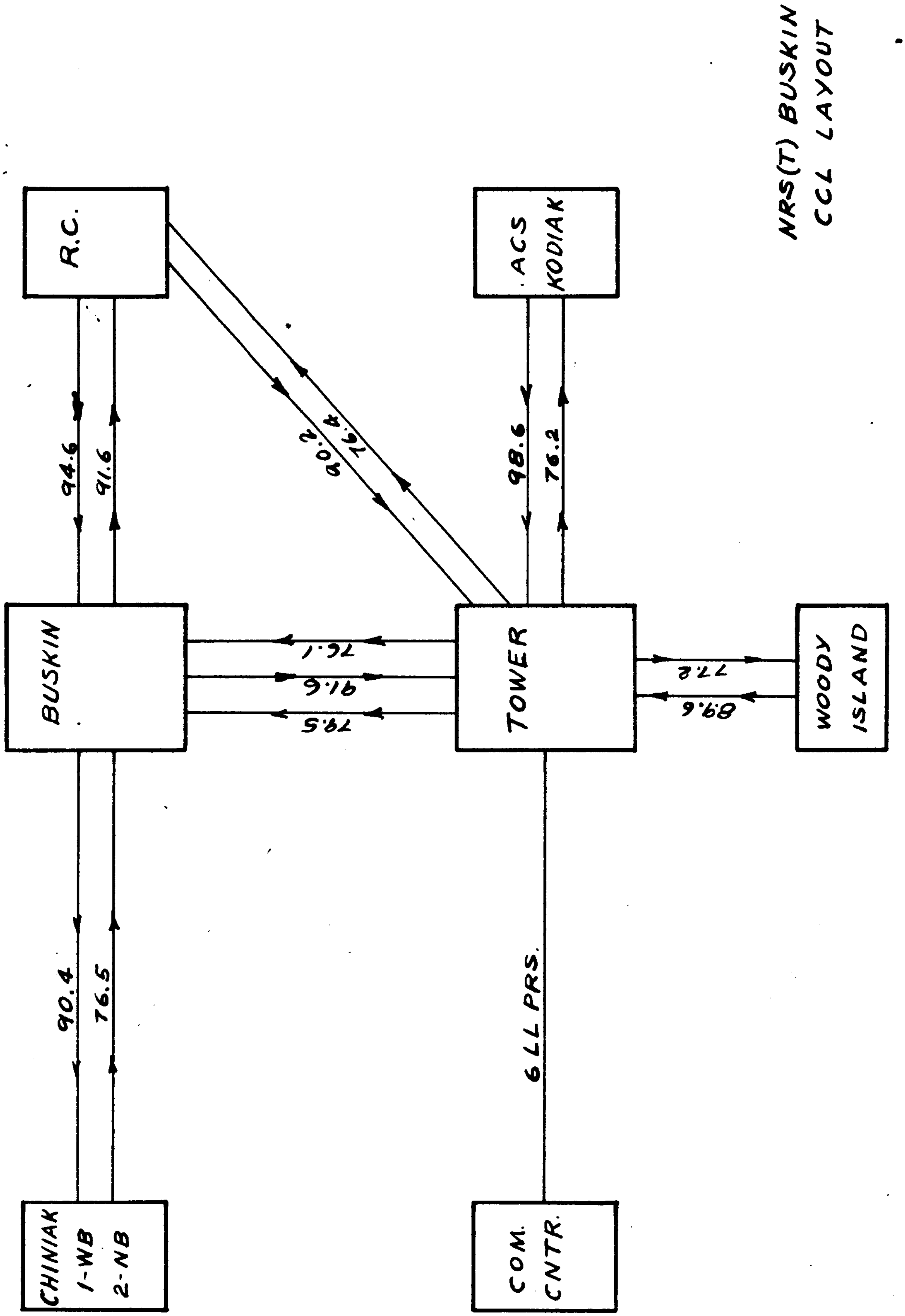


Fig. 3-9 Carrier control link communication diagram.

T-15 1	T-16 2	T-25 3	T-34 4	T-20 5	T-19 6	T-38 7	2000 AMPS 230 volts 3 phase BREAKER AND METER PANEL
VACANT 14	T-26 13	T-21 12	T-35 11	T-29 10	T-17 9	T-23 8	
T-36 15	T-18 16	T-31 17	T-30 18	T-22 19	T-27 20	VACANT 21	BLDG.LOAD 22
VACANT 30	VACANT 29	VACANT 28	T-28 27	T-33 26	T-32 25	T-24 24	T-37 23

Fig. 3-12A **EAST POWER CUBICLE PANEL - BUSKIN**
Loading Distribution Ref: Installation Dwg. RS6E 1466

T-2 1	T-5 2	VACANT 3	VACANT 4	VACANT 5	T-14 6	T-4 7	2000 AMPS 230 volts 3 phase MAIN BREAKER AND METER PANEL
T-11 14	T-13 13	T-8 12	VACANT 11	VACANT 10	T-6 9	T-3 8	
VACANT 15	T-7 16	VACANT 17	VACANT 18	T-9 19	VACANT 20	T-12 21	T-1 22
VACANT 30	VACANT 29	VACANT 28	VACANT 27	VACANT 26	VACANT 25	T-10 24	VACANT 23

Fig. 3-13A WEST POWER CUBICLE PANEL - BUSKIN
Loading Distribution Ref: Installation DWG RS 6E1465

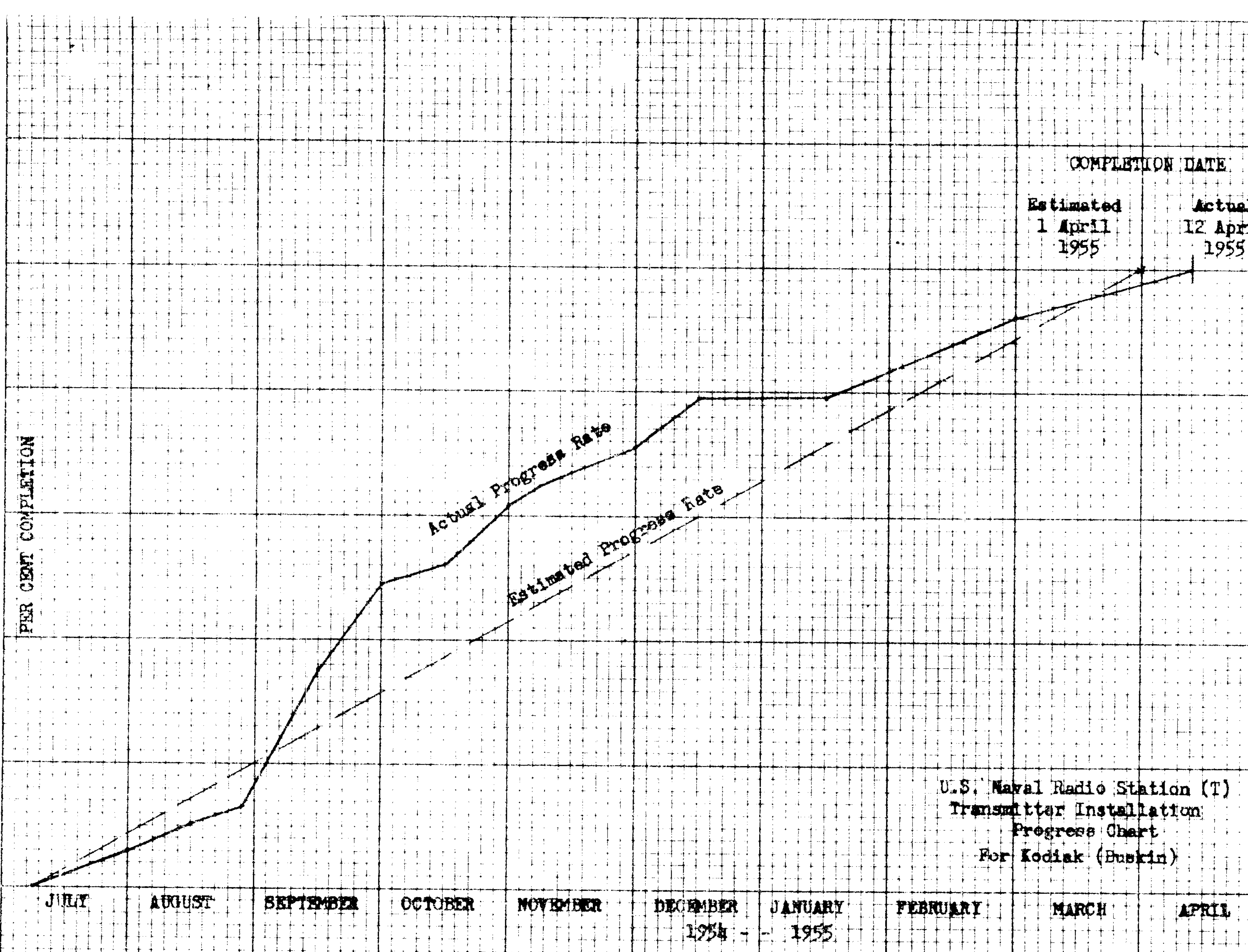


Fig. 3-27 Progress chart

A P P E N D I X

AND

T E S T D A T A

4-1. Procedures for the adjustment of transmission-line stubs for doublet antennas and parasitic arrays at U. S. Naval Communication Station (Transmitting), Kodiak, Alaska

1. MATCHING A DOUBLET ANTENNA TO ITS TRANSMISSION LINE

1.1. When a doublet antenna is excited by radio frequency energy, delivered to it over a transmission line, standing waves will usually exist along the transmission line between the antenna and the transmitter. The standing waves are caused by energy reflected from the antenna back toward the transmitter, due to:

a. Reactive component at the antenna terminal when the antenna is excited either above or below its resonant frequency.

b. Mismatch between the transmission line's characteristic impedance and the terminating load resistance presented by the antenna. These standing waves are objectionable because (1) they represent a loss of power and (2) they contribute to the difficulty of tuning the transmitter's output network for best balance and efficiency.

1.2. At NRS(T) Kodiak, the transmitting doublets, as constructed, are two-wire folded antennas which will present a load (R_L) of approximately 300 ohms, resistive, to the transmission line when excited at the resonant frequency of the antenna. The transmission lines, as constructed, have a characteristic impedance (R_C) of 600 ohms. The standing wave ratio (SWR) on the transmission line, before stubbing, will therefore be R_C/R_L= 600/300 = 2, when the antenna is excited at its resonant frequency. Many of the antennas will be used at frequencies lower than resonance; in accordance with BUSHIPS design criteria, the vertical doublets are constructed with an electrical length of 0.4 wave length, instead of the resonant length of 0.5 wave length, so that SWR's greater than 2 to 1 may be expected, before stub attachment.

1.3. The simplest way to minimize standing waves is to connect, near the antenna, a section of shorted transmission line, called a "stub", across the main transmission line. The length of stub required, and its location, are determined by the frequency at which a particular antenna is to be excited, in relation to its resonant frequency. Reference drawing RS 66D 1311 has been prepared to indicate by diagram and tables the location and length of tuning stubs for each Kodiak antenna. Stubs, as specified by RS 66D 1311, were fabricated and installed in their approximate locations by the antenna construction contractor. Stub relocation and adjustment by Assistant Industrial Manager, USN, Seattle engineers has been completed to obtain minimum SWR at the assigned frequency of the antenna.

2. ADJUSTMENT OF SINGLE STUBS AT VERTICAL DOUBLET ANTENNAS

2.1. As pointed out in paragraph 1.2, all vertical folded doublets at Kodiak were constructed for an electrical length of 0.4 wave length. A total of 25 vertical doublets were constructed. Each has been tuned to its assigned frequency, and adjusted to match its 600 ohm transmission line, by means of a single closed stub, placed on the transmitter side of the first standing wave current minimum (Imin) nearest the antenna.

2.2. Figure 1B and Table 1B of RS 66D 1311 B provide a diagram and table of dimensions showing the location of stubs at the completion of adjustments by Assistant Industrial Manager electronics engineers.

a. Length and location for a closed stub of length (F), to be attached a distance (D) toward the transmitter from a standing wave current minimum (Imin), may be calculated from the formulas:

(1) STUB LENGTH $\cot F = R-1 \sqrt{R}$ where F is the electrical length of stub, in degrees, and R is the SWR before stubbing.

(2) STUB LOCATION Tan D = $\sqrt{R}$ where D is the electrical length of transmission line between a standing wave Imin and the stub attachment point, in degrees, and R is the SWR before stubbing. For example, with a measured SWR of 2.5, the length and location of stub becomes 45 and 58 degrees, respectively. Converted to fractions of a wave length, the stub length (F) is 45/360 = 0.125 wave length and the stub location (D) is 58/360 = 0.160 wave length, nearer the transmitter from Imin.

b. The stub length or location shown in Fig. 1B of the reference drawing is the average for all the single-stubbed antennas at U.S. Naval Radio Station (T) Kodiak, after adjustments were completed for minimum SWR at the assigned frequency. The dimensions, in electrical degrees, are applicable to other vertical doublets of similar construction, and may be used as a guide for future adjustment of the Kodiak antennas for new operating frequencies.

NOTE: To convert electrical length of transmission line, in degrees, to length of line in feet, use the formula $\frac{2.73D}{fmc} = Lft$, where D is the electrical length in degrees, fmc is the frequency in megacycles, and Lft is the physical length in feet.

2.3. It is suggested that the adjustment of a single-stubbed vertical doublet, for minimum SWR, be accomplished as follows:

a. Set the physical location (E) of the stub at a dimension calculated from Fig. 1B.

b. Install an RF ammeter in a piece of #6 wire to be used as a shorting bar for the closed stub. Set the shorting bar at (F) distance from the stub attachment point and secure it with solderless connectors.

c. Apply radio frequency power to the transmission line at the building end, at the assigned operating frequency for the antenna. Adjust the stub shorting bar for a maximum current indication on the shorting bar meter.

d. Measure the standing wave ratio (SWR) on the main transmission line between the transmitter building and the stub attachment point. (It is preferable to couple the SWR meter to one side of the line and move along to read SWR, ignoring line balance at this time.)

e. Unless the measured SWR is less than 1.2, relocate the stub attachment point nearer or farther from the antenna and re-adjust the stub shorting bar for maximum current in the bar. Again measure the SWR.

f. Repeat (d) and (e) until the SWR is as low as feasible. A SWR less than 1.2 is required.

g. Substitute a #6 wire shorting bar for the meter bar, and make all stub connections permanent.

NOTE: If unusual difficulty is experienced in lowering the SWR, it is suggested that the stub be disconnected, SWR of the unstubbed antenna be measured, and the stub re-connected at the correct distance from actual Imin at dimension (D) calculated from measured SWR, using formula $\tan D = \sqrt{R}$. Refer to paragraph 2.2 (a) (2).

2.4. In the previous instructions for stub tuning no adjustment has been made for transmission line balance (equal currents in adjacent sides of the transmission line). It is well not to worry about balanced currents in the transmission line during the initial adjustments of the antenna stub match. The folded vertical doublet antenna is inherently unbalanced, due to the proximity of one end to the earth. Inherent unbalance is greatly exaggerated during conditions of high SWR, before stub adjustments are complete.

2.5. After stub adjustments are completed, the antenna is ready to be excited by its normal transmitter at its assigned frequency. Balanced currents in the two sides of the transmission line are to be attained by adjustment of the transmitter output network or antenna coupler. Two RF meters have been provided at each transmitter to facilitate this balancing adjustment.

3. ADJUSTMENT OF DOUBLE STUBS AT HORIZONTAL AND TILTED DOUBLET ANTENNAS

3.1. Although the single-stub method used to match a vertical folded doublet to its transmission line is an extremely simple and effective method, the length required for the matching stub becomes greater as the design frequency for the antenna is lowered. For the lowest frequency vertical doublet antenna listed in Table 1B, (antenna DV 26 for 5500 kilocycles) the length of the matching stub is approximately 15 feet. If the single-stub method were to be used for the horizontal and tilted doublets listed in Table 1A, a stub length of 40 feet would be required for antenna DH17. Stub lengths greater than about 30 feet become increasingly difficult to handle physically. The double-stub method was therefore adopted for the lower frequency doublets listed in Table 1A. Using the double-stub method, the matching stub (F-2) becomes only two-thirds as long as the usual single stub. The other stub (F-1) is three-fourths as long as a single stub, but may be located, as indicated by Fig. 1A, so that excess length may be easily installed without mechanical conflict with the transmission line poles.

3.2. The double-stub method of impedance matching has another advantage besides stub length. It is more convenient to adjust, since no change in the stub attachment points are required. All adjustments are accomplished by moving the location of the stub shorting bars.

3.3. Figure 1A and Table 1A of RS 66D 1311 provide a diagram and the approximate dimensions for locating and adjusting the two stubs. The dimensions, as specified in Table 1A, were determined from the following considerations:

a. All horizontal and tilted folded doublets, as constructed at Kodiak, are intended to have an electrical length of 0.5 wave length. The antenna transmission line attachment point is therefore at a current loop (Imax) when the antenna is excited at its resonant frequency. A standing wave current minimum (Imin) will therefore be found at 0.25 wave length from the antenna, on the unstubbed transmission line.

b. The double stub impedance match may be considered to be a half-wave transformer extending from the closed end of one stub, along the intermediate transmission line, and down to the closed end of the other stub. A current loop (Imax) will exist in the shorting bar of each stub. The tuning stub nearer the antenna may be adjusted to tune out antenna reactance, while the other stub adjusts the transmission line "match". The two stubs cannot, however, be adjusted independently: when one stub is lengthened, the other must be shortened to maintain an approximate half wave length of transmission line between shorting bars.

c. Spacing between the two stubs, (E-2) in Fig. 1A, determines the <u>range</u> of impedances which can be matched by the double-stub method. At a spacing of 0.25 wave length (90 degrees) a 600 ohm transmission line may be matched to any antenna load in the range 600 ohms to infinity. With a spacing of 0.375 wave length (135 degrees) a 600 ohm line may be matched to any antenna load in the range 300 ohms to infinity. Half-wave (180 degree) spacing is not useful, since all transformer action is lost. A stub spacing of 0.375 wave length (135 degrees) was therefore adopted for the double-stubbed antennas at Kodiak.

d. Location of the stub F-1 (dimension E-1 in Fig. 1A), in relation to the standing wave pattern of the unstubbed transmission line, determines the amount of reactance which must be tuned out by the double stub transformer. The best range of adjustment is obtained by attaching stub F-1 at a standing wave current minimum (Imin). Calculation of stub length for this location is also simplified, because antenna reactance is zero at an Imin.

e. Stub lengths F-1 and F-2, as specified in Table 1A, were calculated from the formulas:

(1) STUB F-1 LENGTH $\text{Cot } B_1 = 1 + \sqrt{2R-1/R}$

(2) STUB F-2 LENGTH $\text{Cot } B_2 = 1 + \sqrt{2R-1}$

where B_1 and B_2 are the electrical lengths of stubs F-1 and F-2, respectively, and R is the SWR before stubbing.

The foregoing formulas apply when the stub F-1 is located at a standing wave current minimum (Imin). The calculated lengths for stubs F-1 and F-2, using an estimated SWR of 2.0, are 28 degrees and 20 degrees, respectively. These lengths were converted to the nearest fractional wave length, 1/12 wave length (30 degrees) for F-1 and 1/16 wave length (22.5 degrees) for F-2, for listing in Table IA as a guide to the initial setting of stub shorting bars.

3.4. It is suggested that the adjustment of each double-stubbed doublet be accomplished as follows:

a. Disconnect both stubs, excite the main transmission line with RF power at the assigned operating frequency for the antenna, and measure the unstubbed SWR.

b. Reconnect stub F-1 at the standing wave Imin nearest the antenna. Reconnect stub F-2 at a distance E-2 on the transmitter side of F-1, using the spacing specified by Table 1A.

c. Install RF meters in two stub shorting bars and secure with solderless connectors at lengths F-1 and F-2, as listed in Table 1A.

d. Again apply RF power to the transmission line at the assigned operating frequency. Adjust stub shorting bar F-1 for maximum current. Measure the SWR between the transmitter building and stub attachment point F-2.

e. Unless the measured SWR is less than 1.2, move stub shorting bar F-2 to lengthen or shorten the stub. Readjust stub shorting bar F-1 for maximum current. Again measure the SWR.

f. Repeat (d) and (e) until the SWR is as low as feasible. A SWR less than 1.2 is required.

(g) Substitute #6 wire shorting bars for the meter bars, and make all stub connections permanent.

NOTE: Paragraph 3.4 (c) suggests the installation of two RF meters, for convenience if a variation in adjustment procedure is desired. One meter, installed in stub shorting bar F-1, is sufficient for complete stub adjustment in accordance with the foregoing procedures.

3.5. Location of stub F-1 at other than Imin, with a consequent relocation of stub F-2 at 3/8 wave length spacing toward the transmitter, is permissible if mechanical limitations for stub attachment so dictate. With such relocation, stub lengths F-1 and F-2 will differ from values given in the table.

3.6. After stub adjustments are complete, the antenna is ready for excitation by its normal transmitter at its assigned frequency. Balanced currents in the two sides of the transmitter are to be attained by adjustment of the transmitter output network or antenna coupler.

4. ADJUSTMENT OF VERTICAL PARASITIC ANTENNA ARRAYS

4.1 A total of 12 directional antenna arrays, consisting of two vertical doublet antennas of the folded type, spaced 0.25 wave length apart, have been constructed at Kodiak, to be used on fixed frequencies assigned for wide-area point-to-point, or what might be considered point-to-area communications. These antenna arrays consist of one folded-doublet element, or antenna, driven by a single-stub matched transmission line, exactly like the vertical doublet antennas discussed in section 2, and a second folded-doublet parasitic element, or reflector, excited by mutual coupling from the driven antenna, and tuned by adjustment of the position of a shorting bar on a short tuning line.

4.2. Figure 1C and Table 1C of RS 66D 1311 provide a diagram and approximate dimensions for locating and adjusting the single antenna stub, and for the initial location of the shorting bar on the parasitic reflector's tuning line. Dimensions specified in Table 1C were determined from the following considerations:

a. The length (F) and location (E) for the antenna tuning and matching stub were determined in exactly the same way as discussed in paragraphs 2.2 (a) through (c) for simple vertical folded doublets.

b. The location (G) for the parasitic element tuning bar was chosen to provide approximate resonance of the reflector element at the operating frequency of the antenna. Further adjustment will be required to obtain the desired radiation pattern from the array.

4.3. It is suggested that the adjustment of each vertical parasitic array, for minimum SWR in the main transmission line, and for the required radiation pattern from the array, be accomplished as follows:

a. Check the physical dimensions (E), (F) and (G) as installed by contract. Relocate the stub, as required, to agree with the (E) dimension shown in Table 1C. Set the shorting bar on the reflector element tuning line to agree with dimension (G) of Table 1C.

b. Follow the procedure for vertical folded doublets, as outlined in paragraphs 2.3 (b) through (f), to reduce SWR in the main transmission line to a low value.

c. Set up an AN/PRM-1 field intensity meter at least 500 feet distant in the forward direction from the antenna array. Adjust the shorting bar in the reflector element tuning line for maximum field intensity in the forward direction, as indicated by the AN/PRM-1.

d. Recheck SWR in the main transmission line and readjust stub dimensions (E) and (F) if required.

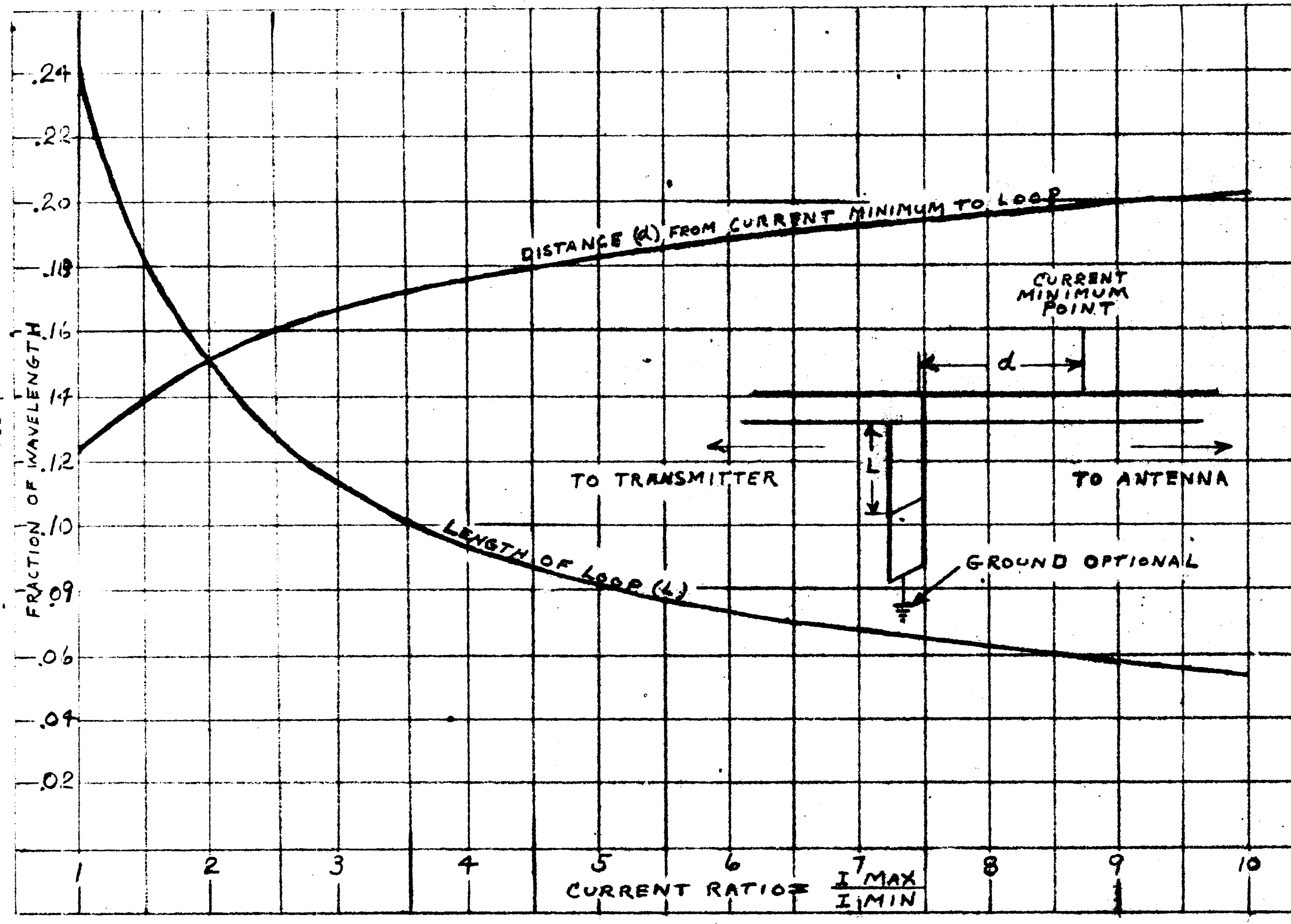
e. Recheck field intensity in the forward direction and readjust reflector shorting bar dimension (G) if required.

NOTE: In the foregoing instructions it is assumed that maximum gain in the forward direction is desired from the array, rather than best front-to-back ratio. Alternate procedures and a re-adjustment of the reflector shorting bar would allow adjustment of the array for minimum field in the back direction, if this condition were required. In fact, the reversal of field pattern, to provide maximum gain in the back direction, is possible by adjustment of the reflector shorting bar. It is therefore important to make this adjustment using a field strength indicator, rather than an RF meter in the shorting bar, to obtain the desired radiation pattern.

f. After stub and reflector adjustments are completed, substitute a #6 wire shorting bar for the RF meter in the antenna tuning stub, and make all stub and shorting bar connections permanent.

5. ASSIGNMENT OF OPERATING FREQUENCIES

5.1. Tables 1A, 1B and 1C list an operating frequency assignment for each of the 53 folded doublet antennas and parasitic antenna arrays. The frequencies listed are in agreement with data obtained from the Commanding Officer, U.S. Naval Communication Station, Kodiak, Alaska during August 1954. Whenever it becomes necessary to use one of the stubbed antennas at a new frequency differing by more than 2% from the original frequency assignment, it is highly desirable to re-adjust the stubbing for the new frequency, following procedures outlined in the foregoing instructions. It is considered feasible to operate a folded doublet antenna, or array, at frequencies either above or below the design frequency, with some loss of radiation efficiency, without changing the antenna length, provided that stubs are readjusted for minimum SWR on the transmission line.



.24
.22
.20
.18
.16
.14
.12
.10
.09
.06
.04
.02
FRACTION OF WAVELENGTH
1
2
3
4
5
6
7
8
9
10
CURRENT RATIO = I MAX / I MIN
DISTANCE (d) FROM CURRENT MINIMUM TO LOOP
LENGTH OF LOOP (L)
CURRENT MINIMUM POINT
d
L
TO TRANSMITTER
TO ANTENNA
GROUND OPTIONAL

4-2. Characteristics of the Wave or Beverage Antenna for Transmission. (Excerpts from RCA Report F-45-65)

The Wave or Beverage Antenna may be used for transmission as well as for reception. For some applications it has several outstanding advantages over conventional antennas, such as:

1. Low cost. No expensive towers are required.

2. Ruggedness. Since the antenna is supported on relatively low supports, such as wooden poles, it is not exposed to the high winds experienced aloft on high towers.

3. Reduced hazard to airplanes. Obviously the low supporting structures are of substantially no hazard as compared with high towers.

4. The Wave Antenna can often be put up with materials at hand eliminating transportation of heavy towers.

5. The Wave Antenna works best over ground of poor conductivity, which is the worst condition for the conventional antenna.

6. The antenna is aperiodic and changing frequency is a very simple operation as far as the antenna is concerned.

The functioning of the Wave or Beverage Antenna depends greatly upon the electrical properties of the soil such as resistivity and dielectric constant. These properties determine the variations in the orientation of the electromagnetic field which in turn determines whether or not the system shall have any appreciable radiation characteristics.

For a better understanding of this statement let it be assumed that the ground is a perfect conductor and that the overhead conductor is free of losses. A charge or wave train after having been initiated at one end of the line will proceed toward the other end entirely unimpeded in its momentum. If absorbed by a resistance at the other end at the rate of propagation along the line, there will be no reflection. If the charges are entirely unimpeded, their fields, although they slide along the conductor, remain invariable. No radiation, therefore, takes place during their travel along the line. However, radiation does take place at the points of input and absorption, since these are the points where the fields are dynamic, i.e. put into existence and again eliminated. The direction of the flow of the electromagnetic energy E x H known as the Poynting vector, is in this case, parallel with the wire. That this should be so is easily understood since both overhead conductor and ground are assumed to be of such nature that no potential gradient can exist parallel to these conductors so that the electric field and consequently the magnetic field must lie in a plane perpendicular to these conductors. It can thus be said that under these conditions the electric field enters the conductors perpendicularly. All the energy remains untapped until reaching the termination of the line where it will be absorbed by the resistor and a small amount be spent in radiation due to the extinction of the fields at that point.

If it is desired that energy should be exchanged in the transit along the line, this can be expressed by saying that the fields must be so modified or re-oriented that the Poynting vector is thrown out of parallelism with the line. More completely expressed it may be said that the total energy vector "field" must lose its parallelism and become either divergent or convergent. Part of the energy exchange thus obtained may then be in the form of radiation.

It was discovered by Beverage that receiving antennas of this type could be made very effective by selecting localities where the soil characteristics were such that a substantial transit energy exchange could be produced. The general requirement is high resistance soil.

The effect of high ground resistivity is twofold. It permits the formation of "surface" potential gradients. It also permits the electromagnetic field to enter into the ground and be subject to its dielectric properties. Both these phenomena are conducive to "wave tilt". In this way the Poynting vector can be deviated downward. Energy will then partly enter the ground to be absorbed and partly be reflected. The reflected energy will be radiation.

It should be noted that the viewpoint taken so far has been for wave antennas used as a radiator, i.e. primarily as a transmitting antenna. Naturally a device of this nature is reciprocal in application and there should be no need to distinguish between receiving and transmitting antennas. However, it is somewhat difficult to introduce common concepts which are equally lucid to cover both cases.

A complete analysis of the wave antenna is not as yet available. However, some of its more important engineering aspects can be derived with the present knowledge. So for instance, regardless of the relative magnitudes of influence from resistivity and dielectric constant of the ground, it is a safe conclusion that when the resistivity is low the performance can be boosted by lowering the characteristic impedance of the antenna. This is equivalent to decreasing the gradient of the field above the ground. Hence a greater portion of the total gradient will exist in the ground. In this way a stronger surface component will follow which results in greater wave tilt. Such tilt is, of course, necessary in order that transit radiation may occur.

Since much of the signal strength obtained with wave antennas derives from its directive characteristics and since the forward radiation is additive, increased performance can be obtained by lengthening the antenna. When the velocity for a certain given characteristic impedance over a certain locality is known the ultimate possible length of antenna can be calculated. This length is limited by the phase difference between the space and the line waves and should not exceed three wavelengths.

The design, therefore, becomes somewhat dependent upon the soil condition. Localities with high conductive soil, however, should be avoided since this condition can only be partly compensated for by design. The construction of long, low impedance wave antennas also becomes very expensive.

Wave antennas may be supported in a manner similar to transmission lines. Wooden poles permitting an average wire height of about 20 feet are sufficient. A three-wire antenna with three No.10 wires connected in parallel and arranged in an equilateral triangle and spaced five feet apart will have a characteristic impedance of 275 ohms. This impedance appears to be about right for a one wave-length long antenna at 150 kc under high resistance soil conditions. For lower resistivity a four or six wire cage is recommended. It should, of course, be appreciated that no gain in wave tilt or in attenuation is to be had from paralleling wire systems which have no mutual impedances such as independent, parallel lines 25 feet or more apart.

The three-wire antenna can then be constructed like a three phase line with one cross-arm supporting two wires while the third is supported at the top of the pole. Since the voltages involved are low, regular glass telephone insulators on wooden pegs furnish sufficient insulating supports for powers up to five or six kilowatts. Metal pegs should be avoided for insulator supports. The antenna wires are connected in parallel.

It is necessary to provide a ground wire system at each end of the antenna. The grounding system at the input end should have as low resistance as possible. An 18-24 wire starfish type ground system having a radius from 50 to 100 feet is satisfactory. On rocky ground screen material over a radius of 50 feet will probably be satisfactory.

A couple of examples of successful wave antennas for transmission may be quoted:

1. Frequency = 152 kc
   Wavelength = 1974 meters = 6474 feet
   Length of antenna = 5700 feet
   Characteristic impedance = 350 ohms
   Ground condition = deep mica sand
   Antenna attenuation = 2 : 1
   Velocity = 82.4%

2. Frequency = 117 kc
   Wavelength = 2600 meters = 8200 feet
   Length of antenna = 5800 feet
   Characteristic impedance = 275 ohms
   Ground condition = deep mica sand
   1 foot snow blanket
   Antenna attenuation = 1.53 : 1
   Velocity - not measured

Both of these antennas gave a reported signal gain at 800 miles distance of approximately 3 : 1 over a 180 foot tower flat top antenna having an antenna resistance of 2.5 ohms.

The first of these antennas was a two-wire receiving antenna which had been temporarily converted to a transmitting antenna. It was 0.9 wavelength long. After experimental data had been taken it was used in traffic for 24 hours. The second antenna, which was built for transmitting purposes, is of the three-wire type. It is used in regular traffic. Its length is only 0.7 wavelength.

The procedure used in measuring the velocity was to set a wavemeter directly under the antenna on the ground at points along the line and measure the pickup. The terminating resistor at the far end was disconnected for this test. The three-quarter wave voltage minimum from this end was found and the distance was divided by the figure for a three-quarter wave in free space.

As can be seen from the attenuation data tabulated above, the absorber resistor may be required to handle as much as half of the power put into the antenna. More often, in the case of a full wave long antenna, the residual power will amount to the order of one-third or one-quarter of the power put into the antenna. Good non-inductive resistor units should be used for this purpose. As an example of a suitable resistor, the 120 NIF Ferrule type, 120 watts, 25 ohm resistor made by the Sprague Specialties Company, North Adams, Massachusetts may be used. These cartridges are about ten inches long. They should be mounted vertically in one or two stacks forming a cylindrical cage. This mounting lends itself conveniently to enclosure within a cylindrical metal container which can be mounted directly on the pole. The container should be well ventilated but be made weather and bug proof. It is extremely practical to make the amount so that it can be slipped into the container from below. The lead-in insulator should be mounted at the bottom which should be recessed into the cylindrical container. In this way the lead-in will be protected from the weather. One end of the resistance stack is connected to the antenna and the other end should be connected to the container. The container should be connected to the ground system.

it is aperiodic and non-selective to frequency. If it is desirable to retain these features, resonant auxiliary circuits must be avoided. This is relatively easy to do when using this antenna for receiving purposes, where appreciable losses can be tolerated as long as they do not affect the signal to noise ratio.

High signal to noise ratio derives from directivity, selectivity and power used at the transmitting end. It is therefore obvious that greater care against circuit losses must be exercised at the transmitter.

In practice, it is often found inconvenient to locate the transmitter close to the input end of the Wave Antenna. Transmission lines must then be used.

The losses in an open two wire transmission line per se are very low since the characteristic impedance of such lines is high relative to conductor and insulation resistance. The figures for such lines as taken from a paper by Sterba and Feldman in the I.R.E. Proceedings for July 1932 are as follows:

#4 wire	100 kc	0.025 db/1000 feet
#4 wire	200 kc	0.035 db/1000 feet
#6 wire	100 kc	0.029 db/1000 feet
#6 wire	200 kc	0.041 db/1000 feet

These figures will, of course, only be right if a line is carefully matched and extremely well balanced. In such cases, the indications are that very long lines of this type could be used. Long, open lines will, however, always introduce the hazard of considerable variations in efficiency under rain and sleeting conditions both from direct loss and also from mismatch. Transmission lines, only a few thousand feet long, at the most, should be considered. It does not, therefore, appear too practical to locate the transmitter at the end opposite to the input end, in which case the antenna may be used also as a transmission line, as is often done at receiving stations using the Wave Antenna. The possible success of such an arrangement for transmission remains to be proven.

Since the Wave Antenna does not represent a push-pull balanced load and since its characteristic impedance in most cases will differ from that of the feed line, special link circuits must be provided. The ideal solution to this problem is to employ iron core transformers. Suitable core material for such transformers is now available thanks to recent intensive efforts in this field. For a balanced two-wire line having a characteristic impedance of 550 ohms terminating into a Wave Antenna having a characteristic impedance of 275 ohms, the impedance ratio of the transformer would be 2 : 1. The voltage or turn ratio will thus be $\sqrt{2 : 1}$.

As has already been pointed out, a long open two-wire line should be well balanced. Loss due to ground and radiation may otherwise be encountered due to the presence of a push-push component on the line. Excessive capacity coupling between windings in the transformer should therefore be avoided. However, it may be possible to use an auto-transformer which is midtapped to ground for the feed line connection. The midtap will then also serve as ground return for the Wave Antenna while the antenna itself is connected to one of the two ends of the coil. The midtap and the antenna connection are made permanent whereas, the feed line connections may be tapped symmetrically about the midtap for adjustment of the impedance ratio. If the leakage of this transformer is low, it should provide satisfactory balance of the feed line.

It has been suggested that a cage type coaxial line having the same characteristic impedance as the antenna may be used. In this case both the feed line and the antenna would be unsymmetrical and the antenna may be fed directly by the line. The proposal has considerable merit provided the leakage between center conductor and surrounding cage is small. The cage should then be made large enough so that there will be no possibility of it filling up during a snowfall. This arrangement has the advantage that no transformer is required but may require greater effort and skill to install.

Coaxial lines of lower characteristic impedance such as are available on the market have vastly higher loss; they are more expensive and would require an impedance restoring circuit. Such circuits include inductance and capacity and will tend to make the system selective to frequency. Circuits for such purposes providing the most reasonable frequency selective band width are of the L-type filter section variety.

The old tuned circuit method can, of course, be used for connecting any type of line to any type of antenna, but would probably prove too critical to meet modern modulation requirements in a fully satisfactory manner. Special filter type circuits can be designed which will perform a transformation not only of impedance per se but also, will transform an unbalanced load into a balanced one. Such circuits, however, become complicated and require good understanding and skill in their handling and possess no remarkable superiority over the old tuned circuit method.

Two-direction or two-way usage of the wave antenna is fascinating and also practical in connection with reception. The advisability of the same practice for transmission is rather doubtful.

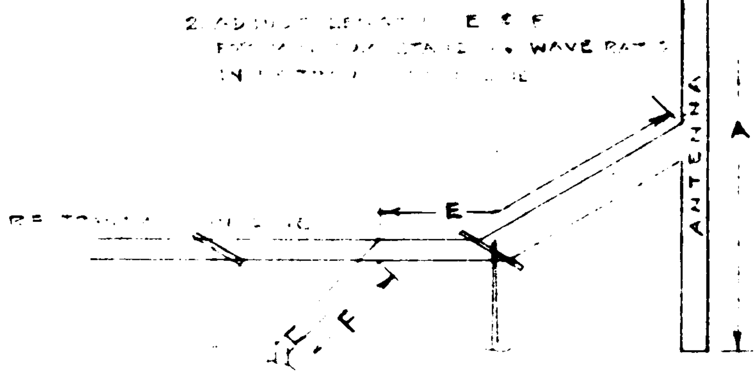
One must, of course, distinguish between two-way operation on the same frequency and on different frequencies. Simultaneous operation on a single frequency seems rather difficult from a cross-modulation standpoint. If simultaneous operation is not required and if communication in one direction is easier than in the other, operation on a single frequency is very easy. The absorber resistor at the far end of the antenna may then be discarded and the thus reflected residual energy may be used for communication in the "easy" direction. It must be born in mind, however, that the impedance at the input end will then become somewhat indeterminate and must be studied in each case for best matching to the feed line.

If more equal signals are desired for the two directions the absorber resistor must be transferred to the transmitter end of the antenna. A push-pull to push-push reflection transformer must replace the absorber resistor at the far end. The absorber and the transmitter can then be switched around between the push-pull and the push-push termination of the antenna at the input end. It is, of course, needless to add that the same procedure can be followed for non-simultaneous operation on different frequencies. If the antenna should have unusually high attenuation or if the transmitters should be unusually non-sensitive to cross modulation it may be possible to discard the absorber resistor and operate the system simultaneously on two frequencies in the opposite directions.

Whether simultaneous in opposite or in the same direction, trap circuits will, however, usually have to be provided. The system then becomes the most complicated when arranged for communication in the opposite direction. The two transmitters as well as the required two absorber resistors must then each be interlinked with individual series - parallel trap circuits. For this type of operation in the same direction such trap circuits need only be used at the transmitter. One common absorber will then suffice.

From a utility and reliability standpoint such procedure is not recommended for the common run of outpost stations. Whenever land is available it will be far better to build several antennas. In that way the non-selective features can also be retained.

NOTES: 1. SEE TABLE 1B FOR DIMENSIONS.



VERTICAL FOLDED DOUBLET ANTENNA
SINGLE STUB MATCHING FOR FREQUENCIES ABOVE 5 MC.

FIG. 1B

TABLE 1B

DIMENSIONS FOR SINGLE-STUBBED ANTENNAS

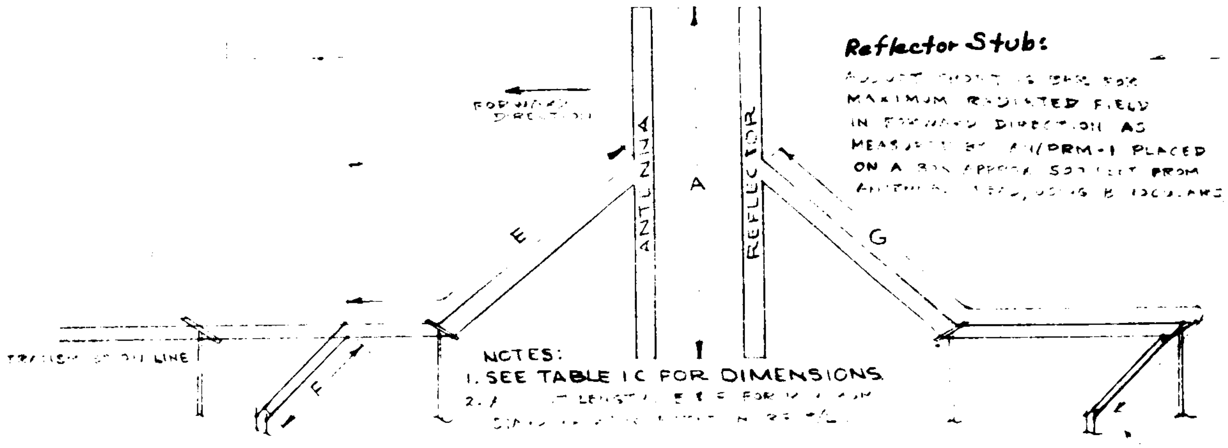
(SEE FIG. 1B)

1	2	3	4	5	
ANTENNA NUMBER & TYPE	OPERATING FREQUENCY (KC)	DBLT LENGTH "A" (FEET) 0.95(0.4)λ	LENGTH "A" AS CONSTRUCTED	STUB (FEET) E 0.5 λ	F .125 λ
2 VERT	8510	44.0		58.0	14.5
3 VERT.	12765	29.5		38.6	9.7
4 VERT.	17020	22.0		29.0	7.3
5 VERT.	22443	16.8	17.6	22.0	5.4
33 VERT.	5500	68.1		89.5	22.4
34 VERT.	9000	41.6		54.8	13.7
34A VERT.	12000	31.2		41.0	10.3
37 VERT.	8650	43.3		57.0	14.3
38 VERT.	128175	29.0	30.6	38.1	9.5
40 VERT.	8280	45.2		59.4	14.8
52* VERT	7385	* 51.0	45.6	67.0	16.8
53 VERT.	12315	30.4		40.6	10.2
54 VERT	16420	22.5		29.5	7.4
55 VERT.	20850	18.0	18.2	23.6	5.9
56 VERT.	24630	15.2		20.0	5.0
59 VERT.	5720	65.6		86.0	21.5
71* VERT.	6700.5	* 56.0	46.3	73.5	18.4
72* VERT.	112565	* 33.5	30.9	44.0	11.0
75 VERT.	6290	59.5		78.8	19.7
76 VERT.	9001	41.5	42.7	54.5	13.6
79 VERT.	7945	47.1		62.1	15.5
80 VERT.	12745	29.4		38.6	9.7
81* VERT	11266	* 33.0	28.5	43.4	10.8
82 VERT	180135	20.7	21.3	27.1	6.8
84 VERT.	11240	33.2		43.6	10.9

* INCREASE DOUBLET LENGTH TO DIMENSION STATED IN COLUMN 3, IF PRACTICABLE, USING EXISTING POLES.

COLUMN 4 SHOWS DOUBLET LENGTH AS ORIGINALLY CONSTRUCTED BY CONTRACT NOY-26646.

Fig. 4-1 Vertical folded doublet antenna.



VERTICAL PARASITIC ARRAY ANTENNA

FIG. 1C

TABLE 1C

DIMENSIONS FOR STUBBING PARASITIC ARRAYS
(SEE FIG 1C)

1	2	3	4	5		
ANTENNA NUMBER PARASITIC ARRAY	OPERATING FREQUENCY (KC)	DBLT LENGTH "A" (FEET) .095(0.4)λ	LENGTH "A" AS CONSTRUCTED	STUB LENGTHS (FT.) E .5λ	F .125λ	G .625λ
10	5677.5	62.[illegible]	64.3	87.	21.7	109.
12	11930	31.4	36.1	41.	10.2	51.
14	15595	24.0		31.5	7.9	39.5
16	22491	16.6	18.5	22.	5.5	27.5
18	6330	59.1		78.	19.5	97.
20	12975	28.8		38.	9.5	47.5
22 *	15525	* 24.0	22.3	31.5	7.9	39.5
65	5915	63.2		83.	20.8	104.
86 *	8080	* 46.5	41.7	61.	15.2	76.
87	12145	30.8		40.5	10.1	50.5
88	15990	23.3		31.	7.7	38.5
89	17690	21.1		28.	7.0	35.

* INCREASE DOUBLET LENGTH TO DIMENSION STATED IN COLUMN 3, IF PRACTICABLE, USING EXISTING POLES.
COLUMN 4 SHOWS DOUBLET LENGTH AS ORIGINALLY CONSTRUCTED BY CONTRACT NOY-26646.

Fig. 4-2 Vertical folded doublet parasitic array antenna.

HORIZONTAL OR TILTED FOLDED DOUBLET ANTENNA
DOUBLE STUB MATCHING FOR FREQUENCIES 2-5.5 MC.

FIG. 1A

NOTES
1. ATTACH STUBS AT E-1 & E-2. SEE TABLE 1A FOR DIMENSIONS.
2. ADJUST STUB SHORTING BARS TO VARY LENGTHS F1 & F2 FOR MINIMUM STANDING WAVE RATIO IN RF TRANSMISSION LINE. DO NOT VARY DIMENSIONS E-1 & E-2.
3. INSTALL TUNING STUBS F1 & F2 ON A LINE PARALLEL WITH THE TRANSMISSION LINE.

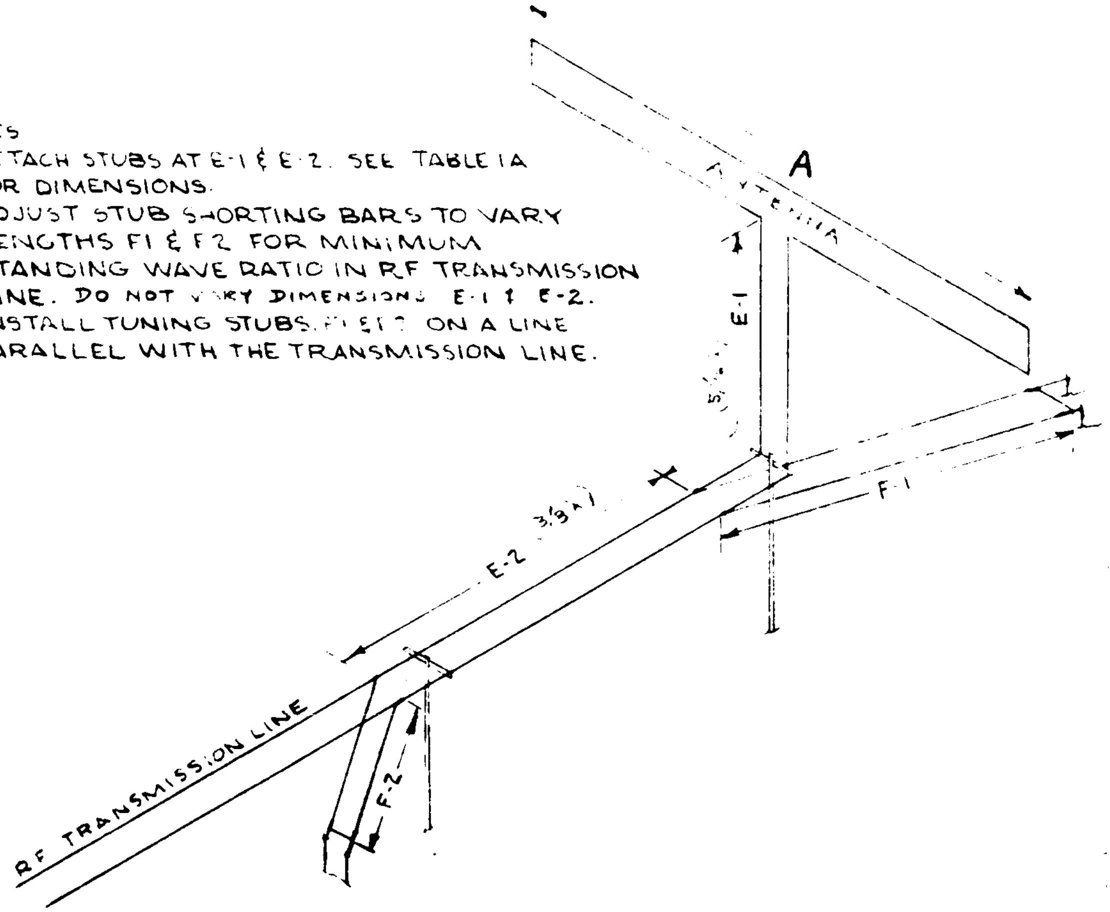


TABLE 1A
DIMENSIONS FOR DOUBLE-STUBBED ANTENNAS
(SEE FIG. 1A)

1	2	3	4	5			
ANTENNA NUMBER & TYPE	OPERATING FREQUENCY (KC)	DBLT. LENGTH "A" (FEET) 0.95(0.5)λ	LENGTH "A" AS CONSTRUCTED	STUB DIMENSIONS (FEET)			
				E-1 .312λ	E-2 .375λ	F-1 APPROX .083λ	F-2 APPROX .063λ
1 TILTED	4255	110		72	86	19.2	14.4
6 HORIZ.	2836	165	164.6	108	130	28.8	21.6
7 HORIZ.	2716	172		113	136	30.1	22.5
32 HORIZ.	2500	188		123	148	32.7	24.6
35 HORIZ.	2356	198		130	156	34.7	26.0
36* TILTED	4825	* 97	114.8	64	77	17.0	12.8
51* TILTED	5052.5	* 93	114.0	61	73	16.2	12.2
58 HORIZ.	3045	154		101	121	26.8	20.1
66 HORIZ.	2196	214		140	168	37.3	28.0
67 HORIZ.	2550	184		121	145	32.0	24.0
70 HORIZ.	4040	116		76	91	20.2	15.2
73 HORIZ.	3195	146		96	115	25.6	19.1
74 HORIZ.	4385	107		70	84	18.7	14.0
77 HORIZ.	3023.5	155	156.0	102	122	27.0	20.3
78* HORIZ.	4475	* 105	141.4	69	83	18.2	13.7
83 HORIZ.	4975	94		62	74	16.4	12.4

* SHORTEN DOUBLET LENGTH TO DIMENSION STATED IN COLUMN 3.
COLUMN 4 SHOWS DOUBLET LENGTH AS ORIGNALLY

4-3. Procedures for testing and installing the Navy Model AN/FRT-4 radio transmitting equipment at U. S. Naval Communication Station, Kodiak, Alaska.

1. Helix house. Conductance Test for Litz cable terminations.

The cable furnished for winding the AN/FRT-4 antenna variometer (L2001) and antenna loading coil (L2002) is designated as 20/12/32/.005 Litzendraht or "Litz". It is composed of twenty conductors arranged around a central core. Each conductor is made of twelve "strands" or bundles of thirty-two #36 AWG annealed copper wires (0.005" diameter). Each wire is separately insulated with enamel and silk.

After the Litz cable ends are terminated by soldering to terminal plates, in accordance with pages 3-13 to 3-18, inclusive, of the AN/FRT-4 instruction book, it is necessary to make the following test to determine if all wires of the Litz cable are properly soldered and making low-resistance contact to the terminal plate:

a. Measure accurately, to three significant figures, the total DC resistance between terminals for each length of Litz cable used in winding the variometer and loading coil. Use of a "DUCTOR" resistance bridge, for measurement of very small DC resistance values on the order of 0.0001 ohms, is essential.

b. Measure accurately the cable length from terminal to terminal for each length of Litz cable used in winding the variometer and loading coil. From the measured length, in feet, calculate the cable resistance between terminals, using the following data for 20/12/32/.005 Litz cable at 20° C (68° F):

OHMS per 1000 feet	0.054
OHMS per 100 feet	0.0054
OHMS per 10 feet	0.00054
OHMS per foot	0.000054

Example: Measured length of Litz cable = 132 feet.

DC resistance = 1 x .0054 = .0054

3 x .00054 = .00162

2 x .000054 = .000108

Total - - - - .007128

Calculated resistance, three significant figures, = 0.00713 ohms

c. Compare the measured resistance of each length of terminated Litz cable with the calculated resistance for the same length of cable. If the measured resistance is more than five per cent higher than the calculated value, investigate the soldered terminal plates for defects. It may be helpful to measure the resistance of Litz terminations bundle by bundle, to determine the quality of the termination. The following table provides theoretical resistance values at 20° C (68° F):

	Ohms/1000 ft.	Ohms/100 ft.	Ohms/10 ft.	Ohms/ft.
0.005" copper wire	415	41.5	4.15	0.415
32/.005 strand	13	1.3	0.13	0.013
12/32/.005 conductor	1.08	0.108	0.0108	0.00108
20/12/32/.005 cable	0.054	0.0054	0.00054	0.000054

2. Helix house - Calibration of antenna variometer (L2001) and antenna loading coil (L2002).

Figure 3-16, page 3-30 of the AN/FRT-4 instruction book, specifies the number of turns of Litz cable between taps for the variometer (L2001) and loading coil (L2002). After installation of the antenna tuning equipment perform the following measurements:

a. Measure the inductance and resistance of the variometer (L2002) at both minimum and maximum positions of the rotor, for each combination of link connections listed in figure 3-16.

b. Measure the inductance and resistance of the loading coil (L2002) for each combination of link connections listed in figure 3-16.

Compare the measured values of inductance with the design values listed in figure 3-16. Re-measure any doubtful values. When certain that measurements are correct, record the measured values of inductance and resistance, and attach to page 3-29 of the AN/FRT-4 instruction book (NAVSHIPS 91169) for the benefit of station personnel.

Make calibration charts for the variometer and loading coil to show graphically the change of inductive reactance with change of frequency through the 50 to 150 kilocycle range, as follows:

c. Plot a family of six curves for the antenna loading coil (L2002) making one curve for each of the six values of inductance measured in paragraph b. Plot reactance in ohms as ordinates against frequency in kilocycles as abscissa. Label each curve with number of turns, measured inductance, and link connections required to obtain the inductance value represented by the curve.

d. Similarly plot a family of curves for the antenna variometer (L2001) showing minimum and maximum reactance in ohms against frequency in kilocycles. Use two sheets of graph paper, one to show four sets of minimum reactance and maximum reactance curves for parallel connection of the variometer rotor coils, the other to show similar data for series connection of the rotor coils. Four pairs of maxima and minima curves will be required on each sheet to show data for the four possible arrangements of stator turns.

e. Plot a curve of reactance against frequency to show the amount of inductive reactance contributed to the antenna tuning system by the line terminating transformer (T2001) through the frequency range 50 to 150 kilocycles. Assume its inductance to be 50 microheneries.

f. Plot on separate graphs the variation of loading coil and variometer resistance with frequency.

3. Helix house - Calibration of vertical radiator.

Upon the completion of the 600 foot vertical radiator at Kodiak, the following measurements of electrical characteristics are required:

a. Measure the resistance and reactance of the vertical radiator at frequencies from 30 to approximately 250 kilocycles. Measurements should be made at every five kilocycle interval throughout the specified range. Connection of the measuring equipment (in all probability a Model OH radio frequency bridge) should be made to the vertical antenna within the helix house at the inboard end of the lead-in trunk.

Make a calibration chart for the vertical radiator to show graphically its change in capacitive reactance (Xc) with frequency, through the 50 to 150 kilocycle range, plotting reactance in ohms as ordinates against frequency in kilocycles as abscissa. Extend the graph by dashed line to show antenna characteristics above and below the AN/FRT-4 transmitter frequency range; particularly extend to zero reactance, to record the resonant frequency of the vertical radiator. Plot on the same graph the measured values of antenna resistance against frequency.

Although the antenna characteristics for the 600 foot radiator at Kodiak will not parallel those for the 800 foot vertical radiator at NPC, the following data is provided as a sample:

Electrical properties of 800-foot vertical radiator at NPC:

(Battle Point, Bainbridge Island, Washington)

Frequency (KC)	Resistance (Ohms)	Reactance (Ohms)
30	1.6	1060 (Capacitive)
40	1.3	785
50	1.4	610
60	1.5	500
80	2.0	360
120	4.0	200
150	6.2	135
180	8.9	80
210	12.7	30
233	16.8	0 (Resonant frequencies)
250	20.0	25 (Inductive)

4. Helix house - Adjustment of antenna system for specific operating frequencies.

For all operating frequencies within the range of the AN/FRT-4 transmitter (50 to 150 kilocycles) the antenna reactance will be capacitive, requiring the use of series inductance from the antenna loading coil (L2002) and the antenna variometer (L2001) to tune the antenna to resonance. Adjustment of the antenna system to a specific operating frequency may be made by using the calibration curves prepared in paragraphs two and three above. The following steps are required:

a. From the reactance/frequency curve for the vertical radiator, read the antenna reactance in ohms at the desired operating frequency.

b. From the reactance/frequency curves for the antenna loading coil, antenna variometer, and terminating transformer select strap and jumper connections to insert a reactance equal to the antenna reactance. Select as large a value of loading coil reactance as possible, in order to leave a small value of reactance for the variometer to supply. Use of the parallel connection for the variometer rotor coils is desirable, to avoid rapid change of tuning with small rotation of the variometer coil. This is of particular importance at the higher frequencies. Avoid a selection of reactance values which places the resonant value near the extreme end of the variometer range (either minimum or maximum).

c. Prepare a tuning chart for adjusting the strap and jumper connections of the AN/FRT-4 antenna tuning equipment at specific operating frequencies including 50, 100, and 150 kilocycles and other operating frequencies which the Commandant, Seventeenth Naval District, may request by official correspondence. A typical tuning chart, showing fictitious values, is developed below for guidance:

Operating Freq. (KC)	Antenna Xc (Ohms)	T2001 and Load Coil X_L (Ohms)	Variometer X_L (Ohms)	Load Coil Turns	Variometer Stator Turns	Variometer Rotor
50	610	500	80-150	32	26	Parallel
61.75	485	325	100-170*	20	26*	Parallel*
			80-210	20	18	Series
100	265	150	70-150	9	18	Parallel
135.6	162	52	50-130	4	14	Parallel
150	135	60	25-80	4	10	Parallel
			55-145**	4	14**	Parallel

* Preferred connection to avoid rapid change in tuning with small variometer rotation.

** Preferred connection to avoid resonance at the extreme end of variometer rotation range.

After choosing antenna loading coil and antenna variometer strap and jumper connections for each operating frequency, in accordance with the foregoing instructions, antenna tuning is completed as follows:

d. At each operating frequency, follow the procedure outlined in section 3, paragraphs 9c (2) through 9c (10) pages 3-31 and 3-32 of the AN/FRT-4 instruction book. By these procedures the antenna system is tuned to resonance and the termination of the 600-ohm transmission line is adjusted to present a pure resistance load.

5. Helix house - Adjustment of safety gap at the antenna lead-in bushing

A safety gap is installed at the antenna entrance (HV lead-in bushing) within the helix house to provide a path for discharge of abnormal voltages between the antenna and ground. Installation and adjustment of this antenna sphere gap (E2001) is described in section 3, paragraphs 6m (1) through 6m (5), page 3-20 of the AN/FRT-4 instruction book. Paragraph 6m (5) specifies a gap spacing of approximately four inches. Setting of the antenna sphere gap should be made in conjunction with full power tests of the AN/FRT-4 transmitter. The gap spacing must be set wide enough to allow full power operation, without flash over, at the lowest transmitter frequency.

Sphere gap (E2001) is not to be considered a protective device for high RF voltages developed by the transmitter, since flashover at this point will cause detuning of the antenna system and may result in damage to antenna tuning components from abnormal voltages developed.

It is recommended that protective gaps be installed from each side of the 600 ohm transmission line to ground near the input terminals of transformer T-2001. These gaps should be set to break down at approximately 5000 volts (a ball-gap spacing of between 0.05" and 0.1" is indicated). A practical means of setting is to increase the gap spacing by 50 per cent over a spacing which will just flash over at full transmitter power. Primary to ground flashovers at transformer T-2001 have caused burn out of the primary Litz winding in a similar installation not equipped with protective gaps.

6. Project completion report as of 1 August 1955 - Project to install, test, calibrate and conduct full-power heat runs on AN/FRT-4 radio transmitting set.

Final testing of the AN/FRT-4 radio transmitting set at U. S. Naval Radio Station (T) Buskin Lake had been delayed pending receipt and installation of the PA blower assembly. The original blower assembly of the Buskin Lake installation had been shipped to the transmitting station at Mt. Moffett, Adak upon failure of theirs.

Upon notification by the Industrial Manager, Seventeenth Naval District that a replacement blower assembly had been received at Buskin Lake for the AN/FRT-4 installation, arrangements were made by this office to place the equipment in operational status. Initial testing was begun by Assistant Industrial Manager, USN, Seattle personnel on 13 July 1955 with the assistance of station personnel as a familiarization program.

The transmitter and antenna load inductances were calibrated on the following frequencies: 53 kc/s, 61.75 kc/s, 105.85 kc/s, 109.75 kc/s, 135.6 kc/s, and 139.1 kc/s. Circuit discrepancies, minor in nature, were corrected when found. A major failure was PA tank capacitors.

Full power sustained heat runs were attempted on 109.7 kc/s, with failure of C-323, a final PA tank capacitor, after six hours duration. The capacitor was replaced from spares and centigrade reading thermometers were then secured to each tank capacitor in the circuit and the heat run continued. Thermometer readings were recorded quarter-hourly and tracked against the ambient level. A second capacitor C-324 overheated and a third, C-325, heated sufficiently to be considered defective. These capacitors were replaced from equipment spares and the heat run continued. None of the other originally installed capacitors showed overheating effects nor did any of the replacement capacitors. The heat run under full-power was continued successfully with no undue heating of any transmitter components.

Power tests were then attempted on the assigned frequency of 53 kc/s. Operation of the transmitter at its lowest voltage tap resulted in an antenna current of 125 amperes into an antenna resistance of 1.35 ohms. This represents a power output of 21 kilowatts and, based on an antenna reactance of 898 ohms, a voltage in excess of 112 kilovolts develops across the antenna helices. This voltage is considered excessive. The helix house sphere gap, set to eight inches, continually broke down under this potential with consequent dumping of the transmitter load. The transmitter was then unloaded slightly by decoupling the driver stage output into the final amplifier grid circuit. This allowed an antenna current of 108 amperes, a power output of 15.5 kilowatts, and a tower voltage of 97 kilovolts. Although the sphere gap jumped only sporadically at this voltage, the tower itself developed corona of such a magnitude as to be heard as an audible hissing a considerable distance away. Corona also developed at points on the helices and antenna variometer. It is recommended that the transmitter not be operated on this frequency due to the excessive voltage developed across the antenna circuitry even at the lowest possible operating power.

The transmitter was then put in full-power operation on 109.7 kc/s, and frequency shift and CW on/off keying tests conducted. Satisfactory reports were received from U.S. Naval Radio Station (R) Clam Lagoon, Adak. Control circuit and stability tests completed the final testing of the transmitter and the installation of the AN/FRT-4 was considered by this office to be complete.

Transmitter calibration charts were prepared and turned over to the Officer in Charge with limitations of the antenna system noted. Station personnel were instructed as to helix house and transmitter change-of-frequency methods. Several changes for training purposes were also accomplished.

RECOMMENDATIONS

To obtain full rated power output of this transmitter without developing dangerous voltages across the antenna loading helices, it is recommended that a frequency between 100 kc/s and 150 kc/s be assigned. Antenna reactances in this frequency range will be sufficiently low so as to prevent voltages from approaching the 100 kilovolt danger point regardless of antenna current. An assigned frequency below 100 kc/s will result in decreased power output if safe operating voltages on the antenna circuits are not to be exceeded.

AN/FRT-4 RADIO TRANSMITTING SET
TYPICAL OPERATIONAL DATA

Compiled 5 Aug 1955

FREQ. KC/S	VOLTAGE TAP	TANK AMPERES	PLATE AMPERES LEFT	PLATE AMPERES RIGHT	PLATE KILOVOLTS	ANTENNA AMPERES	KILOWATT POWER IN	KILOWATT POWER OUT	EFF. %	ANTENNA R_A	ANTENNA Z_A	ANTENNA E_A (KV)
109.7	6	50	2.5	2.8	14.0	170	74.1	52.6	71	1.82	406	69
105.85	4	46	2.9	3.1	10.75	168	64.5	48.0	74	1.70	415	69.7
135.6	5	34	3.3	3.25	12.45	141	81.6	49.0	60	2.47	310	43.7
139.1	5	34	3.55	3.5	12.20	141	86.0	52.7	62	2.65	300	42.3
61.75	1	30	2.1	2.1	6.50	134	27.3	*	*	1.35	755	101.0
53.0	1	32	1.15	1.2	6.55	108 +	15.4	*	*	1.35	898	97.0

\+ Grid drive on PA lowered from normal 500 ma. to 180 ma. to bring antenna current down.
* Not computable for this frequency as antenna characteristics change as tower enters corona state.

FREQUENCY-SHIFT KEYING DATA
85 cycle shift

FREQ. KC/S	VOLTAGE TAP	TANK AMPERES	PLATE AMPERES LEFT	PLATE AMPERES RIGHT	PLATE KILOVOLTS	ANTENNA AMPERES	KILOWATT POWER IN	KILOWATT POWER OUT	EFF. %	ANTENNA R_A	ANTENNA Z_A	ANTENNA E_A (KV)
109.7												
space	6	36	2.85	2.83	14.0	164	79.5	48.9	62.8	1.82	406	66.6
carrier	6	36	2.75	2.7	14.0	170	77.0	52.6	68.3	1.82	406	69.0
mark	6	37	2.4	2.25	14.15	162	65.0	47.7	73.4	1.82	406	65.7

Carrier power @ 170 amps. = 52.6 kw P_1
FSK power @ 164 amps. = 49.0 kw P_2

$$10 \log \frac{P_2}{P_1} = .305 \text{ db down on FSK on 109.7 kcs}$$

4-4

ANTENNA TUNING DATA

FOR

AN/FRT-4 TRANSMITTER

U. S. NAVAL RADIO STATION (T) BUSKIN LAKE

KODIAK, ALASKA

KODIAK, ALASKA
U. S. NAVAL RADIO STATION (T) BUSKIN LAKE

**ANTENNA LOADING HELIX
and
VARIOMETER TUNING CALIBRATION
for
600 FOOT TOWER RADIATOR**

9 May 1955

Frequency Kilocycles	Connections to taps on Antenna Helix	Connections to taps on Antenna Variometer	Variometer Rotor Connections
* 50	1 and 12	A and L	Series
* 53	1 " 12	A " J	Series
55	1 " 12	A " H	Parallel
* 57	5 " 12	A " J	Series
60	1 " 10	A " L	Series
* 61.75	1 " 10	A " L	Series
65	1 " 10	A " J	Series
70	1 " 8	A " L	Series
75	1 " 8	A " J	Series
80	1 " 8	A " J	Series
85	1 " 8	A " H	Series
90	1 " 6	A " L	Parallel
95	1 " 6	A " L	Parallel
* 100	1 " 6	A " J	Parallel
* 105.85	1 " 6	A " J	Parallel
* 109.70	1 " 6	A " H	Parallel
115	1 " 6	A " F	Series
120	1 " 6	A " F	Series
125	1 " 4	A " H	Series
130	1 " 4	A " H	Parallel
* 132.1	1 " 4	A " H	Parallel
* 135.6	1 " 4	A " H	Parallel
* 139.1	1 " 4	A " H	Parallel
145	1 " 2	A " J	Parallel
* 150	1 " 2	A " J	Parallel

Note: 1. See AN/FRT-4 Instruction Book, Figure 3-16 for information on variometer rotor connections.

2. CAUTION: Use short Litz jumper lead to connect antenna trunk on upper taps of antenna helix for operation on lower frequencies.

* Transmission line termination calibrated for these frequencies.

KODIAK, ALASKA
U. S. NAVAL RADIO STATION (T) BUSKIN LAKE

TRANSMISSION LINE TERMINATION TUNING CALIBRATION
AN/FRT-4

10 May 1955

For termination circuit capacitors, variometer L2003 and transformer T2001. Refer to AN/FRT-4 Instruction Book, Figure 3-16.

Frequency Kilocycles	Capacitor Links	Variometer Rotor (L2003)	Transformer Rotor (T2001)
50	D-2, D-6, B-C	88	61
53	D-2, D-6, B-C	88	76
57	D-2, D-6, B-C	34	69
61.75	D-2, D-6, B-C	34	73
100	D-2, B-C	74	87
105.85	D-3, B-C	80	88
109.7	D-3, B-C	40	90
132.1	D-4, B-5	85	92
135.6	D-4, B-5	86	92
139.1	D-4, B-5	86	92
150	D-4, B-5	61	92

KODIAK, ALASKA
U. S. NAVAL RADIO STATION (T) BUSKIN LAKE
600 FOOT TOWER RADIATOR

HELIX AND VARIOMETER CALIBRATION
(Rotor in series with ten turns)

Inductances - for various coil combinations 6 May 1955

Loading Coil		Variometer							
Turns	Inductances	10 Turns		14 Turns		18 Turns		26 Turns	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
0	0	82	340	150	445	217	568	419	795
4	51	133	391	201	496	268	619	470	846
9	227	309	567	377	672	444	795	646	1022
14	456	538	796	606	901	673	1024	875	1251
20	799	881	1139	949	1244	1016	1367	1218	1594
32	1460	1542	1800	1610	1905	1677	2028	1879	2255
47	2420	2502	2760	2570	2865	2637	2988	2839	3215

KODIAK, ALASKA
U. S. NAVAL RADIO STATION (T) BUSKIN LAKE

HELIX AND VARIOMETER CALIBRATION
AN/FRT-4
(Rotor in parallel with ten turns)

INDUCTANCES - for various coil combinations

6 May 1955

Loading Coil		Variometer							
Turns	Inductance	10 Turns		14 Turns		18 Turns		26 Turns	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
0	0	20	81	51	150	120	248	303	437
4	51	71	132	102	201	171	299	354	488
9	227	247	308	278	377	347	475	530	664
14	456	476	537	507	606	576	704	759	893
20	799	819	880	850	949	919	1047	1102	1236
32	1460	1480	1541	1511	1610	1580	1708	1763	1897
47	2420	2440	2501	2471	2570	2540	2668	2723	2857

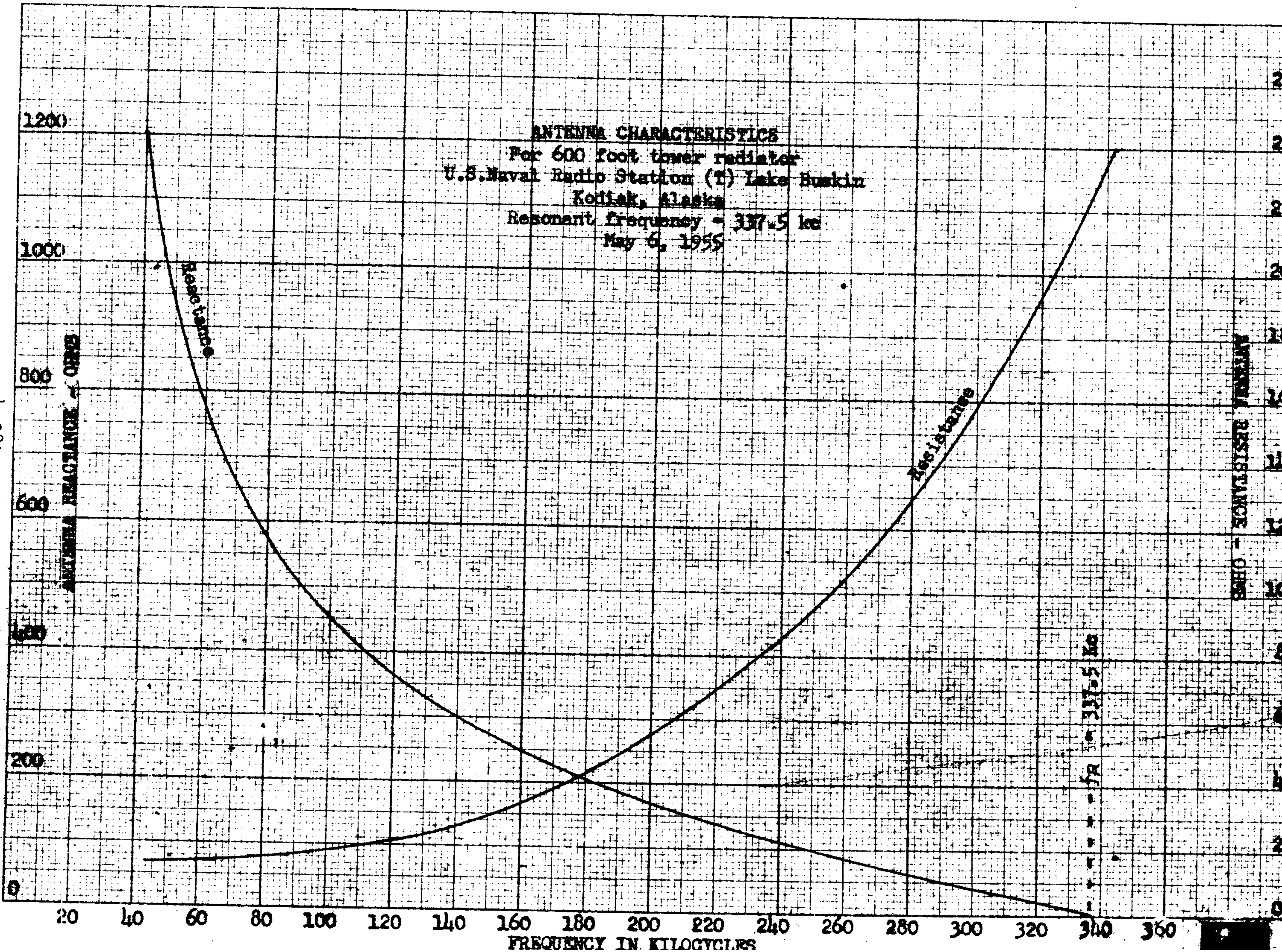
KODIAK, ALASKA
U. S. NAVAL RADIO STATION (T) BUSKIN LAKE

ANTENNA LOAD CHARACTERISTICS
for
600 FOOT TOWER RADIATOR

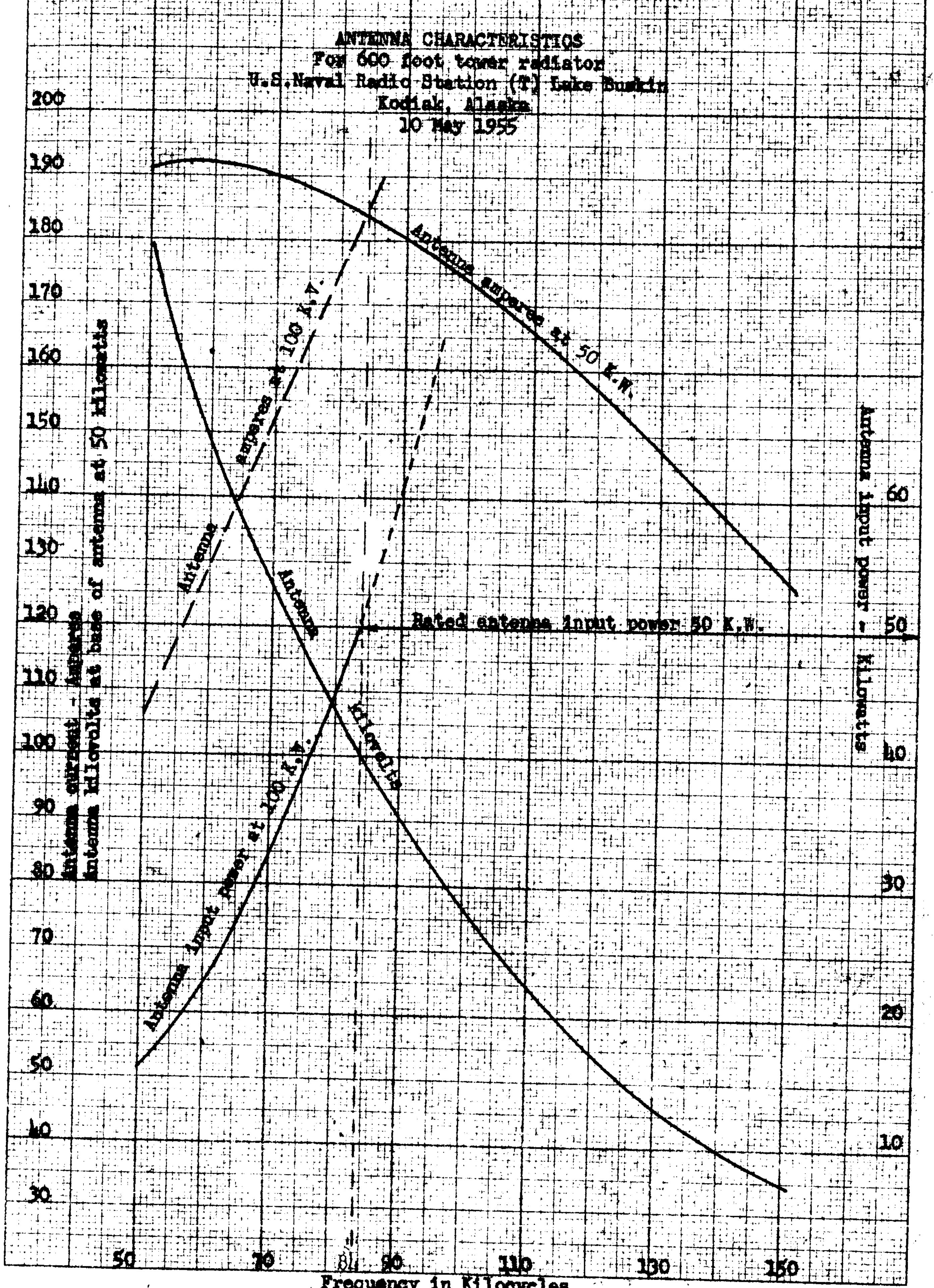
Resonant Frequency f_r = 337.5 kilocycles

9 May 1955

Frequency, Kilocycles	Reactance Ohms	Resistance Ohms	Antenna Current at 50 KW Amps	Antenna Kilovolts
50	940	1.37	191	179
53	898	1.35	192	173
55	852	1.34	193	165
57	812	1.34	193	157
60	772	1.35	192	148
61.75	755	1.35	192	145
65	713	1.37	191	136
70	660	1.40	188	125
75	613	1.42	187	115
80	567	1.45	186	105
85	525	1.49	183	96
90	502	1.52	181	91
95	470	1.59	177	83
100	448	1.65	174	78
105.85	415	1.70	172	71
109.70	406	1.82	166	68
115	375	1.90	162	61
120	360	2.02	157	57
125	340	2.15	152	52
130	322	2.30	147	47
132.1	318	2.35	145	46
135.6	310	2.47	142	44
139.1	300	2.65	137	41
145	280	2.85	132	37
150	272	3.05	128	35



ANTENNA CHARACTERISTICS
For 600 foot tower radiator
U.S.Naval Radio Station (T) Lake Buskin
Kodiak, Alaska
Resonant frequency = 337.5 kc
May 6, 1955
Reactance
Resistance
ANTENNA REACTANCE - OHMS
ANTENNA RESISTANCE - OHMS
fR = 337.5 kc
FREQUENCY IN KILOCYCLES
1200
1000
800
600
400
200
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360


ANTENNA CHARACTERISTICS
For 600 foot tower radiator
U.S.Naval Radio Station (T) Lake Buskin
Kodiak, Alaska
10 May 1955
Antenna amperes at 50 K.W.
Antenna amperes at 100 K.V.
Antenna Kilovolts
Rated antenna input power 50 K.W.
Antenna input power at 100 K.V.
Antenna current - Amperes
Antenna kilovolts at base of antenna at 50 Kilowatts
Antenna input power - Kilowatts
Frequency in Kilocycles
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
60
50
40
30
20
10
50
70
84
90
110
130
150

4-5. Instructions for installation and maintenance of 2-wire/4-wire teletype repeater for use with AN/FCC-3, -7, or -8 carrier telegraph terminals

Reference drawing: ASTINDMAN,USN, Seattle RS 23E 545

1. Need for a 2-wire/4-wire repeater.

When it is necessary to provide the functions of "half-duplex" teletypewriter service via a radio link, then a 2-wire/4-wire repeater will be required to connect the "2-wire" terminal of the half-duplex teletype loop into the separate "send" and "receive" channels (i.e., the "4-wire" terminals) of the radio link. Such a repeater is built into certain tone telegraph terminals, for example the Navy Model UG, so that no external repeater is needed. Other tone telegraph terminals, such as the Navy Model UN and the AN/FCC-3, require an external teletype repeater. The RS 23E 545 teletype repeater, to be described here, was designed to provide half-duplex teletype service in conjunction with Navy AN/FCC-3, -7, or -8 tone telegraph terminals.

2. Description of RS 23E 545 repeater.

This repeater is assembled on a seven inch standard relay rack panel, with a self-contained power supply operating from 115 volts 60 cycle AC. Signal connections are made to the repeater by means of a 6-contact "AN" type connector, J-1, as designated in the reference drawing. The repeater supplies line current or "battery" for a 60-mil neutral teletype loop, with an external loop resistance of 700 ohms or less. Adjustment of the teletype loop current is made at rheostat, R-7, on the front panel, and a looping jack, J-3, is provided for reading the loop current by means of an external milliammeter. A 1000-ohm resistor, R-6, in series with the teletype loop, limits current to a safe value even when the external loop connections, E and F of J-1, are short circuited. The "send" terminals, A and B of J-1, carry open-and-close signals from the repeater's SEND relay to key a tone telegraph transmitter channel of the AN/FCC-3. The "receive" terminals, C and D of J-1, connect the operate coil of the repeater's RECEIVE relay to external 60-mil signals coming from a tone telegraph receiver channel of the AN/FCC-3. The 30-mil bias for the repeater's RECEIVE relay is supplied internally when the polar-neutral switch, S-2, is thrown to neutral. The "polar" position of the RECEIVE relay switch is not used in normal operation, but is provided to allow opening the bias circuit to the RECEIVE relay to accept polar signals, if this is required. Normal operation of the repeater is with a 60-mil NEUTRAL loop connected to the teletype side, and with the AN/FCC-3 channels, switched for "BATT FROM EQUIP" and "NEUTRAL OUTPUT", connected to the CCL side.

3. Installation of RS 23E 545 repeater.

The repeater is intended for installation in a relay rack cabinet in the vicinity of the associated AN/FCC-3 tone telegraph equipment. The rack mounting rails should be set back far enough in the cabinet to prevent relay covers from extending beyond the front face of the cabinet. One repeater will be required for each AN/FCC-3 channel intended for half-duplex teletype operation. External connections are to be made between control plug, P-1, and a cabinet terminal board, using 6-conductor flexible cable. From the cabinet terminal board the repeater circuits should be carried to jacks in the CCL patching panel and labeled as follows:

P-1	A and B	"RPTR 1 CCL SEND"
P-1	C and D	"RPTR 1 CCL RECV"
P-1	E and F	"RPTR 1 TT LOOP"

When a second RS 23E 545 repeater is installed the corresponding jacks are to be labeled:

"RPTR 2 CCL SEND"
"RPTR 2 CCL RECV"
"RPTR 2 TT LOOP"

4. Operation of the RS 23E 545 repeater.

The repeater has been designed for a minimum of adjustments and controls. Before placing a new repeater in operation, the three 255A relays should be tested, using a standard test set for teletype relays, and relay adjustments should be made, as required, for normal spacing of contacts and pole pieces and for minimum signal distortion. When the AC power switch is turned ON, and the internal rectifier tube (5Y3GT) has heated, the RECEIVE relay (K-1) will move to SPACE and the BREAK and SEND relays (K-2 and K-3) will move to MARK. Patch the "CCL SEND" and "CCL RECV" repeater circuits into AN/FCC-3 SEND and REC channels (DC loops). Make sure that the AN/FCC-3 transmitter is set for "BATT FROM EQUIP" and that the AN/FCC-3 receiver is set for "BATT FROM EQUIP" and for "NEUTRAL OUTPUT". Patch the repeater "TT LOOP" into a local teletypewriter loop connected for 60-mil neutral half-duplex operation. With a MARKING signal furnished from the AN/FCC-3 receiver, the repeater REG relay (K-1) will close to MARK and repeater relays K-2 and K-3 will remain in a MARK condition. Now adjust the current in the local TT loop to 60 milliamperes at the repeater control R-7, "ADJUST LOOP CURRENT", using a DC milliammeter plugged into J-3. Adjust the current in the repeater receive relay coil by adjusting the TT LOOP CURRENT control in the AN/FCC-3 receiver for 60 milliamperes. The loop current control in the AN/FCC-3 transmitter is not critical, but will normally be set for 60 milliamperes also.

The repeater is now ready for operation and will transfer teletype signals in either direction over the radio link associated with the AN/FCC-3 channels in use. An incoming signal from the AN/FCC-3 receiver will key the repeater RECEIVE relay and the local TT loop, while repeater BREAK and SEND relays hold steady MARK. If the local TT loop is opened, the repeater BREAK and SEND relays move to SPACE and "break" the distant operator by opening the send side of the radio link. When the distant operator stops sending the repeater RECEIVE relay holds steady MARK and the local TT loop may be keyed with outgoing traffic. Repeater BREAK and SEND relays key together during the transmission of outgoing traffic. The distant operator may "break" by opening his TT loop, in which case the AN/FCC-3 receiver channel SPACES, the repeater RECEIVE relay moves to SPACE and the local TT loop is broken.

The teletypewriter equipment at the "distant" end of the radio link may use a similar repeater to work into its AN/FCC-3 channels, or half-duplex teletypewriter service is also possible with a repeater at only one end of the radio link. Assuming the "distant" end of the link has no repeater, its teletype machine may be connected "split" (separate send and receive connections) into the AN/FCC-3 transmitter and receiver. In this case the teletype loop is closed by the repeater at the "near" end of the link, so that half-duplex operation is provided to the distant station. At a small communication facility where patching of "split" teletype machines, using two patch cords, is not considered too inconvenient, such operation will save the cost of a repeater. It is essential, however, to have a 2-wire/4-wire repeater installed at one end of the radio link for half-duplex operation.

5. Maintenance of the RS 23E 545 repeater.

Routine maintenance of the repeater consists of regular test of the three relays following the same routine set up for other teletype relays on the station. In addition to relay tests, the condition of the 5Y3GT rectifier tube should be checked, and the rectifier output voltage should be measured across the resistor string R-3, R-4, R-5. Normal operating voltage, with 60 milliamperes in the local TT loop, is 120 volts DC.

4-6. Electronic facility instruction for printing telegraph equipment-2

Department of Commerce
Civil Aeronautics Administration
Washington 25, D. C. (COPY)

May 8, 1953

To: All Regional Administrators
From: Chief, Electronics Maintenance Branch

Subj: Oscilloscope telegraph signal distortion measurements

The following procedure describes a method of determining the distortion content of teletypewriter signals. The primary advantages of this method are:

1. An oscilloscope, which is a common piece of test equipment, is used. This then means that teletypewriter distortion may be measured without the use of a signal analyzer. (The CAA possesses a very limited number of signal analyzers)

2. The method of oscilloscope analysis has been used in the past, but was usable only if a series of one single character was being transmitted to the teletypewriter line. The method described here works equally well on both single character transmissions or miscellaneous transmissions.

Equipment required to make distortion measurements is as follows:

1 ea. Oscilloscope with slow sweep speed (approximately 6 cps)
1 ea. 47 ohm, 1 watt resistor
1 ea. 30 mmf condenser
miscellaneous wire and teletypewriter line plug

Connect the resistor and condenser as shown in Figure 23. The line cord leads are connected to the resistor terminals, one side of the resistor is then connected through the condenser to the Y input terminal of the scope, and the other side of the resistor is connected to scope ground. (The adaptor shown in Figures 11 and 23 is not a necessity. It is a convenience: the terminals provide for easy connection to the scope terminals; the switches provide for easy reversing of the signals, and for easy shorting of the capacitor.) After the connections are made, the line plug may be inserted in a teletypewriter line for test purposes.

For proper display of the signals, the resistor should be connected to the line in a manner such that negative going impulses (mark to space transitions) are shown as negative "pips". Since the mark to space transition at the beginning of the start impulse is always present, this transition will be used to synchronize the oscilloscope. Some oscilloscopes however, cannot be made to synchronize on a negative signal. In general, scopes in this class are those which do not have a "sync" voltage control which provides for both positive and negative synchronizing voltages.

In the event that a scope that can be synchronized only on positive signals is available, it will be necessary to connect the resistor so that mark to space transitions are displayed as positive impulses on the oscilloscope; the resulting signal displays will be the inverse of those shown in the accompanying figures.

Recommend Procedure for Observing Signals

a. Turn scope "locking" or "sync" control to zero.

b. Transmit a series of "R's" to dummy circuit.

c. Adjust scope "freq" control until the trace illustrated in Figure 4 of the attached photographs moves to the left at a slow rate of speed. (Sweep frequency slightly slow.)

d. Adjust "locking" or "sync" control to stop movement of scope trace. This control will cause one of the negative going impulses (mark to space transition) to be displayed on the left side of the scope trace.

e. Miscellaneous signals may then be transmitted to the circuit for viewing with the scope. Since the mark to space transition which occurs at the beginning of the start impulse is the only transition consistently present with each character transmitted, this negative going impulse will be displayed at the left of the scope trace.

The attached figures show some of the patterns that may be expected when viewing various signals. Figures 1, 2, 3 and 5 are pictures of the scope pattern produced by the resistor alone; the other figures were taken with the capacitor in the circuit. Figures 6 - 10 show the manner in which the signals are changed when different types of distortion are present. Bias changes only the upper pips (space to mark transition) as shown in Figures 7 and 8; end distortion (Figures 9 and 10) changes only the lower, or mark to space, pips. Figures 13 to 17 show the type of pattern produced by miscellaneous transmission. This pattern however, was not produced during a single sweep of the scope; many sweeps were necessary. In Fugure 13, an R-Y transmission would cause the pips to flip-flop or pulse, below the line on one transmission, and then above the line on the following transmission. Miscellaneous transmission will also cause the pips to "flip-flop" but not quite as regularly. Figures 18 to 22 show an individual impulse length expanded to two inches for easier measurement.

DISTORTION MEASUREMENT

Using Figure 19 as an example, it may be seen that the upper pulses have been displaced (to the left) one quarter of the distance between the lower pulses. The following steps will then give us the distortion:

1. The distance between the two lower (or upper) pulses is equivalent to one code impulse length, the distortion is therefore 25%.

2. Since the upper, or space to mark, transitions have moved, the distortion is bias. Another way of differentiating between bias and end distortion is by observing the start pulse length. If it is different than the length between any two adjacent positive impulses, bias distortion is present. End distortion will not change the start pulse length.

3. Under the conditions shown in Figure 19, when a marking impulse is sent, it will start at the first positive pulse and continue to the second negative pulse. Since this

distance is longer than the distance between pulses, the distortion is positive or marking.

It will be noted that the distortion TD used to produce the signals shown in the photographs did not give a true picture of spacing bias or spacing end distortion. In Figures 15 and 17, the last positive impulse should be displaced to the right. Spacing bias should show a stop impulse shorter than normal, Figure 15 shows a normal impulse; spacing end distortion should show a normal stop impulse, Figure 17 shows a longer than normal stop impulse. These errors are caused by using the TD with an ASID unit. A "sneak" path is introduced by the SS relay. The small pulse preceding the stop impulse in each photograph is due to the inductance of the SS relay in the ASID unit.

This system is also very useful for solving problems which have to do with contact bounce or brush bounce. Figures 12 and 24 show a normal E and a distorted E. In this case, the distortion is caused by failure of the contact bail to follow the operating lever.

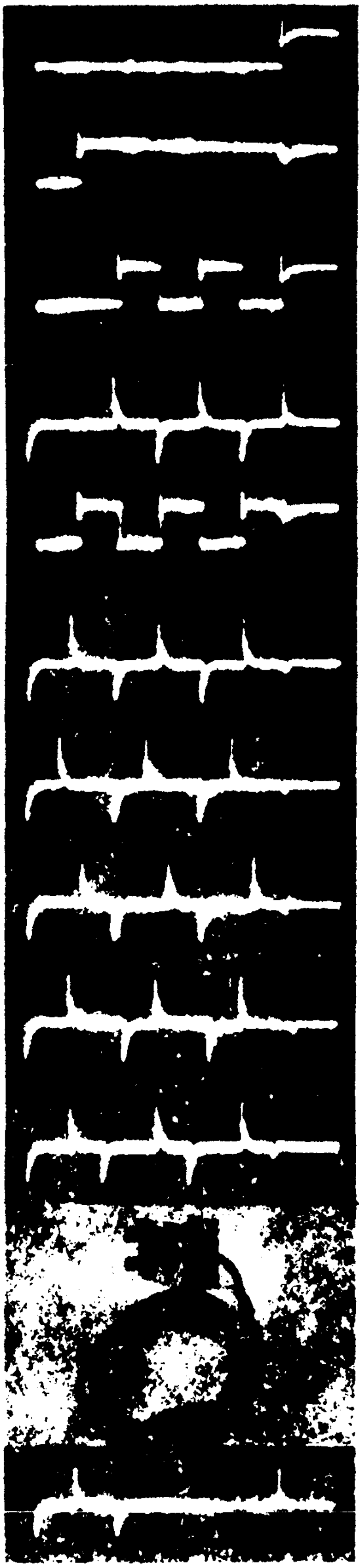
This project has been under study for some time by engineers of W-367 and will eventually be incorporated in a teletypewriter maintenance MANOP.

Note 1: It is imperative that the signal differentiated by the resistor-condenser network be composed of square waves. Check the signals for wave shape by shorting the 30 mmf condenser. If the signals are not square waves, the network should be connected across the contact side of a printer line relay. This relay, of course, must be free from distortion.

Note 2: These photographs were taken using Super XX film with a lens opening of f4.7 and an exposure time of 5 seconds.

/s/ W. M. King W-365

OSCILLOSCOPE TELEGRAPH SIGNAL DISTORTION MEASUREMENTS



1 BLANK 0% BIAS

2 LETTERS 0% BIAS

3 "R" 0% BIAS

4 "R" 0% BIAS

5 "Y" 0% BIAS

6 "Y" 0% BIAS

7 "Y" 25% M.B.

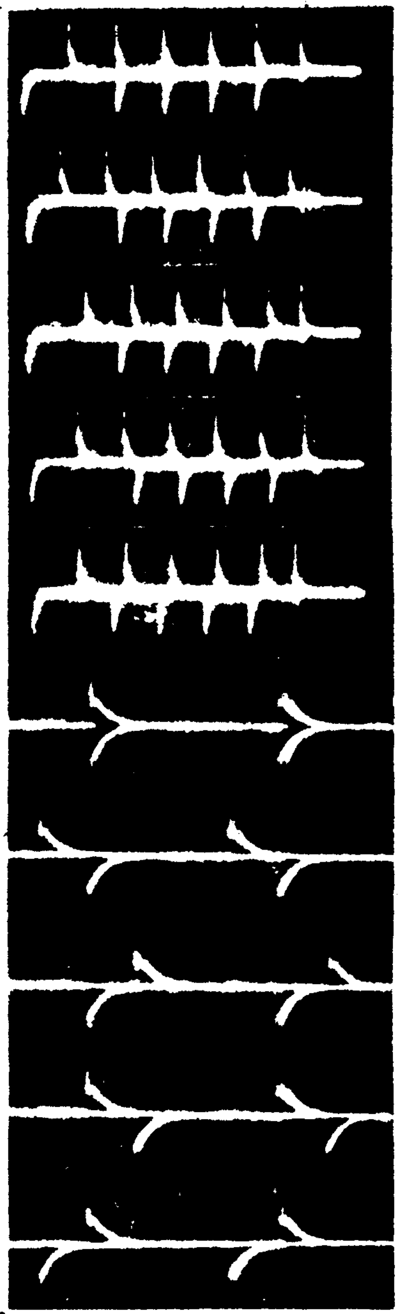
8 "Y" 25% S.B.

9 "Y" 25% M.E.D.

10 "Y" 25% S.E.D.

11 OSCILLOSCOPE ADAPTOR & SCHEMATIC

12 ← NORMAL "E"



MISCELLANEOUS 0% BIAS 13

MISCELLANEOUS 25% M.B. 14

MISCELLANEOUS 25% S.B. 15

MISCELLANEOUS 25% M.E.D. 16

MISCELLANEOUS 25% S.E.D. 17

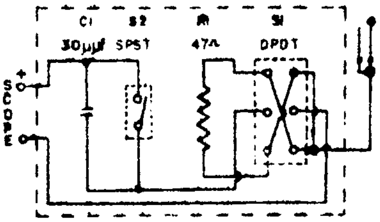
EXPANDED MISCELLANEOUS 0% BIAS 18

EXPANDED MISCELLANEOUS 25% M.B. 19

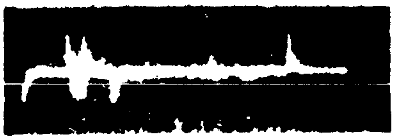
EXPANDED MISCELLANEOUS 25% S.B. 20

EXPANDED MISCELLANEOUS 25% M.E.D. 21

EXPANDED MISCELLANEOUS 25% S.E.D. 22



23



& #1 CONTACT BOUNCE → 24

4-7. Specifications for the installation of electronic equipment in the new transmitter building at U. S. Naval Communication Station, Kodiak, Alaska

SECTION I. GENERAL CLAUSES 16 March 1954

1.01 Intent.

It is the declared and acknowledged intention and meaning to provide and secure installation of and connections to the radio transmitters and associated equipment mentioned in these specifications. The installation shall be complete and in operating order.

1.02 General description.

The work includes relocating certain transmitters taken from the old transmitter station and uncrating and installing government furnished transmitters and auxiliary equipment in an existing new transmitter building, a helix house and four tuner huts. Wiring connections shall be installed from incoming communication cables to the equipment. Antenna connections and switching arrangements shall be installed between the transmitters and existing insulator bowls on the walls of the buildings. Power wiring from the existing power panels to each piece of equipment and also inter-unit wiring shall be installed. Minor modifications, described in Section 3 of these specifications, shall be made to certain transmitters to adapt them to this installation. The contractor shall furnish all the material required, except that designated on the drawings as furnished by others, and all the tools and labor required to complete the installation in a workmanlike manner.

1.03 Location.

The work shall be located at the U. S. Naval Station, Kodiak, Alaska.

1.04 Time of Completion.

The entire work shall be completed within 180 days after date of receipt of a notice to proceed.

1.05 Drawings accompanying specifications.

The following drawings are a part of this specification:

Bu.Ships Dwg. No.	Title
RS 6 E 1441	Title Sheet
RS 6 E 1442	Material List
RS 6 E 1443	Equipment Arrangement, First Floor, West Side
RS 6 E 1444	Equipment Arrangement, First Floor, East Side
RS 6 E 1445	Equipment Arrangement, Basement, West Side
RS 6 E 1446	Equipment Arrangement, Basement, East Side
RS 6 E 1447	AN/FRT-4 Power & Control Connections
RS 6 E 1448	AN/FRT-4 Interconnections
RS 6 E 1449	AN/FRT-4 Helix House Equipment Arrangement and Elementary Wiring
RS 6 E 1450	TDH-4, TDO, and AN/FRT-19 Power and Control Connections
RS 6 E 1451	TAB-7 Power and Control Connections
RS 6 E 1452	TDN-3 Control Connections
RS 6 E 1453	TDN-4 Control Connections
RS 6 E 1454	TDN-3 and TDN-4 Power Connections
RS 6 E 1455	AN/FRT-5 Power, Control and Interconnections
RS 6 E 1456	Antenna Entrance & T/L Switching, West Side, Plan
RS 6 E 1457	Antenna Entrance & T/L Switching, West Side, Elevations
RS 6 E 1458	Antenna Entrance & T/L Switching, East Side, Plan
RS 6 E 1459	Antenna Entrance & T/L Switching, East Side, Elevations
RS 6 E 1460	AN/FRQ-3 Control Console Wiring & Designations, West Side
RS 6 E 1461	AN/FRQ-3 Control Console Wiring & Designations, East Side
RS 6 E 1462	OA-489/FRQ-3 Monitor Equipment, Arrangement & Jack Designations
RS 6 E 1463	OA 489/FRQ-3 Monitor Equipment, Audio Wiring
RS 6 E 1464	OA 489/FRQ-3 Monitor Equipment, RF Wiring
RS 6 E 1465	Power Cabling Plan, West Side
RS 6 E 1466	Power Cabling Plan, East Side
RS 6 E 1467	Control Cabling Plan, West Side
RS 6 E 1468	Control Cabling Plan, East Side
RS 6 E 1469	Monitor Cabling Plan, West Side
RS 6 E 1470	Monitor Cabling Plan, East Side
RS 6 E 1471	Isolation Keyer
RS 6 E 1472	AN/FRT-18 Power, Control & Interconnections
RS 6 E 1473	Comm. Control Link, Equip. Elevations & Jack Assignments
RS 6 E 1474	Comm. Control Link, Elementary Wiring Diagram
RS 6 E 1475	Comm. Control Link, Antenna Installation
RS 6 E 1476	Cable Running List, Power Cables
RS 6 E 1477	Cable Running List, Control Cables
RS 6 E 1478	Cable Running List, Monitor & Antenna Cables

1.06 Proprietory Articles .

Similar and equal items may be substituted for specified proprietory items, when approved by the Assistant Industrial Manager, USN, Seattle.

1.07 Optional Requirements.

Where a choice of materials and/or methods is permitted herein, the right to exercise the option will be given unless stated specifically otherwise.

1.08 Government Work and Material.

The Government will furnish the material so designated on the drawings, including all the transmitters, the console and monitoring bays. The transmitter building, the helix house for the AN/FRT-4 transmitter and the four antenna tuning houses for the TAB-7 transmitters are being built by others and will be near completion prior to award of electronics work.

The transmitter building, as furnished by the Government, will include:

a. Suitable electrical service and breakers for all the equipment listed in these specifications, the wiring being complete to the breakers except panels F and G which shall be installed under these specifications.

b. Lighting.

c. Cable trays in the basement.

d. Plugged 3" round floor sleeves for pulling cables from the trays up to the equipment.

e. Steel angles on the inside walls above and below the antenna transmission line entrance insulator bowls, and overhead T-section beams along the center line of the transmitter room and transverse at columns 5 and 10 to support interior transmission lines.

f. Insulator bowls complete with 1/2" x 13 threaded brass studs.

g. Plywood sheets secured to the walls below the insulator bowls to permit the installation of T/L stand-off insulators and antenna switches with wood screws .

h. Antennas and transmission lines outside of the building complete and connected to the outside of the insulator bowls.

Each TAB-7 tuner hut as furnished by the Government will include:

a. One antenna and two transmission line insulator bowls in the walls complete with external RF connections to the transmitter building and the antenna.

b. A ground cable stubbed up through the floor.

c. Three 3" empty ducts from the tuner hut to a junction box in the basement of the transmitter building for installation of control cables.

The helix house as furnished by the Government will include:

a. Bowl insulators for the transmission line and antenna leads, complete with external RF connections to the transmitter building.

b. Antenna tower complete with obstruction lights, lighting transformer installed, and with connection to the antenna entrance insulator on the helix house.

c. Ground mat with connections to copper floor of the helix house.

d. Helix house lighting and heating system including a 3-1/2" duct and secondary power cable installed and connected from the power house.

e. Two 4" ducts to transmitter building basement, one for spare and one containing a 32 conductor No. 12 lead cable pulled in place but not connected. This cable has sufficient excess length to permit direct connection from the control terminals of the AN/FRT-4 transmitter to the helix house control equipment.

f. Interior conduit and junction boxes less wiring and devices for gate interlocks.

1.09 Electronics Engineer.

The Assistant Industrial Manager, USN, Seattle will furnish an electronics installation engineer while work under this contract is underway. The electronics engineer will provide technical guidance, inspect the work, and test the transmitters and equipment. He will be responsible to install all fuses. He must be present whenever power is applied to any of the transmitters.

SECTION II. INSTALLATION METHODS - GENERAL.

2.01 Uncrating and Assembly.

Items indicated as "Government furnished equipment" will be available at the Naval Station, Kodiak, Alaska, and shall be transported to the job site. Transmitters and associated equipment shall be uncrated and installed where shown on the arrangement plan. The equipment is partially disassembled for shipping. The components shall be reassembled in conformance with instructions furnished with each piece of equipment. All wiring that was disconnected for shipment shall be reconnected even though some of these connections may not be shown on the drawings accompanying these specifications. The equipment shall be bolted to the concrete floor (or wall as applicable) with 3/8" expansion bolts or with 1/4" studs, power driven into the concrete.

2.02 Relocation of Existing Equipment.

The following equipment, located in the old transmitter building and presently in use, shall be disconnected and relocated to the new transmitter building. The equipment shall be installed in the new transmitter building in accordance with applicable plans.

Three	(3)	Model TDH-4 radio transmitters
One	(1)	Model TDN-3 radio transmitter
One	(1)	Model TDN-4 radio transmitter
Four	(4)	Model FSA frequency shift keyers
Two	(2)	Model FSH frequency shift keyers
Four	(4)	Model KY-44C/FX photo keyer adapters
One	(1)	Model LAJ-1 (FSK monitor)
One	(1)	Model CBL-3a (FSK monitor)
Two	(2)	Model LR frequency meters
One	(1)	Model OBQ-4 VT multimeter
Three	(3)	Monitor receivers (RBG-2, RBO-2, RCH)
One	(1)	Model FRF (FSK monitor)

2.03 Cable Installation.

Install cables in the existing cable trays, control and monitor cables in the top tray and power cables in the lower tray. Pull control cables into existing ducts from the transmitter building to the TAB-7 tuner huts. No splices shall be permitted except where runs exceed the lengths of cable procured. Radii of bends must be 10 times the radius of the cable. Do not use any kinked sections of cable. Provide adequate mechanical support at cable ends to eliminate any strain at electrical terminations.

2.04 Cable Markings.

Cable markers shall consist of branded synthetic sleeving slipped over each active conductor before lugs are attached. Markers shall carry an identifying number corresponding to the terminal board and terminal number to which the conductor will be attached. In addition, each conductor shall be marked with the cable designation when such designation is specified on the drawings. Spare conductors shall be marked with the cable designation only. Three metal cable markers bearing the cable designation shall be attached to each cable carried by the cable trays; one marker at each end and one near the center of the cable run. See notes 4 and 8 of drawing RS 6E 1441.

2.05 Wire Terminations and Joints.

a. Five XV lead cables shall be terminated with their lead sheath carefully belled out, per detail 1/5 of the drawings, to reduce the voltage gradient.

b. Lead sheaths and basket weave shields shall be terminated without damage to the insulation.

c. Lugs shall be used for all wire terminations. Compression type lugs shall be used for wires size #10 and larger; soldered lugs shall be used for wires size #12 and smaller.

d. Ground connections shall be soldered to lead sheaths and shields at each termination. Connection to the ground pin of a plug connector, with grounding connection to the ground pin of the associated socket, is applicable for plug and socket connections. Grounding of coaxial shields to the coaxial plug body is sufficient if the receptacle is grounded.

2.06 Antenna Connections.

Transmission-line wiring from transmitter outputs to switches and insulator bowls shall be carefully arranged as shown on the drawings to obtain a neat installation. The spacing between wires of each transmission-line shall be accurately maintained at 6" on all lines except for AN/FRT-4 and TAB-7 transmitters, where 12" spacing shall be used.

Sharp turns shall be avoided. Maximum practical spacing between transmission lines shall be maintained to reduce coupling from one line to another. The electrical path along transmission line wires from radio transmitter terminal to antenna or switch terminal must be continuous and without metallic side branches, to avoid "stub" tuning effects.

2.07 Grounding.

a. Ground the frames of all equipment including transmitters, breaker panels, transformers, wire gutter installations and safety switches. Connections shall be made to the existing ground bus which runs along the ceiling of the basement. (See notes 1 and 2 of drawing RS 6E 1441)

b. Ground antenna switches to the existing 4" ground channel iron in the wall beneath plywood panels by means of 1/4-20 machine screw. (See detail 1/18)

c. Do not ground the transmission line support wires which are sectionalized to a 15 foot maximum length between insulators.

d. Grounding of the base of pedestal insulators used on the walls for transmission line support is not required.

2.08 Testing.

The Navy Electronic Engineer will conduct all equipment tests. Testing shall consist of an operational test plus those tests detailed in the instruction books for the specific equipment. All equipment must be so tested before its installation is acceptable. Corrections and changes to installation wiring as required by the Electronics Engineer will be made under this specification.

2.09 Transmitter Identification.

The transmitters have been assigned consecutive numbers from 1 to 38. These numbers are used for identification on the control console and monitoring jacks. Each transmitter shall be labeled with its assigned number by means of a laminated phenolic plate, engraved with one inch numerals and attached to the face of the transmitter. Also, identify all circuit breakers feeding transmitters with the appropriate transmitter number.

2.10 115-Volt Receptacles.

Install a 115-volt duplex receptacle at each transmitter not having a factory installed receptacle.

2.11 Cleaning Up.

a. Old packing crates and other waste shall be removed from the site and disposed where directed by the Electronics Engineer.

b. Small material surpluses which would be useful for maintenance shall be stored in the electronics repair room of the transmitter building.

c. Other material surpluses shall be stored where and as directed by the Electronics Engineer.

SECTION III. SPECIAL INSTRUCTIONS FOR EACH EQUIPMENT

3.01 Instruction Books.

Instruction books will be furnished for each equipment. The installation instructions therein are very complete and must be followed. The following paragraphs describe special features which are additional to the typical installation described in the instruction book. Approximate quantities and weights are indicated where known for each equipment to indicate the magnitude of the job.

3.02 AN/FRT-4 Transmitter and Tuning Equipment.

This installation includes setting up the transmitter in the transmitter building and assembling the helix coils and associated equipment in the helix house.

The AN/FRT-4 transmitter is shipped in 84 boxes, with a total weight of 67,000 pounds, the heaviest box weighing 6270 pounds. The tuning equipment for the helix house installation is shipped in 71 boxes, with a total weight of 32,000 pounds, the heaviest box weighing 1850 pounds.

Special additions to the FRT-4 are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install an RF pickup loop for monitoring the transmitter output.

c. Install a switch box, item 43 of the material list, for selecting keying circuits and monitor pickups.

3.03 AN/FRT-5 Transmitters

Five AN/FRT-5 transmitters shall be installed in the transmitter building. Each AN/FRT-5 is shipped in 13 boxes with a total weight of 7300 pounds, the heaviest box weighing 2305 pounds.

Special additions to each FRT-5 are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install an RF pickup loop for monitoring the transmitter output.

c. Connect three existing plugs and jacks for monitoring connections, as shown by the drawings.

3.04 AN/FRT-18 Transmitters.

Sixteen AN/FRT-18 transmitters shall be installed in the transmitter building in accordance with applicable drawings.

Special additions to each AN/FRT-18 are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install an RF pickup loop for monitoring the transmitter output.

c. Install switch box, item 43 of the material list, for selecting keying circuits and monitor pickups.

3.05 TDO Transmitters.

Four TDO transmitters shall be installed in the transmitter building.

Each TDO has a total weight of 1392 pounds uncrated, the largest unit weighing 1140 pounds.

Special additions to each TDO are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install an RF pickup loop for monitoring the transmitter output.

c. Install a switch box, item 43 of the material list, for selecting keying circuits and monitor pickups.

d. Install an isolation keyer.

e. Make internal connections for a monitor pickup and to utilize an existing jack for the audio signal from the frequency meter.

f. It is assumed that the TDO transmitters furnished for this installation will not be complete with the field change for frequency shift keying. This field change is not required.

3.06 TDH-4 Transmitters.

Four TDH-4 transmitters shall be installed in the transmitter building. Three are installed in the old transmitter building and are to be moved to the new building.

A TDH-4 is shipped in 26 boxes with a total weight of 14,638 pounds, the heaviest box weighing 7413 pounds.

Special additions to each TDH-4 are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install an RF pickup loop for monitoring the transmitter output.

c. Install a switch box, item 43 of the material list, for selecting keying circuits and monitor pickups.

d. Install an isolation keyer.

e. Make internal connections for a monitor pickup and to utilize an existing jack for the audio signal from the frequency meter.

f. It is assumed that the three TDH-4 transmitters presently in use are complete with the field change for frequency shift keying. This field change will have to be installed in the new TDH-4.

3.07 **TAB-7 Transmitters.**

Four TAB-7 transmitters shall be installed in the transmitter building and four antenna tuner units shall be installed in existing antenna tuner huts.

Each TAB-7 transmitter is shipped in eight boxes with a total weight of 3677 pounds, the heaviest box weighing 1649 pounds. The antenna tuner unit and field change #1 are in addition to the above. The tuner unit is estimated to weigh 510 pounds uncrated.

Special additions to each TAB-7 are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install an RF pickup loop for monitoring the transmitter output.

c. Install a switch box, item 43 of the material list, for selecting monitor pickups.

d. Install an isolation keyer in one of the TAB-7 transmitters for use with the KY-43/URT frequency shift keyer.

e. Install a 500-watt power transformer for 110 volt power to the tuner unit.

f. Install telephone jacks for communication between the transmitter and its tuner.

g. Install a frequency shift keyer, KY-43/URT in accordance with NAVSHIPS Instruction Book 91138, in one of the TAB-7 transmitters. Connect the other TAB-7 transmitters for use with Model FSH keyers.

h. Install Navy field change #1 to each TAB-7 transmitter to adapt it to use the remote tuner unit. This field change is described in NAVSHIPS Instruction Book 98248.

3.08 TDN-3 Transmitters.

TDN-3 transmitters shall be installed in the transmitter building.

One is installed in the old transmitter building and shall be moved to the new building. Modify the frequency range of three channels, per RS 13D 500A.

A TDN-3 is packed in 28 boxes with a total weight of 13,650 pounds, the heaviest box weighing 1270 pounds.

Special additions to each TDN-3 are as follows:

a. Install six RF detectors which light indicator lamps at the console when the transmitter units are transmitting.

b. Install six RF pickup loops for monitoring the output of each unit of the transmitter.

c. Install six isolation keyers.

d. Make internal connections for a monitor pickup from the master oscillator. Install six RF pickup loops for monitoring the exciter unit (coil L2) of each transmitter unit.

e. Install cover interlock switches in the plate transformers in the basement.

f. Install two telephone jacks for audio from the frequency meter.

3.09 TDN-4 Transmitter.

One TDN-4 transmitter shall be relocated from the old transmitter building and installed in the new transmitter building. Modify the frequency range of one channel, per RS 13D 500A.

Special additions to the TDN-4 are as follows:

a. Install five RF detectors which light indicator lamps at the console when the transmitter units are transmitting.

b. Install five RF pickup loops for monitoring the output of each unit of the transmitter.

c. Install a keying relay in each RF transmitter channel in accordance with AIM Sketch 2256B-55.

d. Make internal connections for a monitor pickup from the master oscillator. Install five pickup loops for monitoring the exciter unit (coil L-2) of each transmitter unit.

e. Install cover interlock switches in the plate transformers located in the basement.

f. Install two telephone jacks, for audio from the frequency meter.

3.10 **AN/FRT-19 Transmitter.**

One AN/FRT-19 transmitter consisting of four cabinets, each 48" x 50" x 84" and each weighing 2300 to 2900 pounds, shall be installed in the new transmitter building, in accordance with applicable drawings.

Special additions to the AN/FRT-19 are as follows:

a. Install an RF detector which lights an indicator lamp at the console when the transmitter is transmitting.

b. Install antenna coupling transformer TF-11/FRT-19 and switching for two Beverage antennas.

3.11 **AN/FRQ-3** Control Console.

One control console, consisting of six bays, shall be installed in the transmitter building.

Special additions to the control console are as follows:

a. Install a panel with provision for ten polar relays.

b. Place line and equipment designations on the various designation strips as shown on the drawings.

3.12 **OA-489/FRQ-3** Monitor Equipment.

Five bays of frequency monitor equipment shall be installed in the transmitter building.

Install two additional bays, M12 and M13, adjacent to monitor bay, M11, to house Model FSA and Model FSH keyers and control equipment as specified by the drawings.

3.13 Frequency Shift Keyers.

Four Model FSA, two Model FSH, and four Model KY 44C/FX keyers and keyer adapters for frequency shift and photo keying shall be relocated from the old transmitter building and installed in the new transmitter building, bays M12 and M13.

3.14 Communication Control Link Equipment.

New equipment provided by the Bureau of Ships for the transmitter building to Cape Chiniak communication control link shall be unpacked and that portion of the equipment which is assigned to NRS(T) shall be installed in the new transmitter building as specified by the applicable drawings.

Installation of the following equipment is required:

Two Model AS-20/TRC-1 antennas
One Model AN/TRC-1 equipment including transmitter and receiver
One Model CF-1A terminal equipment (with 4-wire/2-wire switching panel added)
Two Bays, Model AN/FCC-8 tone telegraph equipment, send and receive

The following equipment, located in the old transmitter building and presently in use, shall be disconnected and relocated to the new transmitter building. The equipment shall be installed in the new transmitter building in accordance with applicable plans:

Four Model AS-20/TRC-1 antennas
Three Model R-19/TRC-1 radio receivers
One Model T-14/TRC-1 radio transmitter
Two Model CF-1B voice terminals
Seven Model UG telegraph line terminals

The following equipment, to be provided by the Commanding Officer, Naval Communication Station, Kodiak, shall be installed in the new transmitter building in accordance with applicable plans, to provide a link to the air traffic control tower.

One Model AS-20/TRC-1 antenna
One Model T-14/TRC-1 radio transmitter

3.15 Designation of Terminal Strips.

All terminal boards, items 45 and 133, shall be identified at time of installation with engraved phenolic or other suitable permanent designation marking in accordance with terminal board numbers and conductor numbers assigned by the applicable drawings. (For example: TB-1 to TB-20, and pair numbers, assigned by drawing RS 6E 1474, sheet 34)

3.16 Card Holders for Operational Designations.

Provide and install two metal card holders for three by five cards on the face of each transmitter unit. The purpose of these card holders is for visual display of antenna switching data cards and cards indicating circuit employment by the operating forces. Detailed location of the card holders shall be as requested by the Officer in Charge, Naval Radio Station (Transmitting).