VHF RADIO DIRECTION FINDING SYSTEM P/N 400075-50

GENERAL INFORMATION

1.1 INTRODUCTION

The VHF DF2100 System operates in the 115.975 to 150.025 MHz range to provide air traffic control personnel with an accurate visual indication of the bearing (QDR) of an aircraft from which a radio transmission has been received. This information, processed at the Receiver/Bearing Processor Console (local site), is displayed at both the local and remote sites, if so equipped, in the form of a three digit numeric display and a 72 LED Ring-of-Lights display which are utilized by the controller to assist the pilot during landing approach.

1.2 SYSTEM DESCRIPTION

The DF 2100 System is a quasi-Doppler Direction Finder System consisting of an Antenna Assembly and a Receiver/Bearing Processor Assembly as a minimum (see Figure 1-1).
A Remote Display/Control Console, a Target Transmitter Assembly, and an Antenna Tower Assembly are available as options. .

NOTE

The DF 2100 System is modular and can be configured with various hardware and software options. Refer to the sales order confirmation and packing list associated with the specific order for specific customer configuration.

MODEL 2100 BASE UNIT

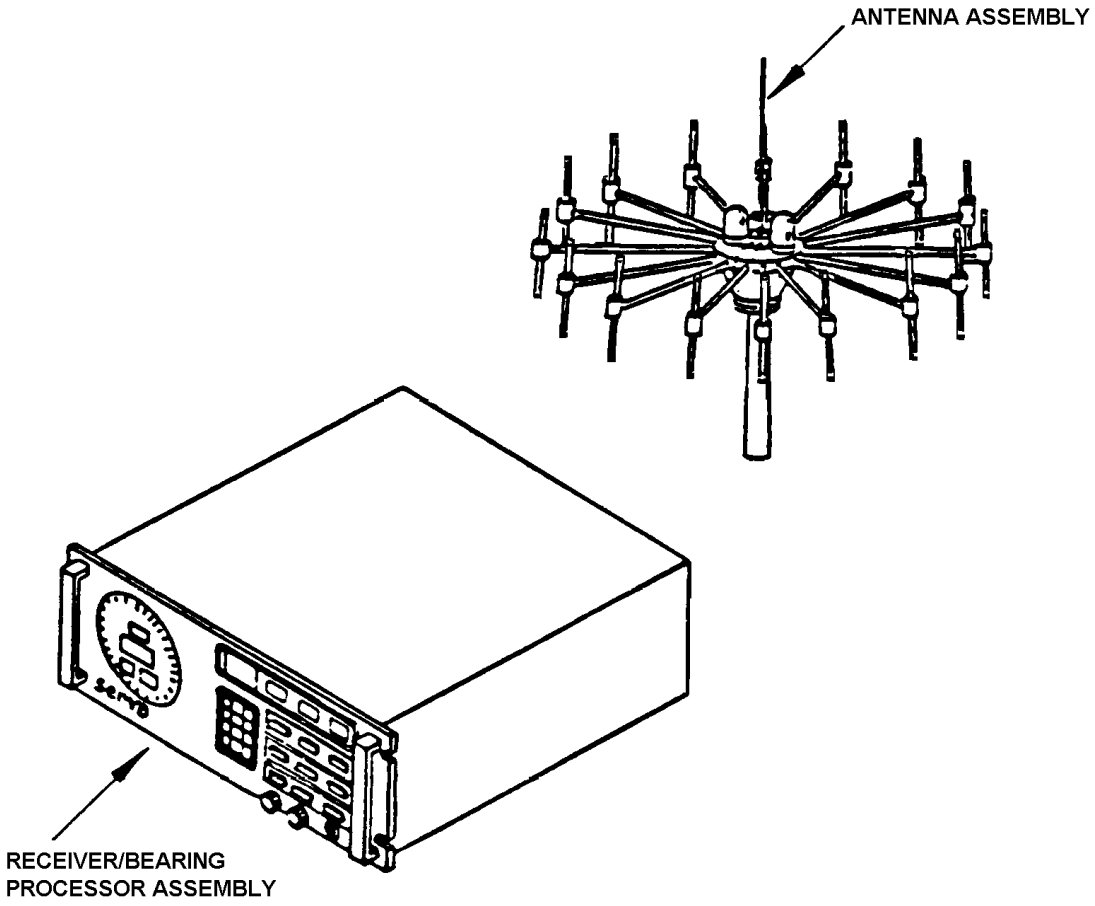

Figure 1-1. DIRECTION FINDING SYSTEM DF2100

1.3 FUNCTIONAL DESCRIPTION - BASIC PRINCIPLES

A standard Doppler direction finder antenna consists of a single dipole revolving around the circumference of a horizontal circle. The revolving dipole delivers an RF signal, frequency modulated by the Doppler effect, to a receiver. The modulation occurs at a rate equal to the dipole speed of revolution with a modulation index dependent upon the diameter of the circle in wavelengths. Detection of this modulation results in a sinusoidal signal which exhibits a phase that is a direct measure of the azimuth angle of arrival (bearing) of the received RF signal.
The quasi-Doppler Direction Finder System, DF 2100, simulates the effect of a revolving single dipole antenna around the circumference of a circle. Sixteen or eight dipoles - depending upon system configuration - are electrically commutated to phase modulate the individually received signals on a sampled data basis.
This phase modulation produces a DF sine wave of approximately 250 Hz which has a phase relationship proportional to the angle of arrival of the DF signal. Further processing measures the phase difference of the DF and reference signals and

converts the difference to a digitally coded number representing the bearing in degrees. The results are displayed in the 3-digit BEARING readout and Ring-of-Lights displays at both the local and remote sites. Commutation of the antenna is accomplished by means of commutation pulses delivered to the antenna by the commutation generator. The DF 2100 uses microprocessor techniques to perform major functions, including receiver channel selection, antenna commutation, bearing calculation and display, and built-in-test.

1.3.1 Antenna Assembly

The DF System can be configured with either a 16-Arm Wide-Aperture Array Antenna (paragraph 1.3.1.1), or an 8-Arm Medium-Aperture Array Antenna (paragraph 1.3.1.2). The entire Antenna Assembly is normally installed on top of a tower or other suitable support to provide sufficient height for the desired line of sight operating range. A 6 meter (approximately 20 foot) tower is available as optional equipment.

1.3.1.1 16-Arm Wide-Aperture Antenna

The 16-Arm Wide-Aperture Antenna, figure 1-2, consists of sixteen vertically polarized dipoles, mounted on arms equally spaced about the periphery of a 3.14 meter (123.5 in) diameter circle. A lightning rod and dual warning lamps are mounted to the top of the antenna structure. The dipole arms are flange mounted to a sixteen-sided antenna hub. Each dipole is sequentially connected through the RF commutator located within the antenna hub, via a multiconductor cable, to the commutation generator in the Receiver/Bearing Processor Assembly. This connection allows for sequential selection of each dipole by the commutation generator. This process (quasi-Doppler) imparts a phase modulation to the received RF signal that is proportional to the angle of arrival (direction) of the intercepted signal. The lightning rod is mounted to the top cover of the Antenna Assembly, figure 1-2, Transient voltages experienced by the lightning rod are passed though a ground cable at the base of the rod and down to a grounding point near the base of the Antenna Assembly. The antenna cover also supports dual warning lamps which are required to warn off low-flying aircraft. Specifications for the 16-arm wide-aperture antenna are listed in paragraph 1.4.

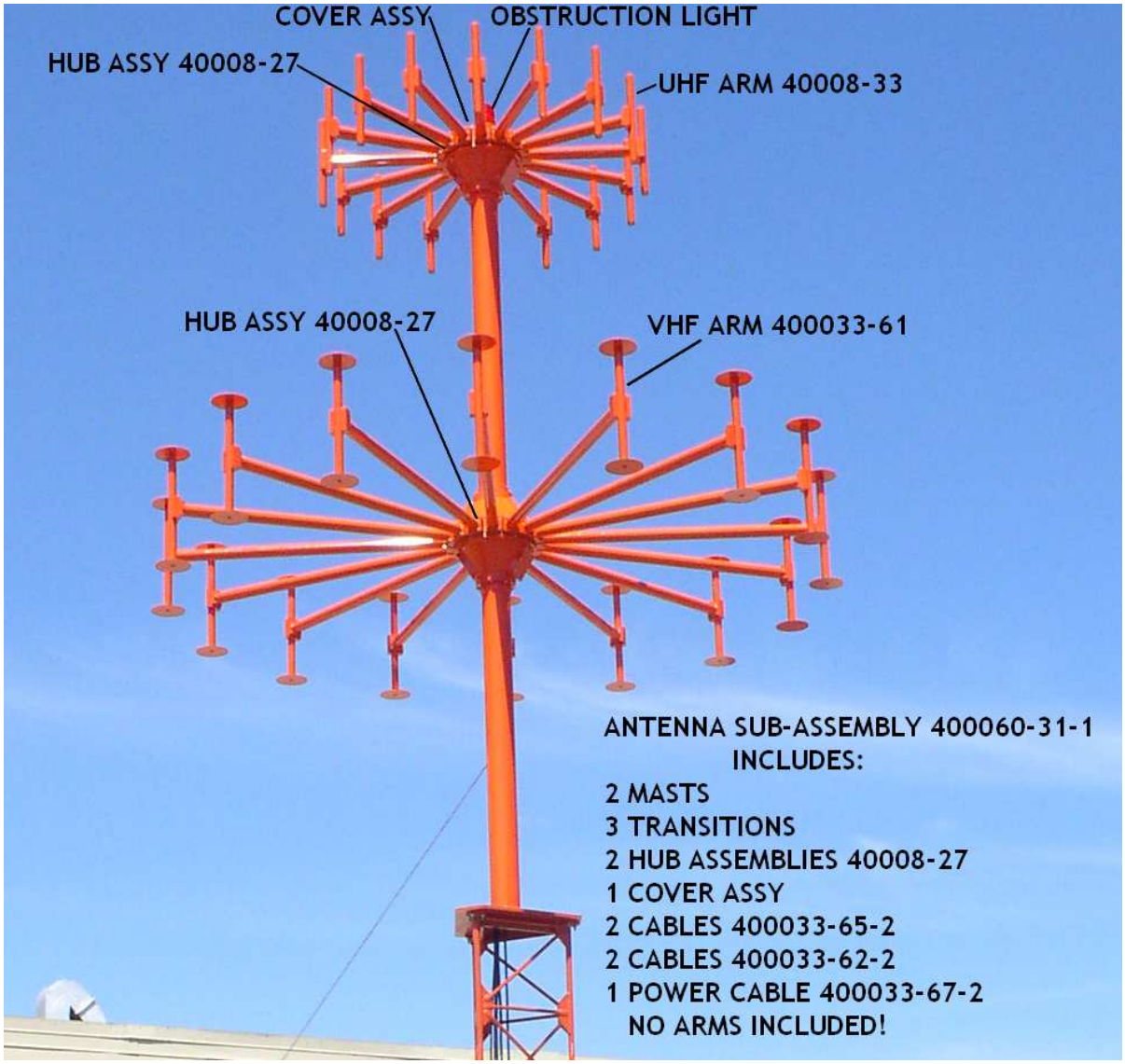

Figure 1-2. 16 ARM DIPOLE ANTENNA SYSTEM VHF (LOWER) AND UHF (HIGHER)

1.3.1.2 8-Arm Medium-Aperture Antenna

The 8-Arm Antenna is normally used for installations that require a small, lightweight antenna and do not require the improved site error suppression that is provided by the wide aperture array.
The 8-Arm Antenna Assembly, figure 1-3, consists of a commutated medium-aperture array of vertically polarized dipoles concentrically mounted on arms, equally spaced around the periphery of a 1.15 meter (45.5 in) diameter circle. The dipoles are mounted on a hub and are secured by compression bushings and hex nuts.

Figure 1-3. 8 ARM DIPOLE ANTENNA

The principle of operation is similar to the large aperture array. Each dipole is selected sequentially (via a multiconductor cable) by the commutation generator in the Receiver/Bearing Processor Assembly through the RF commutator in the antenna hub. This process (quasi-Doppler) imparts a phase modulation to the received RF signal that is proportional to the angle of arrival (direction) of the intercepted signal. Specifications for the 8-Arm Medium-Aperture Antenna are listed in paragraph 1.4.

1.3.2 Receiver/Bearing Processor Assembly (Local Site)

The Receiver/Bearing Processor Assembly is a rack-mounted unit which contains all the necessary electronic equipment to receive and process RF signals in the range of 115.975 to 150.025 MHz. Received RF signals are converted to a digital output suitable to drive the BEARING and Ring-of-Lights displays on the front panel of the unit, and for transmission via a system specified modem over voice-grade telephone lines to a remote control site equipped with a Bearing Display/Control Assembly. Controls and displays located on the Bearing Display/Control Assembly are identical to those on the receiver processor. However, system control is limited to one site only (either local or remote) as determined by the setting of the LOCAL pushbutton switch on the Receiver Processor Assembly . If the LOCAL pushbutton switch is engaged at the local site, the LOCAL indicator lamp will be illuminated at both sites and system control is possible only at the local site. Control from the Bearing Display/Control Assembly (remote site) is only possible when the LOCAL push- button switch is not engaged. Bearing, frequency, and other status information is displayed at both sites regardless of which has control.
The radio receiver section of the Receiver/Bearing Processor Assembly is a synthesized, double-conversion superheterodyne receiver which amplifies, filters and converts the commutated RF signals from the Antenna Assembly to detected output signals containing both bearing and audio information. The receiver circuits are contained on five (5) separate plug-in assemblies as follows:

A1	Preselector
A2	Synthesizer
A3	Front End - 1st IF
A4	IF/Analog Processor
A5	Tuning Control

The Preselector (A1) is a broad band filter with a passband designed to accepted signals within the receiver tuning range (115.975 to 150.025 MHz) and attenuate undesired signals outside the tuning range. The frequency synthesizer is driven by the tuning control circuit and generates the local oscillator frequency which determines the received channel frequency. Channel frequency selection and resultant receiver tuning is accomplished by operating the front panel keypad at either the Receiver/Bearing Processor Assembly or the Bearing Display/Control Assembly, whichever is in control of the system.

The frequency selected by the operator is displayed at both sites on a six digit numeric frequency display. Receiver signals are amplified and converted through the Front End - 1st IF and the IF/Analog circuits to extract the audio and bearing information which is then passed on to the processor section for further processing and display.

The processing section of the Receiver/Bearing Processor is contained on four (4) separate plug-in PCB assemblies as follows:

A6 Dipole Microprocessor
A7 Bearing Microprocessor
A8 Bearing Frequency Display
A9 Test Board

The Dipole Microprocessor (A6) and Bearing Microprocessor (A7) assemblies each contain a microprocessor and associated memory and I/O circuits that are programmed to generate and synchronize the entire sequence of system control including receiver channel selection, antenna commutation, bearing calculation and display, built in test functions, and various other operating modes. The Bearing Microprocessor Assembly (A7) also contains a Universal Synchronous/Asynchronous Receiver Transmitter (USART) circuit to generate and control the transfer of data between the Receiver/Bearing Processor and the Bearing Display/Control when the system is configured for remote operation. In that case, two (2) additional units are installed in the receiver processor as follows:

A10 Audio Modem
A11 Data Modem

These assemblies permit transmission of audio and digital data between the local and remote sites through a full duplex, 4 wire, voice grade telephone circuit.

The power supply section of the Receiver/Bearing Processor Assembly is a solid-state multiple-output supply with a 115/230 volt, single phase, 50/60-hertz ac input. Filtered and regulated dc outputs provide for operation of all electronic circuits in the Receiver/Bearing Processor Assembly.

1.3.3 Remote Bearing Display/Control Console (Optional)

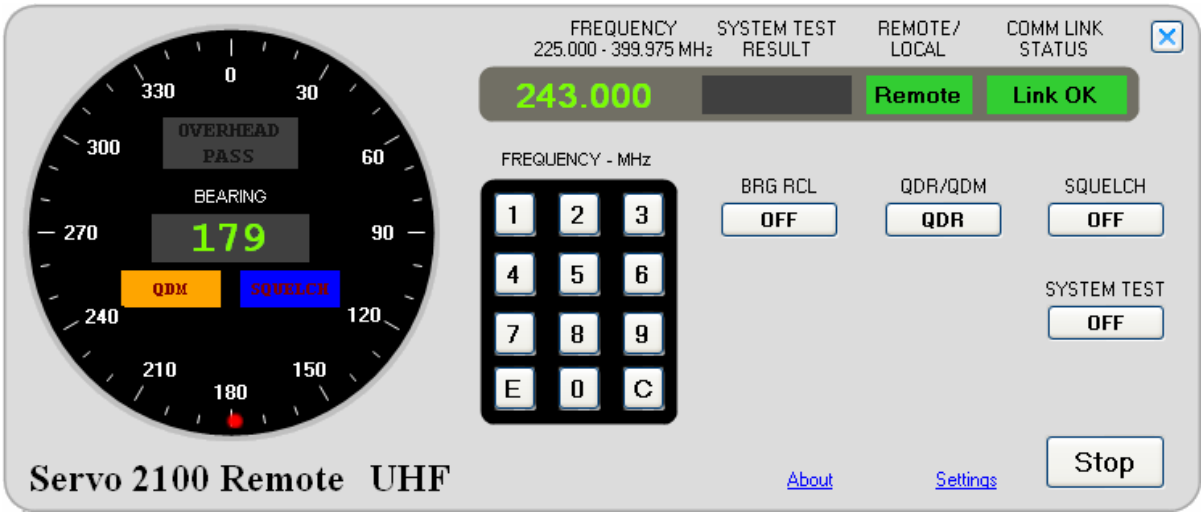

Figure 1-4 Remote Control/Display GUI (VHF and UHF DF receiver)

The Remote Bearing Display/Control Console is a Windows based unit that contains an FSK built-in modem as well as all interface hardware and software needed to:

- remotely control tuning of the DF2100 receiver
- receive and display the DF2100 receiver radio channel frequency
- receive and display the bearing data
- remotely control status and System Test of the DF2100 receiver

Communication between the DF2100 receiver And the Remote Station can be accomplished via 4-wire telephone circuit or LAN.
It comes with 2 applications. Standard shown above. Optional shown below. The only difference between them is that one allows to receive and display data from one DF2100 receiver (shown above) the other allows to receive and display data from 2 or 3 DF receivers allowing target positioning (shown below)

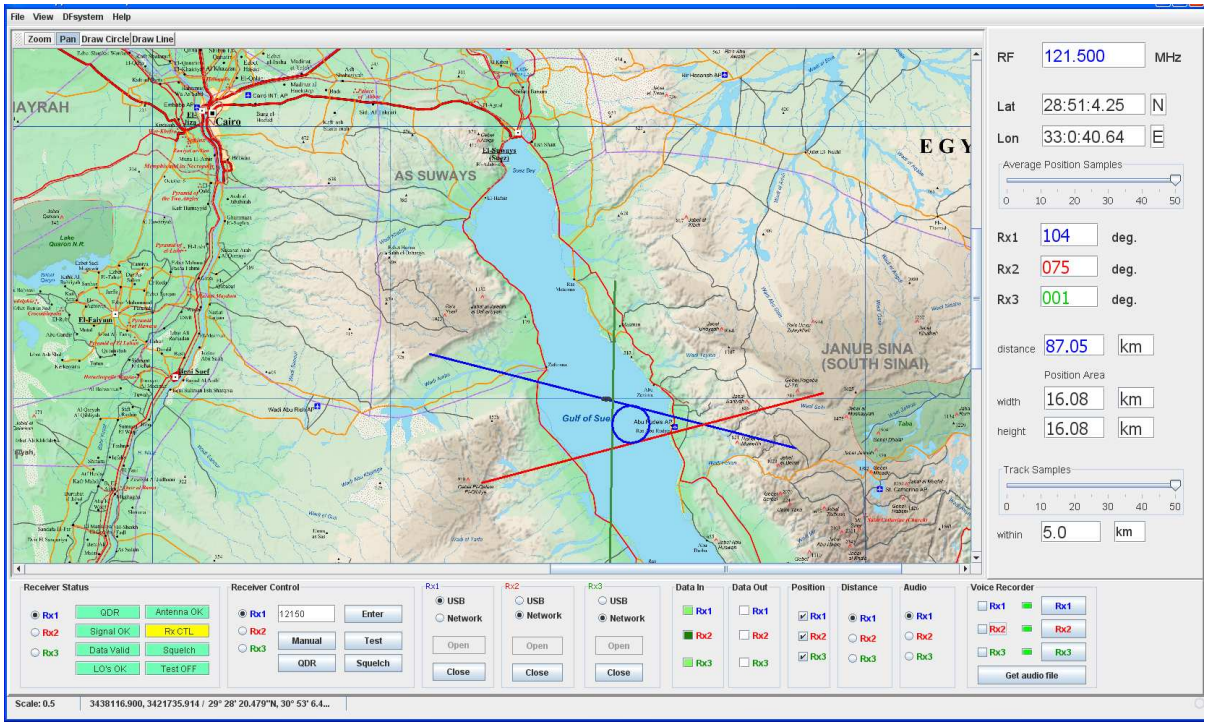

Figure 1-5 Remote Control/Display GUI (for 2 or 3 VHF/UHF DF receivers)

1.3.4 Target Transmitter Assembly (Optional)

The optional Target Transmitter feature, figure 1-4, is controlled by a built in test function which permits selective emission of an RF signal from four separate target antennas to supply known bearing information for verification of overall system operation. It consists of a pedestal mounted Target Transmitter module and RF switch module located at the DF antenna and four separate target antennas located at pre-surveyed bearing angles (approximately 90 degree increments) around the periphery of the DF antenna at a 100 foot radius.

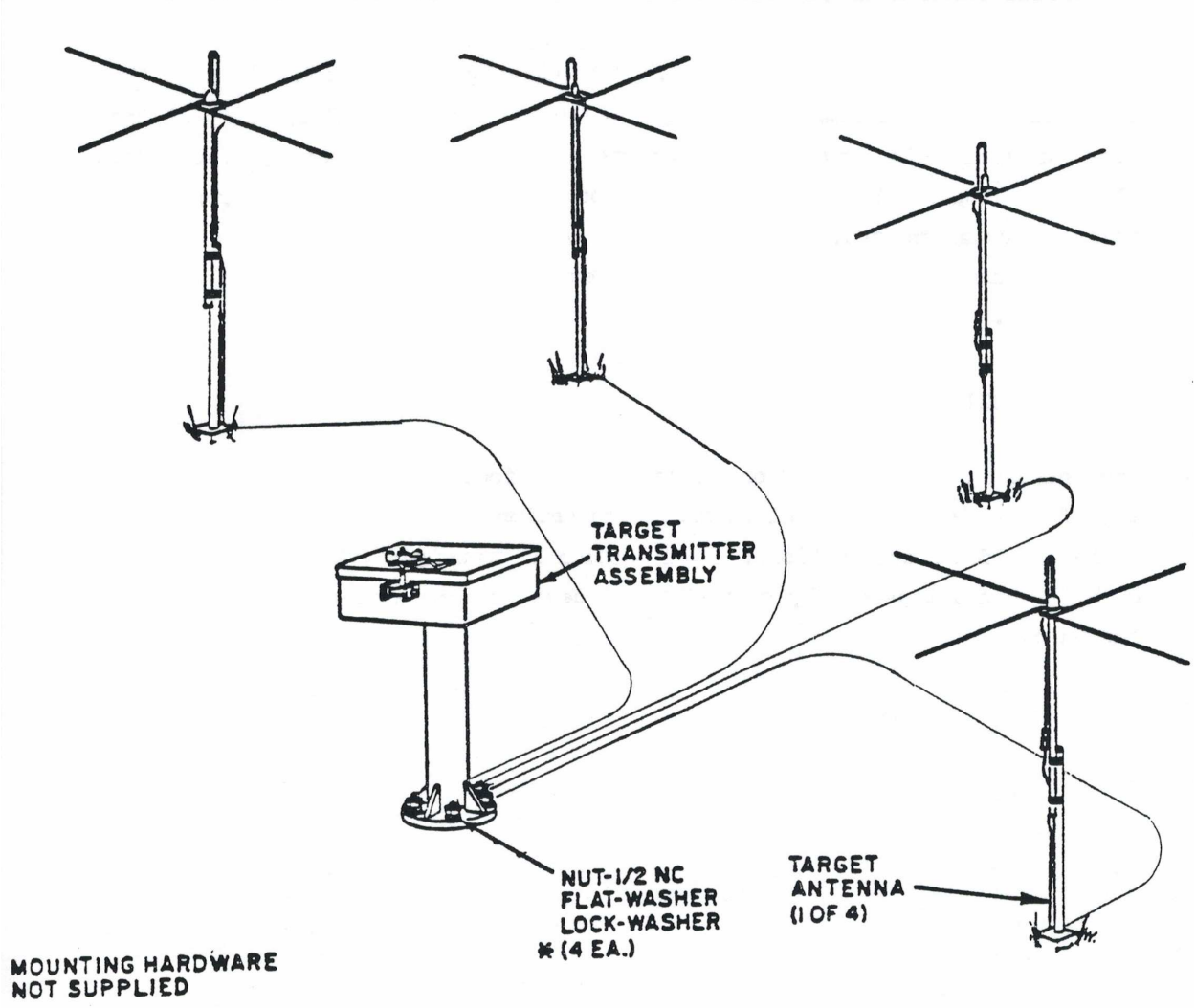

Figure 1-6. TARGET TRANSMITTER AND ANTENNA ASSEMBLY (OPTIONAL)

The transmitting section of the Target Transmitter Assembly generates a crystal controlled RF signal at 135.850 MHz that is transmitted through a self-contained RF switching unit comprising four independently dedicated transmission relays and independent cabling to four separate target antennas. The Target Transmitter is energized when the TARGET pushbutton located on the front panel of either the Receiver/Bearing Processor Assembly or Bearing Display/Control Assembly is pressed. Successively pressing and releasing the pushbutton switch automatically sequences active emission from each of the four antennas, starting with number one and advancing through numbers two, three and four. Holding the pushbutton in on any selected emitter will maintain emission from that antenna. Releasing the switch for a period greater than six seconds will permit restarting the sequence with antenna number one.

1.3.5 Antenna Tower (Optional)

The antenna can be mounted on an optional 20-foot tower which is mounted on top of a sunken cylindrical concrete foundation. The tower consists of two 10-foot welded-steel sections. Each section is made up of three parallel main members joined together by supporting girders to form a triangular top plate and base.

`` Figure 1-7 DF Antenna mounted on a mobile shelter

1.4 VHF DF2100 SYSTEM SPECIFICATIONS

TABLE 1 SYSTEM SPECIFICATIONS

PARAMETER	VALUE
Principle of Operation	Quasi-Doppler
Bearing Accuracy	+/- 1 degree (instrumental) +/- 3 degrees (site)
Frequency Range VHF	115.975 to 150.025 MHz
Operating Channels	1363
Channel Spacing	25 kHz (12.5 kHz 8.33 kHz OPTIONAL)
Channel Selection	Local: Keypad; 10 preset channels with single digit entry Remote: RS-232/Phone Line
DF Sensitivity	5 microvolts per meter for +/- 2 degrees bearing fluctuation
Vertical Angle Coverage	0º (Horizontal) to 60º (Vertical)
Operational Control	Local or Remote
Sensitivity (AM)	1.4µV for 10 dB (S+N)/N with 30% AM at 1000 Hz
Selectivity (IF)	6 dB Passband +/- 10 kHz; 60 dB Rejection +/- 18 kHz
Image, Spurious, IF Rejection	80 dB to within 100 kHz of Channel Frequency
Frequency Accuracy	+/- 20 ppm
Audio Output	Adjustable to maximum output of at least +10 dB into 600 ohms.
Local/Remote Interface	FSK Data, frequency multiplexed with audio, over 4-wire voice grade 600 ohm telecom circuit or LAN
Demodulated Audio Out	VHF: AM 115.975 to 143.975 MHz FM 144.000 to 150.025 MHz
External Power Requirements	
Receiver/Bearing Processor	150 Watts

TABLE 1 SYSTEM SPECIFICATIONS (cont.)

PARAMETER	**VALUE**
Antenna Arrays	200 Watts (for obstruction lamps on wide-aperture array antenna only)
Environmental Characteristics	
Receiver/Bearing Processor	-20 to +65 C; humidity up to 90%
Antenna Arrays	-50C to +70C; humidity up to 100%. Withstand wind velocity to 100 mph with 0.50 inch ice loading.
Dimensions and Weights	
VHF Medium-Aperture (8-Arm)	Diameter: 1.15 m (45.5 in) Overall Height: 1.3 M (51 in) Weight: 8.9 kg (19.7 lbs)
VHF Wide-Aperture (16-Arm)	Diameter: 3.14 m (123.5 in) Height to Center of VHF Arm: 1. 86 m (73.2 in) Overall Height: 2.09 m (82.3 in)
Receiver/Bearing Processor	
Height: 17.8 cm (7 in)	Height: 17.8 cm (7 in) Width: 48.3 cm (19 in) Depth: 50.8 cm (20 in) Weight: 17.6 kg (39 lbs)

1.5 Optional Equipment

The following table is a listing of the different models of the SERVOFLIGHT 2100 series direction finder systems with VHF capabilities.
Table 1-1

	Antenna		Operation	
Model Number	Aperture	Dipoles	Local	Remote
2115	Medium	8	X	X
2120	Wide	16	X	X

Note:
8 arm antennas should only be considered when space for 16-arm antenna is not available. There is a significant accuracy improvement with 16 element antenna especialy when there are RF reflections.