VHF/UHF ANTENNAS
FEDERAL FTR-29C ANTENNA SYSTEM
DESCRIPTION

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1. GENERAL

1.01 This section pertains to the Federal FTR-29C Radio Frequency Antenna Systems. A description of the Federal FLU-5108 Antenna Duplexing Filter which provides the simultaneous operation of a radio receiver and a radio transmitter from a single antenna of this type is included in this section. Circuit and equipment information are included as well as transmission characteristics. Related photographs and drawings are attached, and a reference list is also included.

1.02 The Federal FTR-29C Radio Frequency Antenna Systems are specifically designed for operation with the Federal 10-D PTM Microwave Radio System, and are suitable for transmitting or receiving line-of-sight radio transmissions in the 890 to 940 megacycle band.

2. CIRCUIT DESCRIPTION

(A) Parabolic Antennas

2.01 The antennas employed with this equipment consist of a coaxial fed dipole mounted at the focal point of a mesh type parabolic reflector. The electromagnetic energy radiated by the dipole is reflected into the parabolic reflector where it is converted into a flat wavefront as a result of the contour of the parabola. The larger the diameter of the parabolic reflector, the narrower the beam, and consequently, the higher the gain. The three sizes of parabolic reflectors available for use with this equipment and their gains are as follows:

Type	Construction	Size	Gain*
FLU-5153	Mesh	4 ft	18.5 db
FLU-5154	"	6 ft	21.8 db
FLU-5155	"	10 ft	26.3 db

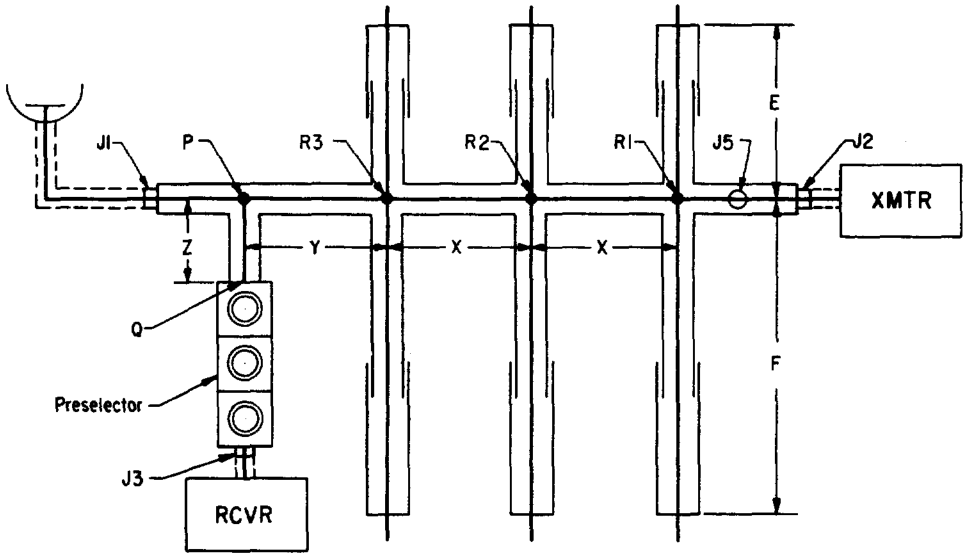
*Approximate gain over an isotropic antenna.

(B) Antenna Duplexing Filter FLU-5108

2.02 The Antenna Duplexing Filter FLU-5108 shown in Fig. 1, provides the facilities for simultaneous operation of a radio transmitter and receiver over a single transmission line with a single antenna. It consists of a coaxial transmission line, a triple cavity preselector, with three micrometer tuning adjustment controls in the receiver leg, and three pairs of adjustable length stubs, one long and one short per pair in the transmitter leg. The tuning adjustments are provided to permit transmission and reception of radio frequency signals within the operating range of the equipment, namely, between 890 and 940 megacycles.

2.03 The preselector in the radio receiver leg is, in effect a band-pass filter, tunable by means of the three micrometers for receiver operation at any frequency within the 890 to 940 megacycle operating range of the equipment. When adjusted, the filter provides a receiver band-pass of 8 megacycles centered about the center-frequency selected for the receiver by the adjustment of the micrometers.

2.04 The three pairs of stubs, one long and one short per pair, are in effect, a three section band rejection filter. The stubs are



X, Y and Z — equal a quarter wavelength at the mid-band frequency
F —— equals two wavelengths at the receiver frequency
E —— together with the reactance shown by the long stubs at the transmitter frequency is a multiple of a half wavelength at the transmitter frequency.

Fig. 1 - Antenna Duplexing Filter

adjustable to permit operation of the transmitter at any frequency within the operating range of the equipment. When adjusted by means of the stubs, the duplexing filter provides a resistive 50-ohm match between the radio transmitter and the antenna coaxial transmission line at the operating frequency of the radio transmitter and over a band-pass of 8 megacycles centered about the center-frequency selected for the receiver by the adjustment of the micrometers.

2.05 The antenna duplexing filter, essentially a combination band-pass - band-rejection filter network with common antenna connection, performs functions analogous to those of a hybrid coil (or 4-wire terminating set) employed in a conventional telephone channel to link an effective 4-wire circuit (transmitting and receiving paths) to a common 2-wire path (antenna) serving both the transmitter and the receiver. As another analogy, the duplexing filter may be compared to a tunable 3-way matching pad with distributed circuit constants. To perform these functions the filter network must accomplish the following:

(a) It must insure minimum crosstalk or "break-through" of the transmitter output energy into the receiver. This function is, in effect, performed by the long stubs, which, in normal operation, are adjusted to a multiple of a half-wave length at the receiver frequency.

(b) It must insure maximum transfer of power from the transmitter to the antenna, without loading down the transmitter oscillator. To do that, the filter must provide a resistive impedance match between the transmitter and the antenna. This function is, in effect, performed by the short stubs of the duplexing filter, which, in normal operation, are adjusted to cancel out reactive components introduced at the transmitter frequency by the long stubs.

(c) It must insure free passage from the antenna to the receiver of signals in the frequency band of the receiver, and to block from entry into the receiver all frequencies outside the receiver frequency band. This function is, in effect, performed by the preselector, which, in normal operation, is adjusted by means of the three micrometer controls for maximum receiver AVC.

(d) The filter must be tunable, to permit operation at any pair of frequencies, one for transmission and one for reception, within the operating range of the equipment, namely 890 and 940 megacycles. The tuning functions are performed by the adjustable shorting caps of the short and long stubs, and by the preselector micrometers, as indicated above.

2.06 If the functions outlined in Paragraph 2.05(a) through (d) are to be performed, a good impedance match must be obtained between the transmitter output and the antenna, and between the antenna and the receiver input. At the same time, high attenuation, must effectively, be provided between the transmitter output and receiver input at the receiver frequencies.

2.07 Signals appearing at the output of the transmitter enter the duplexing filter through connection J2, are routed along the center-section past junctions R1, R2, and R3 of the stub pairs with the center-conductor, past junction P of the receiver leg with the center-conductor, and through antenna connector J1 to the antenna transmission line.

2.08 Those components of the transmitter output energy which lie in the receiver bandpass see a reflected short circuit to ground at each one of the junctions R1, R2, and R3. Accordingly, at each successive junction these signal components are attenuated very sharply, so that at junction P they are below the receiver input sensitivity level. To provide the short circuits, the long stubs are adjusted to lengths corresponding to multiples F of one-half-wavelength at the receiver frequency, and are shorted at their ends by means of the stub-shorting caps. In addition, the junction points are spaced at quarter-wavelength intervals X (at midband frequency from each other and from junction P. In making the adjustment of the long stubs, interference from distant transmitting stations is avoided by disconnecting the antenna transmission line from J1, and connecting a lossy cable to J1, instead. Utilizing the transmitter output as a test signal and an oscilloscope connected to the receiver output as a pulse-measuring device, the long stubs are adjusted until all evidence of signal pulses (which under the circumstances can come only from the transmitter) disappears from the oscilloscope screen, or until the level of these pulses are reduced below the level of the noise normally present in the receiver and shown on the oscilloscope screen as random voltage peaks.

2.09 The shorted long stubs, adjusted to what is, in effect, a series resonant circuit to ground at the receiver frequencies in the transmitter output energy, present to the transmission frequencies proper, a reactive component of impedance at junctions R1, R2, and R3. These reactive components represent mismatches across the line, and must be tuned out, if maximum transfer of transmission energy is to take place. Each shorted stub is adjusted, therefore, to a length, which together with the reactance provided by the long stub is equivalent to a multiple of a half-wave length at the transmitter frequency. This is equivalent to a circuit parallel resonant at the transmitter frequency shunted across the line at each junction, R1, R2, and R3. At each junction, therefore, the transmission frequencies see a purely resistive impedance of 50 ohms (the characteristic impedance of the line), and a match is established between the transmitter and the antenna, insuring transfer of energy with a minimum of attenuation.

2.10 For the receiver frequency components of the transmitter output energy, the short stubs are in shunt with the short circuit provided by the long stubs, and their adjustment has no effect on the long stubs. During alignment, the correct adjustment of the short stubs is determined when maximum power output is measured by means of a wavemeter coupled through J5 to the antenna leg of the duplexing filter. In practice, it is difficult to establish a perfect short circuit at the receiver frequency by means of the long stubs, or a perfect resistance at the transmitter frequency by means of the short stubs. The adjustment of one does, therefore, affect the adjustment of the other, although to only a slight degree. An interpolatory adjustment procedure is therefore employed. For the same reason, three sets of stubs instead of one set are used to obtain greater rejection of the receiver frequency component and to improve the match between the transmitter and the antenna.

2.11 The transmitter output energy within the transmission band proper is between 80 and 110 db above the level of the signals entering the receiver from the antenna. Since such a large level difference is a potential source of interference of signals from the transmitter in the receiver, the distance Z from the preselector cavity input Q to the junction P is made an electrical quarter-wavelength (at the midband frequency). In addition, the preselector cavity is triple tuned to the receiver frequency (i.e. presents a 50-ohm resistive impedance to receiver signals). The input to the cavity, Q, presents, therefore, a low (short circuiting) impedance to the transmitter frequencies. At the junction P, a quarter-wavelength away, this low impedance is transformed into a high impedance, which thus tends to keep out the frequencies in the transmission band proper. As a result, the transmission frequencies are kept out of the receiver and are routed to the antenna transmission line.

2.12 Signals picked up by the antenna are brought into the duplexing filter through connector J1, and are routed past junctions P and Q to the preselector cavity, and from there to the input of the mixer cavity on the receiver proper.

2.13 The distance Y from the adjacent stub junction R3 to junction P of the antenna and receiver legs is made a quarter-wavelength at the midband frequency. The impedance to receiver passband signals at the junction (P) looking into the transmitter leg is, therefore, very high and the incoming receiver signals are prevented from entering the transmitter leg, but are sent into the receiver leg. The distance Z from the cavity input Q to the junction P is, again, a quarter-wavelength at the midband frequency. The preselector cavity is tuned to the receiver band-pass frequencies, and thus present resistive 50-ohm terminating impedances to these frequencies at junctions P and Q. Thus, the receiver frequencies enter the preselector cavity freely.

2.14 Triple tuning of the preselector cavity insures that only frequencies within the receiver band-pass enter the receiver proper, and that signal frequencies outside that band are attenuated very sharply and present no effective voltage at the input to the mixer cavity. During alignment, each micrometer control of the preselector cavity is adjusted in turn to obtain maximum AVC, at the receiver center frequency. The test signal for this purpose may be obtained from a distant transmitting station.

3. EQUIPMENT FEATURES

(A) Parabolic Reflector Antennas FLU-5153, 5154 and 5155

3.01 The parabolic reflectors available for use with the Federal 10-D PTM Microwave Radio System are of mesh type construction to reduce wind loading on the tower and mounting surfaces. Electrically the mesh type reflector is identical to an equivalent solid spun type reflector. They are available in the following sizes:

Type	Diameter
FLU-5153	4 ft
FLU-5154	6 ft
FLU-5155	10 ft

3.02 Photo A on Page 6 illustrates a typical antenna installation. The antenna assembly is supplied with an azimuth adjustment of approximately plus or minus 5 degrees. Vertical adjustment is not usually provided unless specified when the antenna assembly is ordered.

3.03 The antenna is supported by eight radial ribs riveted to a base plate, which supports the square frame and the dipole assembly. The construction of the antenna assembly is shown in Photos B and C on Pages 7 and 8.

(B) Coaxial Transmission Lines

3.04 Several air and solid dielectric coaxial transmission lines are available for use with the Federal 10-D PTM Microwave Radio System. The selection of a certain type of coaxial transmission line is governed by the loss that can be tolerated. The solid dielectric coaxial transmission lines are limited to runs of 50 feet or less because of their high loss.

3.05 The air dielectric lines, 7/8 and 1-5/8 inches in diameter are made and shipped in 20-foot lengths sealed at each end. When assembling these sections the inner conductor of each section is joined by a slotted expandable sleeve. The outer conductor of each section is threaded, one end a female connection, and the other end, a male connection. A rubber (buna) gasket, seated in the recess of the female threaded end provides an air-tight seal when the male connector of the adjoining section of line is connected to it and tightened.

(C) Antenna Duplexing Filter FLU-5108

3.06 The FLU-5108 Antenna Duplexing Filter is 8-3/4 inches high and requires 5 rack mounting spaces in a 19-inch relay rack. Coaxial jack J5 (RX-302555-1B) is provided for coupling the FLU-5005 Frequency Meter into the radio transmission path for frequency measurement purposes. Three UG-58/U coaxial chassis connectors are provided for connecting the long stubs to the duplexing filter. J1, and J2, both of which are UG-58/U coaxial connectors, connect the antenna and radio transmitter to the duplexing filter. The long stubs are extended to the correct length (2 wavelengths at the receiver frequency) by a section of RG-8/U coaxial cable and a length of brass tubing similar in construction to the short stubs. The long stubs are not shown in Fig. 1 on Page 2, since they are laced into the interbay cabling. The stubs have shorting caps made from brass tubing which fit over the stub proper. The shorting caps are fastened in place by a small clamp and screw.

4. TRANSMISSION CHARACTERISTICS

(A) Parabolic Reflector Antennas FLU-5153, 5154 and 5155

4.01 The transmission characteristics for the Federal parabolic type reflector antennas are as follows:

	FLU-5153 4 ft	FLU-5154 6 ft	FLU-5155 10 ft
Gain *	18.5 db	21.8 db	26.3 db
Beam width (3 db points)	17.5°	11.6°	7.0°

* Gain over an isotropic antenna - subtract 2 db for gain over a half-wave dipole.

(B) Coaxial Transmission Lines

4.02 The transmission characteristics of the various coaxial transmission lines used with this equipment are as follows:

	Dielectric	Loss per 100 ft @ 1000 mc	Characteristic Impedance
RG-17/U	Solid	4 db	50 ohms
RG-8/U	"	8.5 "	"
7/8 in. rigid	Air	1.5 "	"
1-5/8 in. "	"	0.8 "	"

VSWR should not exceed 1.7:1.

(C) Antenna Duplexing Filter FLU-5108

4.03 The transmission characteristics of the FLU-5108 Antenna Duplexing Filter are as follows:

Preselector Band Pass	8 megacycles to the 3 db points.

5. PHOTOGRAPHS

5.01 The following photographs of the Federal FTR-29C Radio Frequency Antenna System including the FLU-5108 Duplexing Filter are included:

Photo Desig.	Subject	Page
A	Typical Radio Frequency Antenna Installation, Over-all View	6
B	Dipole and Reflector Assembly, 4 ft Mesh Type Construction, Front View	7
C	Dipole and Reflector Assembly, 4 ft Mesh Type Construction, Rear View	8
D	Antenna Duplexing Filter FLU-5108, Top View	9
E	Antenna Duplexing Filter FLU-5108, Bottom View	10

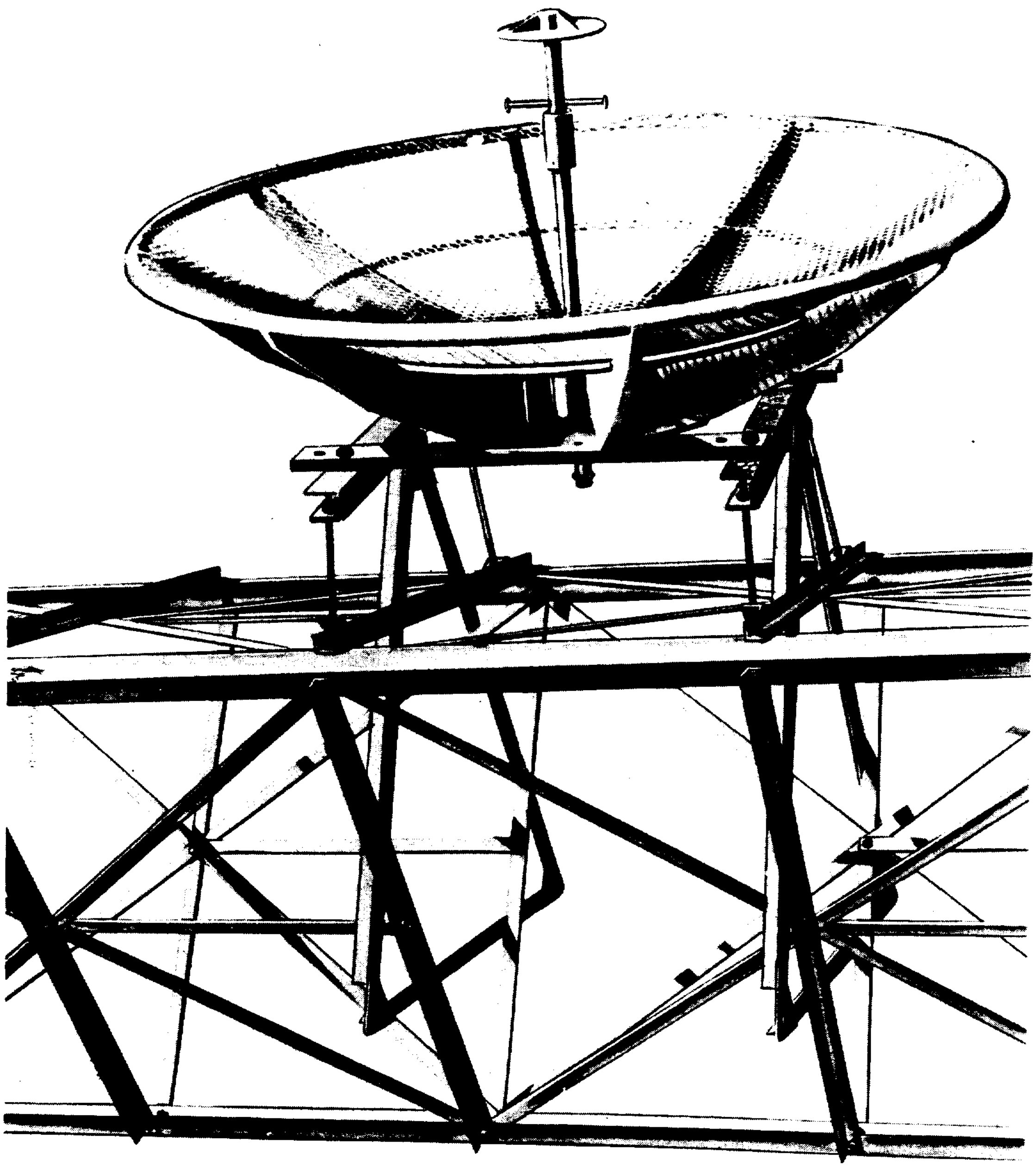


Photo A – Typical Radio Frequency Antenna Installation, Over-all View

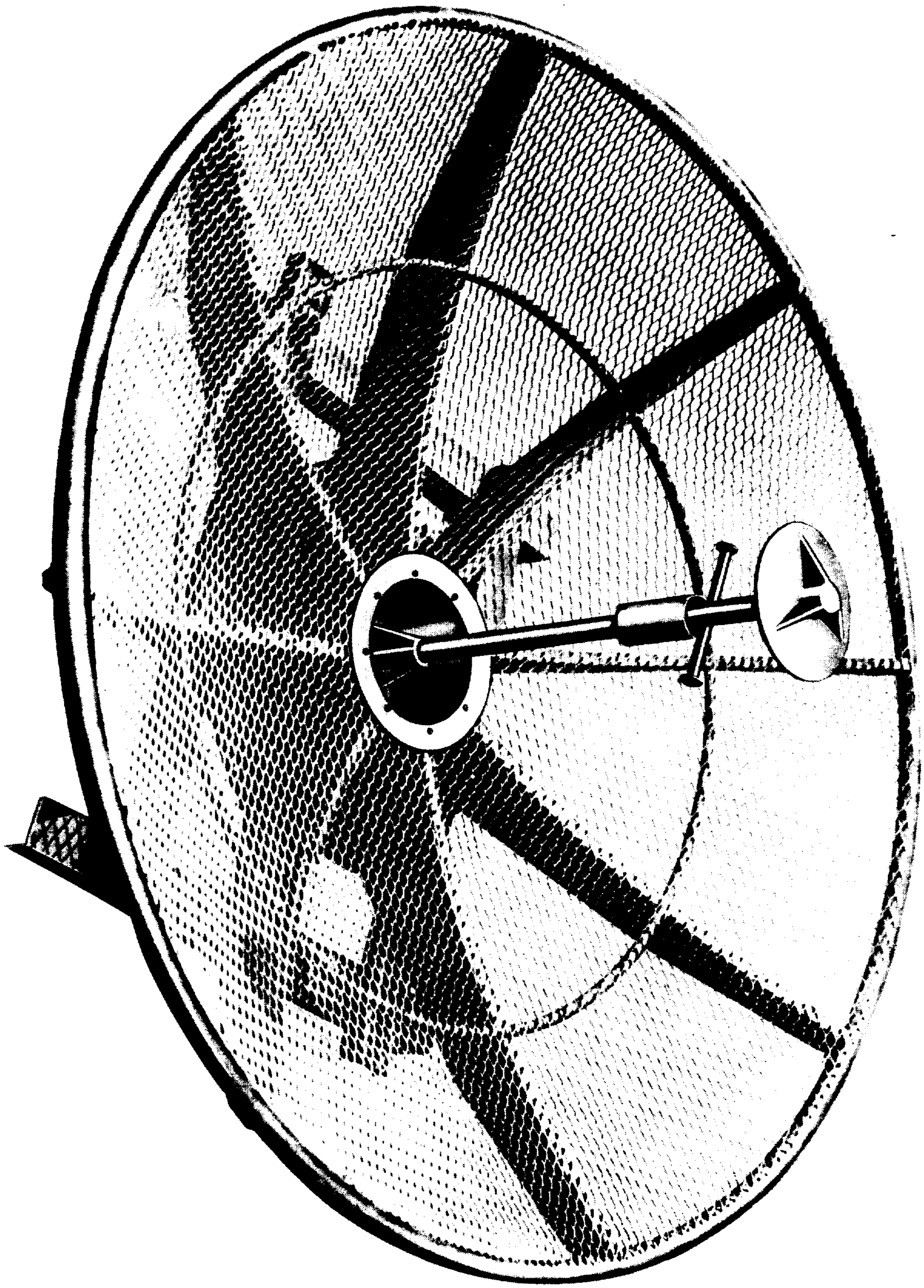


Photo B – Dipole and Reflector Assembly, 4 ft Mesh Type Construction, Front View

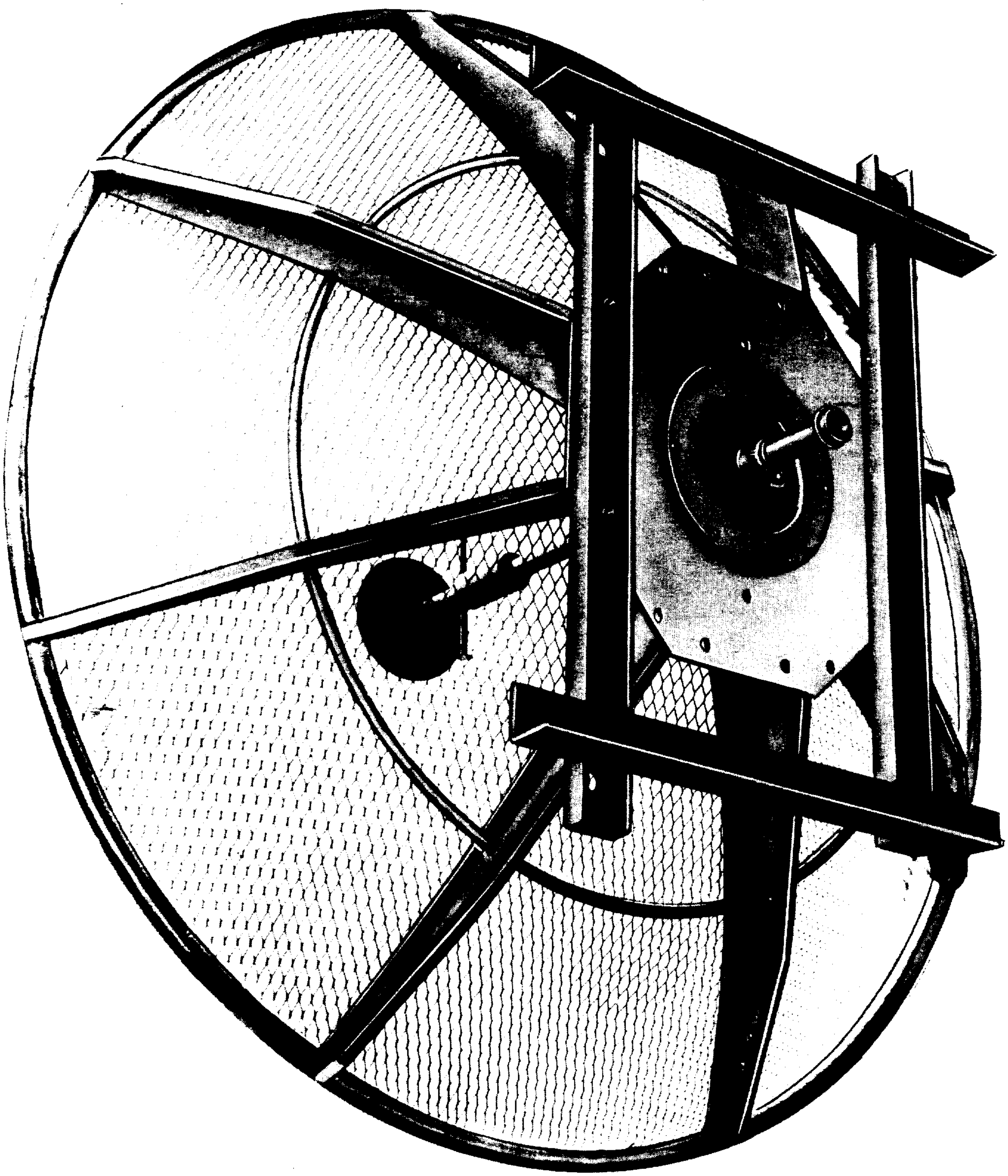


Photo C – Dipole and Reflector Assembly, 4 ft Mesh Type Construction, Rear View

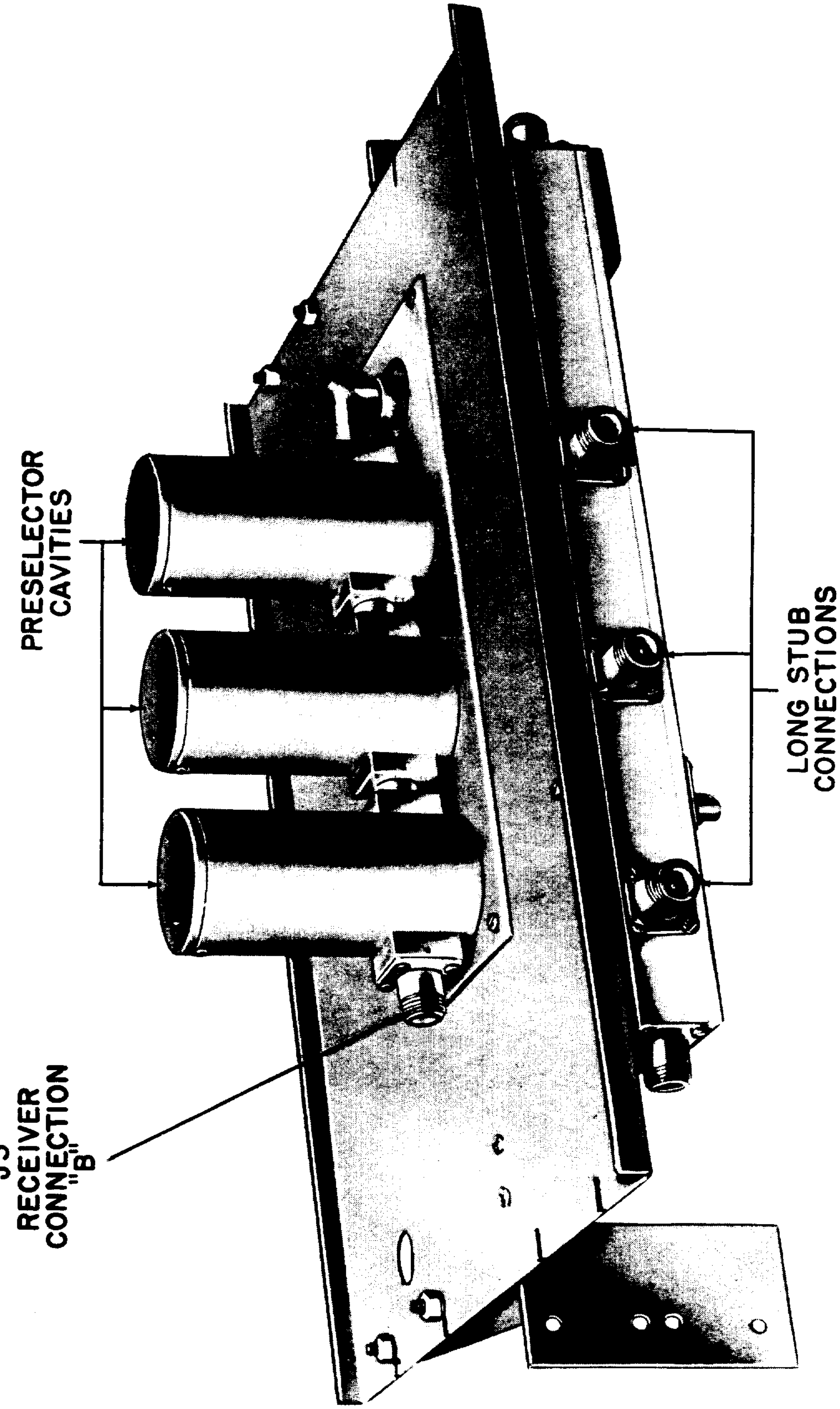


Photo D – Antenna Duplexing Filter FLU-5108 — Top View

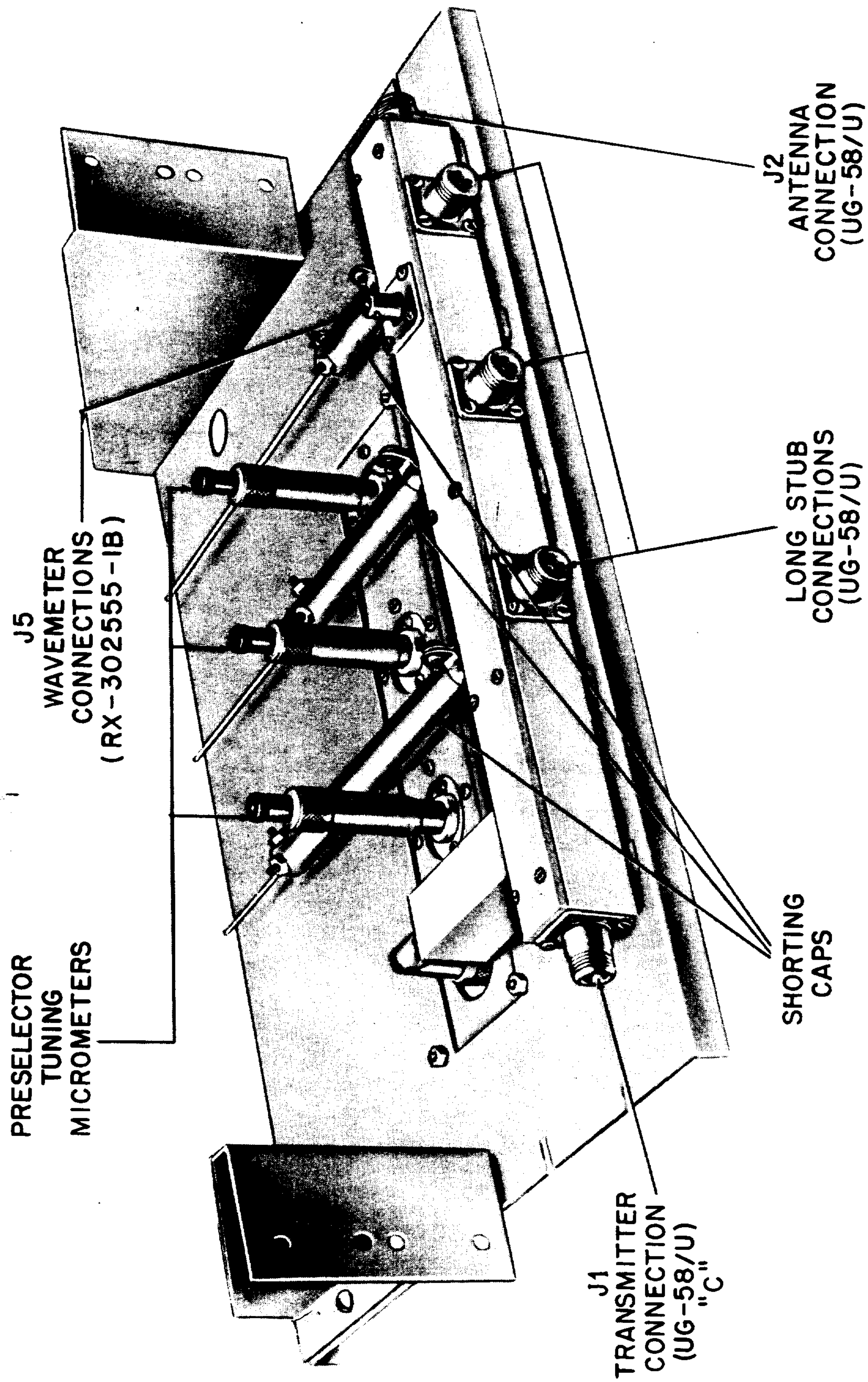


Photo E – Antenna Duplexing Filter FLU-5108 — Bottom View