# MICROWAVE ANTENNAS
# KS-5759 DELAY LENS ANTENNA
# DESCRIPTION

CONTENTS PAGE



## 1. GENERAL

1.01 This section covers the KS-5759, Lists 1, 2, 4 and 5 Delay Lens Antennas. It also covers the List 3 Mounting Sub-base and the KS-16784 Heater-Blower Assembly. The KS-5759, Lists 1, 2, 4 and 5 Antennas are rated manufacture discontinued.

1.02 *Reason For Reissue:* To include the information formerly in the Addendum to Issue 3.

1.03 The antenna has been especially designed for use with the microwave equipment of the TD-2 Radio System. However, it is suitable for use as a transmitting or a receiving antenna for permanently installed line-of-sight broadband microwave radio systems of either the studio-to-transmitter or multi-link variety. In general, this antenna provides high forward gain, and good side and back lobe suppression. It is therefore especially useful on long paths or in situations where good directivity and shielding is required to avoid interference.

1.04 This antenna is designed for operation within the common carrier 3700 to 4200 mc band. Its lens is designed for vertically polarized electric field only.

1.05 *Heater-Blower:* The KS-16784 Heater-Blower is used to dry out the polystyrene foam lens blocks when an accumulation of moisture has caused a reduction of antenna gain.

## 2. DESCRIPTION

2.01 This 10′ square delay lens antenna consists of a pyramidial horn with a 10′ square aperture in which the lens is located, the over-all length being about 10′. It is fed by 2.290″ by 1.145″ I.D. rectangular waveguide at the apex or throat.

2.02 An integral part of the antenna is the feed horn, which is machined to close dimensional tolerances. An iris is used between the feed horn and the waveguide to reduce the reflection and compensate partially for the abrupt transition between the waveguide and the relatively short wide angled horn. This iris is 1/16″ thick at the opening (1/4″ over-all thickness), this opening being 1.916″ ± .003″ for the wide dimension and 1.145 ± .003″ for the narrow dimensions which is the same as the narrow dimension of the waveguide. The rear end of the feed horn is machined to accept the iris. It centers the iris opening with respect to the inside dimension, of the waveguide and maintains the face of the iris toward the antenna at a position in the waveguide from .070″ to .080″ in back of the point of flare of the feed horn. The steel stamped arrows on the iris should point towards the antenna, when in position.

2.03 The operation of the lens is such as to delay the electromagnetic waves passing through it in proportion to the thickness as in a glass lens. This is accomplished by arranging metallic strips in a three dimensional array in such fashion as to create an artificial dielectric material. These strips are placed in slots cut in foamed polystyrene blocks, which are then care-

fully assembled in the front portion of the horn in the position calculated to produce the desired focussing action of the lens. The antenna is set up to accept a field with the E vector vertical. Mechanically it is not adaptable to a mounting arrangement which would accept a field with the E vector horizontal. The lens action is not sensitive to moderate warping or twisting of the assembly. This permits building a tilt in the lens vertically so that reflections are not focussed back to the throat where they would accentuate the standing wave ratio. The standing wave ratio over the 3700 to 4200 mc band averages less than 0.5 db, with occasional peaks up to nearly 0.6 db at the lower and upper end of the band, using a short piece of 2.290" by 1.145" waveguide feed and an iris in place between the waveguide and the feed horn.

**2.04** The steel antenna per KS-5759, List 4 is the electrical and mechanical equivalent of the aluminum design per list 2 and has a weight of approximately 4000 pounds or about twice that of the list 2 antenna. The aluminum antenna per KS-5759, List 5 is the electrical equivalent of the aluminum design per list 2 and weighs approximately 3100 pounds.

**2.05** The antenna per KS-5759, List 5 has been modified so that it will withstand 100 pounds per square foot wind force in any direction.

## 3. EQUIPMENT FEATURES

**3.01** A dimensional drawing ED-63939-011 and 012 of the antenna will be found at the end of Section 402-420-200. From this drawing, it may be noted that the antenna consists of a 10' square microwave lens fed by a shielded pyramidal horn which tapers at the small end to the inside dimensions of the associated 2.290" by 1.145" waveguide feed.

**3.02** The lens itself is a plano-convex volume of spaced metal strips held in position by a low-loss dielectric material (formed polystyrene). Its action in focussing microwave energy is directly comparable to the action of a glass lens on light energy. The word "delay," as applied to it, refers to the phase delay in transmission through it compared to free space transmission.

**3.03** The microwave energy in the region of 4000 mc, fed to the small end of the horn, by means of the waveguide, emanates in diverging rays inside the horn, illuminating the entire rear convex surface of the lens. The greater distance traversed by the outer rays is compensated for by the greater thickness and attendant delay at the center of the lens, so that the energy in a vertical plane at the front of the lens is in phase. Forward of the antenna, therefore, there exists essentially a parallel ray beam. Although this description considers the antenna as a transmitting antenna, the same field configurations obtain when it is used as a receiving antenna.

**3.04** The lens shape cannot be seen because it is embedded in layer-built cubical piles of blocks called lens element assemblies. Eight of these, properly arranged in two piles, four high, comprise a complete lens. Within these assemblies, the plane front surface of the lens itself, instead of being vertical, is sloped backward to minimize the effect of reflection. Alternate layers of the metal strips comprising the lens are staggered forward and back of the true plane surface for the same reason.

**3.05** Over the mouth of the lens housing there is mounted a weather cover consisting of two 5' by 10' sheets of low-loss fiberglas which is sloped backward and to the right to minimize its contribution to troublesome reflections. Three horizontal cross members are provided across the mouth to provide additional support for the cover.

**3.06** The antenna assembly mounting is arranged as follows:

(a) The KS-5759, List 1 includes a front and rear base of hot-galvanized structural steel arranged to be anchored to the top of a tower or building by 5/8" diameter bolts, grounded to the metal work of the building for lightning protection. Two "signboard" type braces extend from the extreme upper rear corners of the lens housing to the rear base support. These braces relieve the stress in the antenna structure proper and provide reinforcement to withstand 55 pounds per square foot wind force in any direction.

(b) KS-5759, Lists 2, 4, and 5 include a base of hot-galvanized structural steel which is arranged for mounting in any direction of azimuth on the KS-5759, List 3 circular sub-base.

(c) The Lists 2 and 4 antenna assemblies are designed to withstand wind forces up to 55 pounds per square foot. The List 5 antenna up to 100 pounds per square foot.

**3.07** When positioning the antenna, the following precautions should be observed.

(a) Using the KS-5759, List 1, it is necessary to establish the roof plate positions by surveying methods in order to roughly align the entire structure in the desired direction. The plates are then bolted in position and the complete antenna secured to them, pointed in the predetermined direction.

(b) Using the KS-5759, List 2, 4, or 5, the KS-5759 List 3 circular sub-base may be mounted on the tower and the complete antenna then roughly pointed in any direction (azimuth) and secured to the sub-base.

(c) For final alignment, the direction of the KS-5759 Lists 1, 2, 4, or 5 antenna may be adjusted $\pm 3°$ in azimuth and $\pm 5°$ in elevation so that the antenna may be accurately aimed at the distant station. This is entirely independent of the rough adjustment in azimuth on the circular subbase.

**3.08** The lens housing and horn are constructed of sheet aluminum alloy with stiffeners.

**3.09** This antenna, including all screws, nuts and hardware (except roof bolts) is shipped to the erection site knocked down and packed in 17 boxes for List 1, 18 boxes for List 2, and 20 for Lists 4 and 5. The mounting base per List 3 is shipped as an assembled mounting ring with associated hardware packed in a (No. 1) box.

**3.10** Assembly and installation information are covered in Section 402-420-200. A copy of this section, an assembly drawing, and a packing list are included in box No. 9 of each antenna shipment for the use of the field crews.

**3.11** Over-all dimensions and mounting arrangements are covered on ED-63939-011 and -012. The horn is constructed with a waveguide flange, having 1/4"-20 threaded bolts at its throat to mate with a 2.290" by 1.145" waveguide flange. The weights of the complete units are approximately as follows:

| | |
|---|---|
| List 1 Antenna | 2200 lbs |
| List 2 Antenna | 2400 " |
| List 4 Antenna | 4000 " |
| List 5 Antenna | 3100 " |
| List 3 Mounting | 280 " |

## 4. TRANSMISSION CHARACTERISTICS

**4.01** The absolute gain of this antenna, which may be defined as the gain with respect to an isotropic radiator (point source), is 39.7 db at 4000 mc. A representative gain versus frequency characteristic curve is shown in Fig. 1. This curve shows measured absolute gain of the antenna over an isotropic radiator. The lens has been aligned to maximize the gain in approximately the center of the 3700 to 4200 mc frequency band.

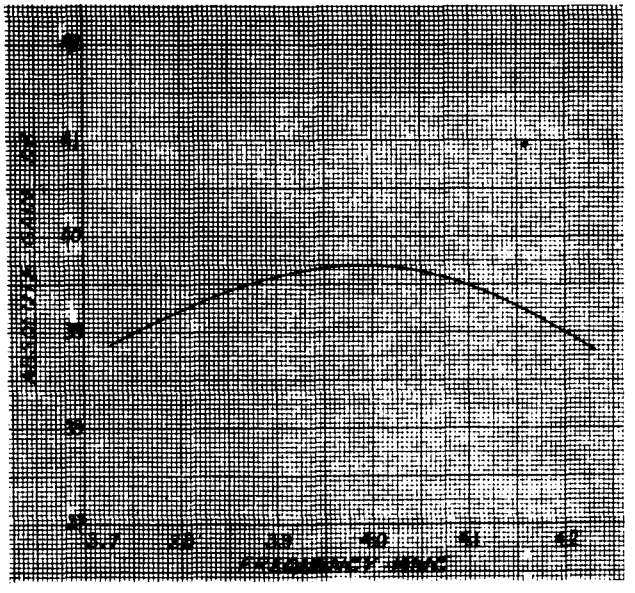

**Fig. 1 – Measured Absolute Gain Over Isotropic Radiator of KS-5759 Antenna**

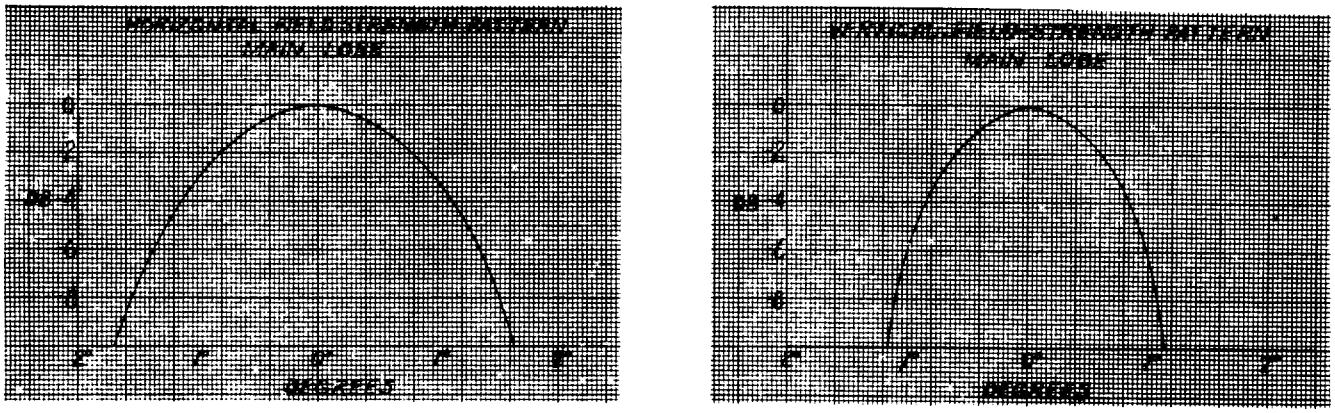

Fig. 2 – Field Strength Pattern of KS-5759 Antenna

**4.02** The shape of the main lobe in both the horizontal (magnetic) plane and vertical (electric) plane is shown on Fig. 2. At 4000 mc the width of the beam between 3-db points is 2.0° in the horizontal plane and 1.5° in the vertical plane. Fig. 3 shows the complete envelope or "maximum" response pattern of the antenna in both planes. The E-plane or vertical response is about 10 db higher than the horizontal over most of the pattern.

**4.03** Representative values of the voltage standing wave ratio that will exist in the flexible waveguide feeding the horn are shown on Fig. 4. The measurements were made using a standard iris, with pressure flange and 14 inches of rigid waveguide behind the horn.

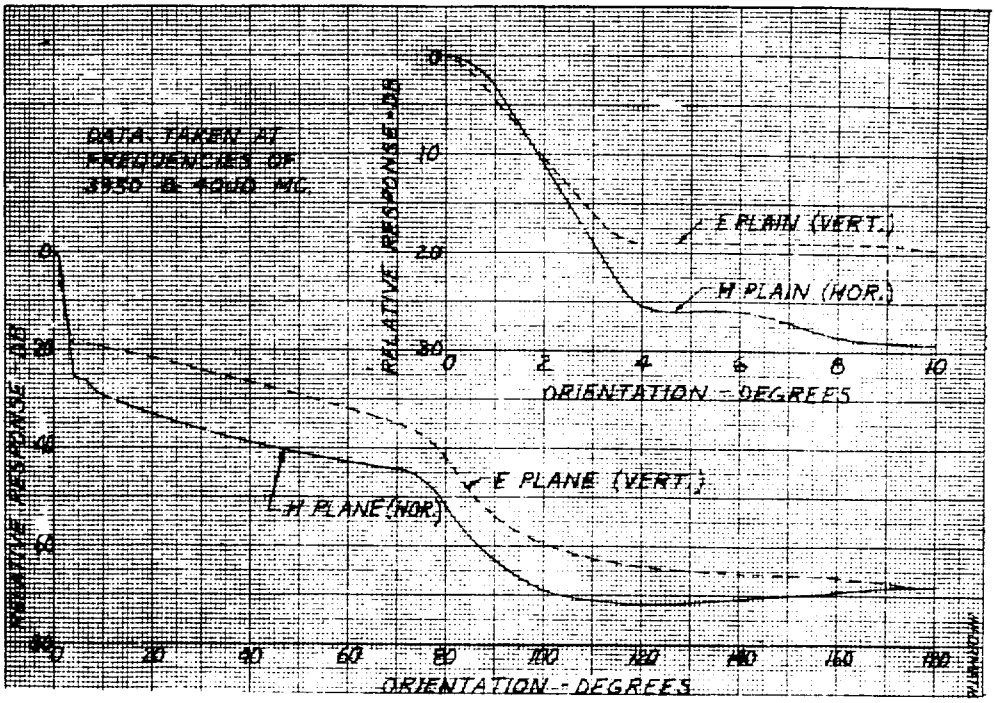


Fig. 3 – Maximum Response Curves for KS-5759 Antenna

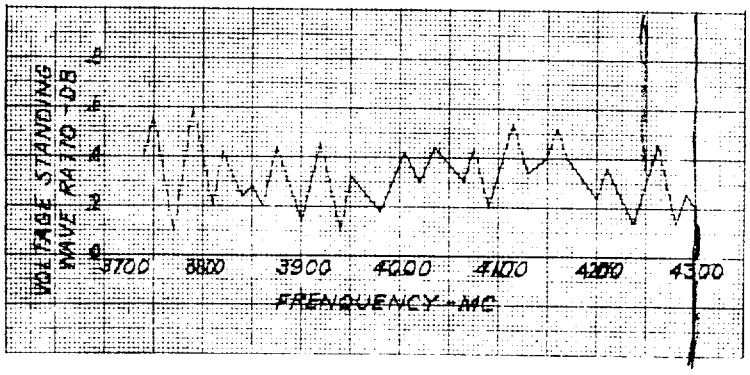


**Fig. 4 – Voltage Standing Wave Ratio**

**4.04** Representative transmission characteristics for the KS-5759 delay lens antenna are as follows:

(a) Absolute gain in forward direction: 38.0 db at 3700 mc; 39.7 db at 3900 mc; 39.0 db at 4200 mc

(b) Beam width at 4000 mc between 3 db points: 2.0 degrees in horizontal plane; 1.5 degrees in vertical plane

(c) Front to back ratio 68 db

(d) Electric field E vector vertical

## 5. KS-16784 HEATER-BLOWER DESCRIPTION

**5.01** In humid areas, and over an extended period of time, the polystyrene foam blocks absorb moisture. As this moisture content increases, the loss to the electromagnetic wave becomes considerable causing more than normal attenuation through the lens system. This, of course, has a direct effect on the path loss between stations, reducing the fade margin for the section.

**5.02** To reduce this moisture content, a KS-16784 Heater-Blower assembly has been provided. This assembly consists of three basic units, (1) the heater unit, (2) the blower unit, and (3) the filter unit. These are shown on drawing B-190072.

**5.03** The heater unit is a 6" x 6" x 6" metal box containing a power connector and a 660 watt heater mounted in a porcelain, Edison base, socket. The current through this heater is such as to raise the temperature only enough to make the heater coil glow a dull red. It is expected this heater coil will have a very long operating life. The heater unit attaches to the entrance port door of the antenna enclosure and is the support for the entire heater-blower assembly.

**5.04** The blower unit consists of a fractional horsepower, 115V, 60 cycle motor attached to a squirrel cage blower, all being enclosed in a metal case, generally cylindrical, 15" in diameter and 6" deep, with an air inlet from the filter unit and an outlet to the heater unit.

**5.05** The filter unit consists of a circular metal case, 15" in diameter and 8" deep, with a removable louvered cover on the intake side. The output side is arranged to be clamped to the input of the blower unit. Two spun glass circular filters, one spare, are provided. These filters can be cleaned locally and reused.

**5.06** The entrance port door to the antenna enclosure must be modified locally to accept the heater unit and provide an entrance for the warmed air from the heater-blower.

**5.07** The warmed air, under the force of the blower, raises the temperature and pressure slightly within the antenna and escapes through sundry small openings in the housing. Under normal or favorable weather conditions this warmed air will dehydrate the foam cells and remove excess moisture, the objective of the system. Under adverse weather conditions the amount of moisture deposited will be greatly reduced and will be removed as weather conditions improve.

## 6. PHOTOGRAPHS AND REFERENCES

### (A) Photographs



### (B) References

**5.02** The following are pertinent reference papers which may be consulted.

(1) ED-63939-011 and -012 — 10 by 10 Delay Lens Antenna.

(2) "Metallic Delay Lens" — The Bell System Technical Journal — January 1948.

(3) Section AA294.001 (J41610) — Antennas for Microwave Communication Systems.

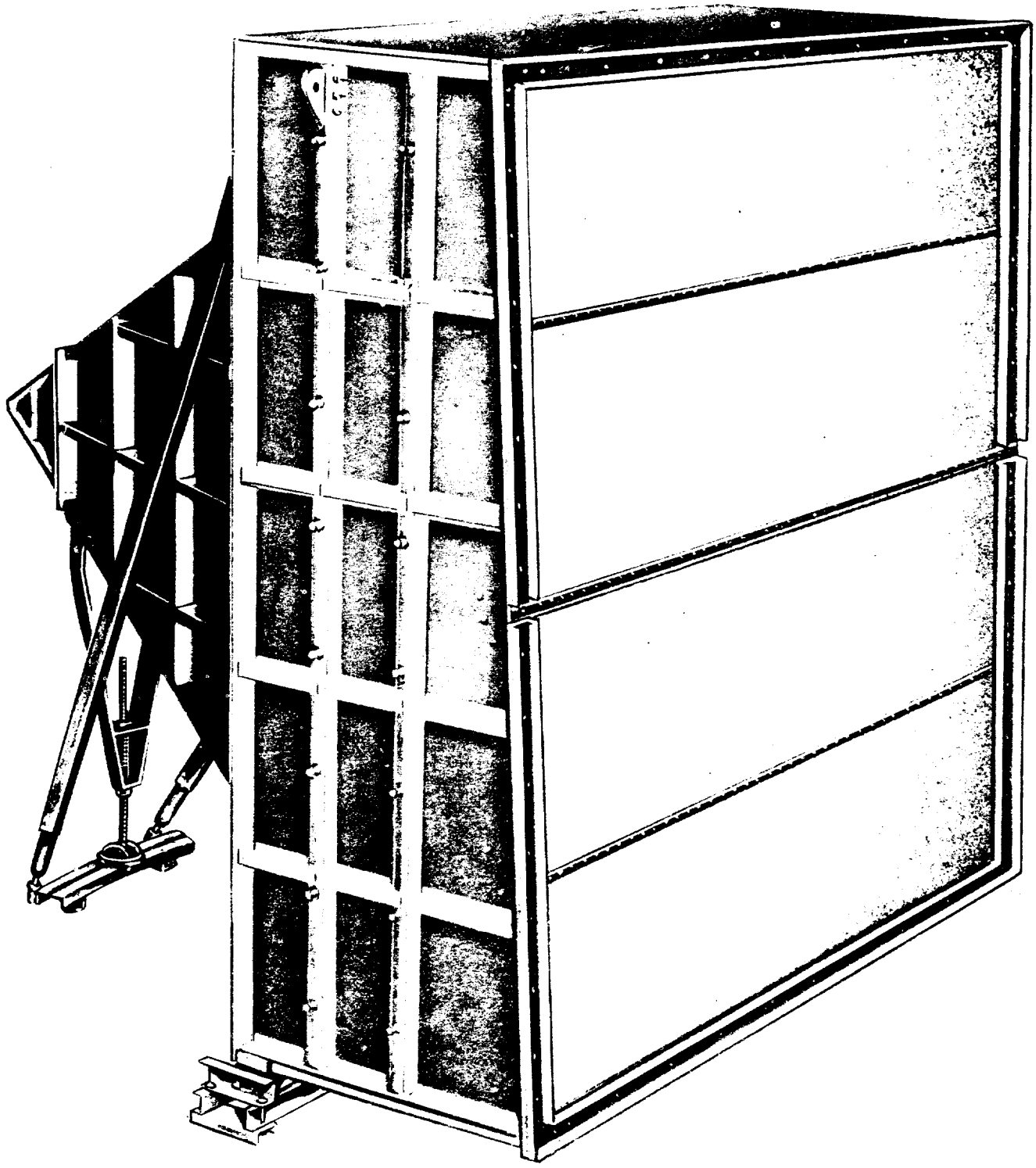

Photo A – KS-5759, List 1 Delay Lens Antenna — Complete Assembly

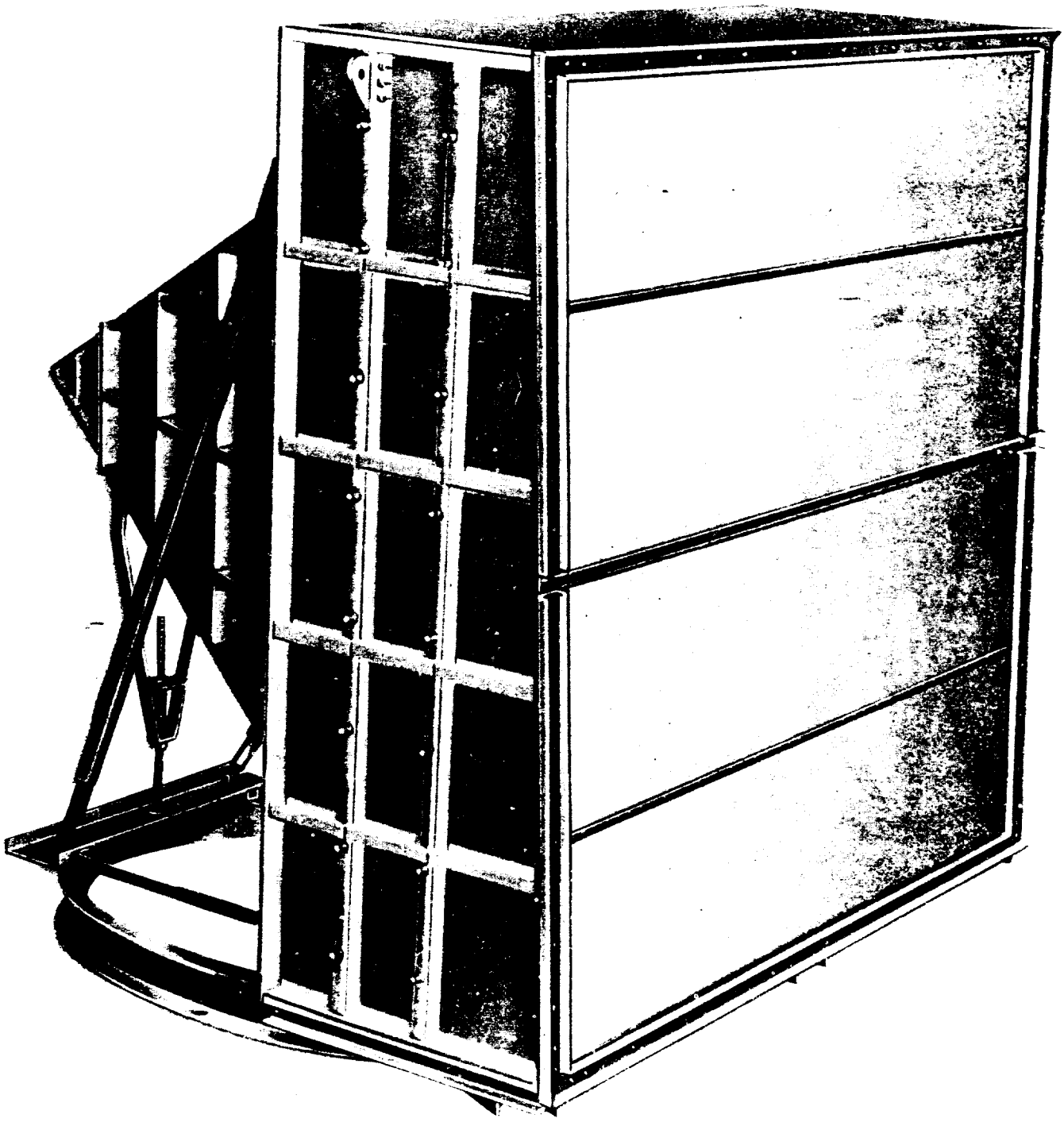

Photo B – KS-5759, List 2 Delay Lens Antenna
With KS-5759, List 3 Mounting Sub-base

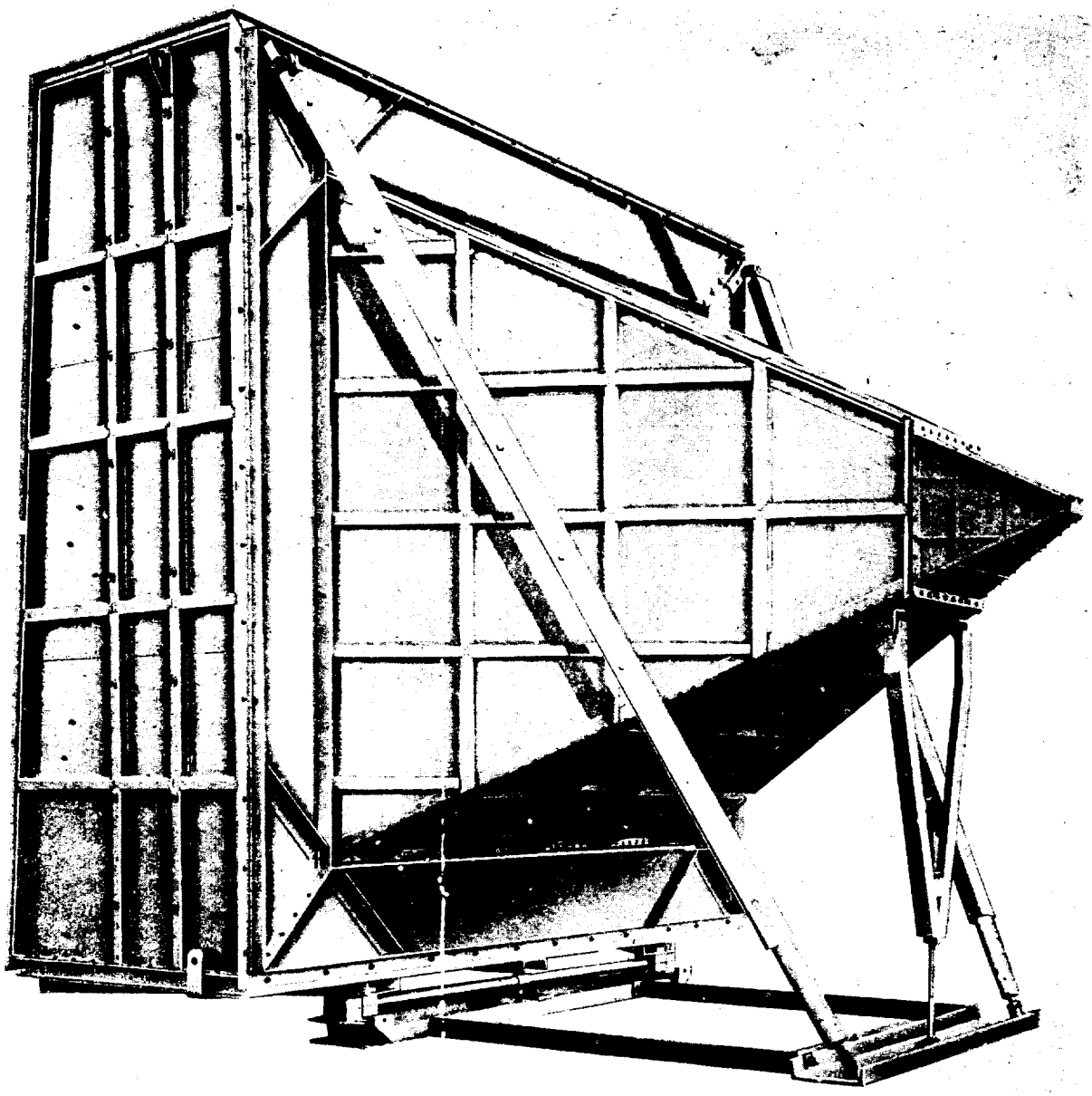

Photo C – KS-5759, List 4 Delay Lens Antenna — Complete Assembly