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LARK TELEMETERING ANTENNAS

NAVAL RESEARCH LABORATORY

WASHINGTON, D.C.

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LARK TELEMETERING ANTENNAS

E. N. Keith and D. H. Russell

Approved by:

Dr. R. M. Page, Superintendent, Radio Division III
Mr. F. M. Gager, Head, Special Research Section

Problem No. 36R05-30 20 November 1947

NAVAL RESEARCH LABORATORY
COMMODORE H. A. SCHADE, USN, DIRECTOR
WASHINGTON, D.C.

CONTENTS

ABSTRACT

This report sets forth three telemetering antenna systems for the new requirements of the Lark (KAQ-1) missile. One system provides two antennas in the 72 to 76 Mc band; the other systems provide either two antennas or a single antenna for operation in the 215 to 222 Mc band. Field patterns and standing-wave ratio are presented for all these systems.

PROBLEM STATUS

This report concludes the work on this problem, and unless otherwise advised by the Bureau, the problem will be closed one month from the mailing date of this report.

LARK TELEMETERING ANTENNAS

INTRODUCTION

The more recent telemetering requirements of the Lark Missile (KAQ-1) necessitate a change from the original 72 to 76 Mc single half-wave antenna to two independent quarter-wave antennas so that the missile will transmit all the required information. The telemetering equipment is also being modified for operation in the 215 to 222 Mc band because the former 72 to 76 Mc band may be closed to this type of operation in the near future.

This report shows modifications and development work which sets forth three new antenna facilities. The 72 to 76 modification results in two quarter-wave antennas for two-channel use. One 215 to 222 Mc modification has two quarter-wave antennas suitable for two-channel use in this frequency range. Another 215 to 222 Mc modification allows operation of the two quarter-wave antennas as an equivalent single half-wave.

The work herein reported was accomplished in accordance with a request of the Bureau of Aeronautics.* A history of the original Lark (KAQ-1) telemetering antenna was published by Electronics Research, Inc.†

MODIFICATION PROVIDING TWO ANTENNAS IN THE 72 TO 76 Mc BAND

The use of coaxial cable and standard connectors is preferable to the open-wire line, used heretofore, because interaction between circuits is reduced and more flexibility obtained. Figures 1 and 2 show details of the connections from RG-58U feeder cables to two independent quarter-wave antennas which replace the original single half-wave antenna. Sufficient wire and tailfin material were removed from the fin bases to allow placement of a standard type BN receptacle (UG-87U) within the base of each fin. These receptacles were secured by four wood screws. Next, through an access port cut into the side of each fin, the antennas were sweated to the receptacle center-pins. The lower left and upper right fins were modified identically. The tailfins were secured to the Lark in the standard way with the addition of phosphor-bronze contact washers to insure low impedance paths between the cable braids and the cleaned metal fuselage.

MODIFICATION PROVIDING TWO ANTENNAS IN THE 215 TO 222 Mc BAND

This system consists of a modification of the arrangement shown in Figures 1 and 2 for 215 to 222 Mc operation. A quarter-wave antenna length at 218.5 Mc in free-space

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* Establishment of BuAer project at NRL, request for; BuAer ltr. Aer-EL-73, F42-10/67, Serial 04266 dated June 5, 1947, Project No. NRL EL7-A-314, P.O. 129-47 (Confidential)

† Report N-102, by Electronics Research, Inc., Kees, H. et al.,Final Tests on Fairchild Lark Antenna, 10 June 1947 (Confidential)

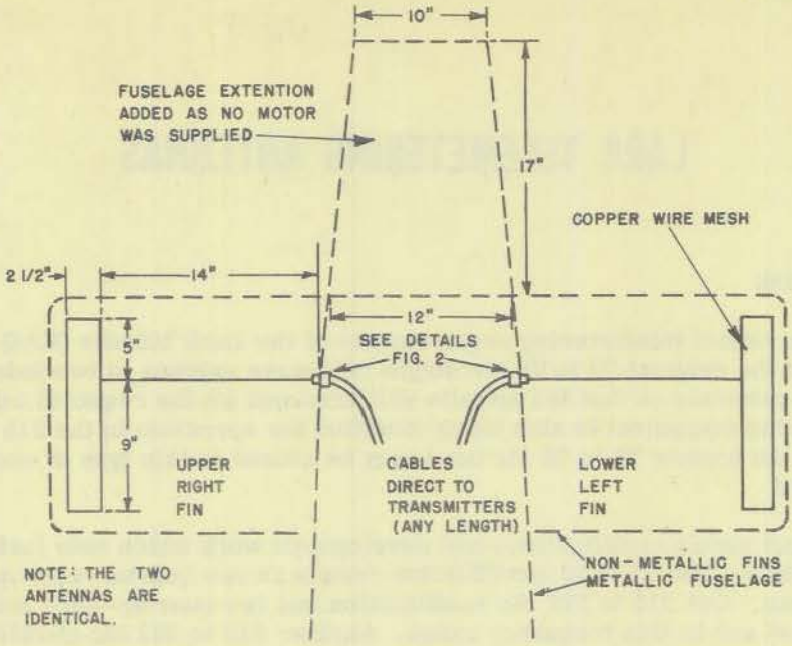

Fig. 1 - Method of Feeding Radiators Separately as Single-Fin Antennas. (This Method of Feed Applies to Both 72 to 76 Mc and 215 to 222 Mc Bands.)

medium is 12.6 inches. Considerable development and measurement work was necessary to determine the correct length of 11.0 inches for this application. It is apparent that the effect of the Lark fuselage and the dielectric fin surrounding the antennas, therefore, was to shorten the neccessary lengths of the resonant radiators. The 11.0-inch length was determined by the voltage standing-wave ratio vs frequency measurements while decreasing the length parameter by 1/16 inch decrements. The cable connections remained as shown in Figures 1 and 2 to provide two separate radiators.

MODIFICATION PROVIDING A SINGLE HALF-WAVE ANTENNA IN THE 215 TO 222 Mc BAND

The previous quarter-wave separate radiators were connected for half-wave operation from a single transmitter by means of a Type-N adapter tee (UG-28U), three Type-N plugs (UG-188U), and other auxiliaries. (See Figure 3.)

An impedance transformer was built to match each quarter-wave antenna to the line at the tee junction. Each antenna branch is approximately 50 ohms and must be transformed to appear approximately 100 ohms at the tee so that the two antenna branches in parallel present approximately 53 ohms to the 53-ohm transmitter cable. These transformations are accomplished by placing a nine-inch quarter-wave transforming section in series with each branch. This is a convenient method when RG-59U cable is used because it's 73-ohm characteristic impedance is approximately the geometric mean value of 50 and 100.

Complete addition of radiated energy to the rear of the Lark missile was accomplished by feeding the antenna branches 180° out-of-phase by use of an eighteen-inch

half-wave delay line placed in series with only one antenna branch. (See Figure 3.)

STANDING WAVE RATIO MEASUREMENTS

These measurements, shown in Figures 4, 19, and 20, were conducted with the Lark in flight position, mounted,with provision for roll and horizontal rotation, on a wooden framework eight feet above a non-metallic roof. A metal section was mounted upon the tail to simulate the motor compartment. A twelve-foot square screen was placed vertically at the nose of the bird to shield personnel and equipment from the antenna field.

Equipment included Measurements Corp. Model 80 Signal Generator Serial 481, r.f. filters, TS-323 Frequency Meter Serial 55, 50-ohm Precision Slotted Line Serial 19, and APR-1 Receiver Serial 374 calibrated as a detector. A 13-ft section of 52-ohm cable was used between the load and the slotted line.

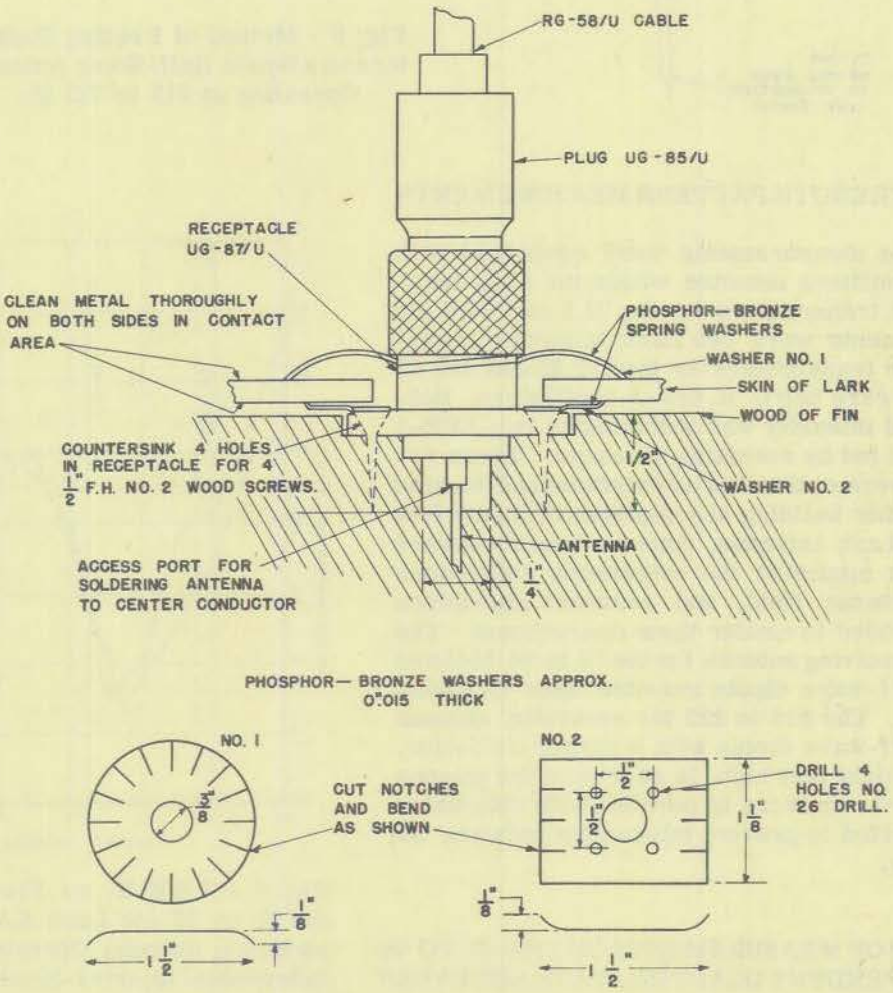

Fig. 2 - Details of Connection from a Feed Cable to a Radiator. (This Connection Applies to Both Bands.)

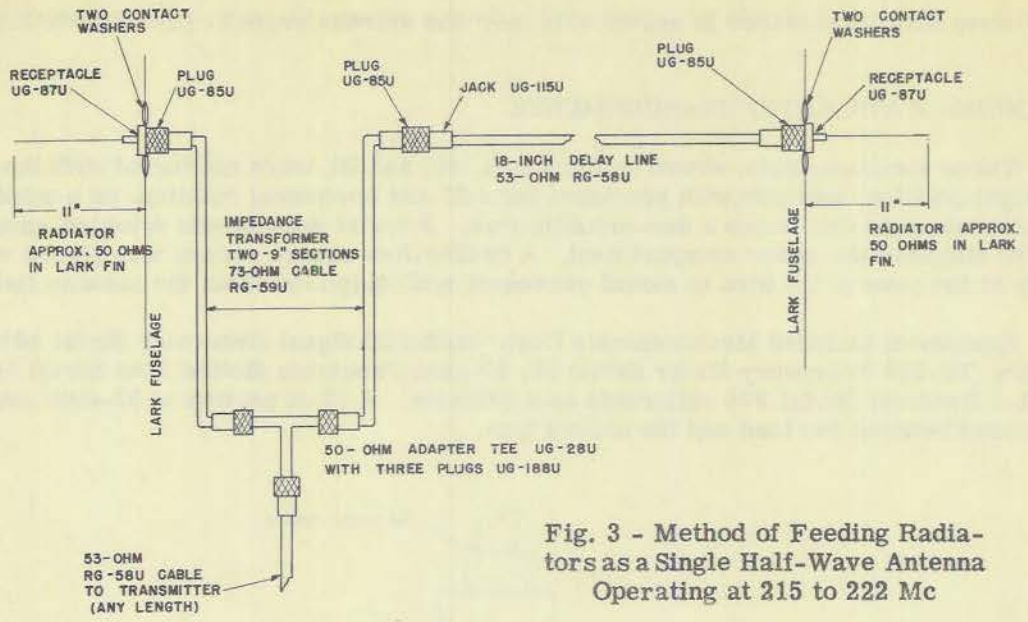

Fig. 3 - Method of Feeding Radiators as a Single Half-Wave Antenna Operating at 215 to 222 Mc

FIELD STRENGTH PATTERN MEASUREMENTS

These measurements were conducted with two transmitters mounted within the Lark fuselage. The transmitters for the 72.5 and 75.5 Mc measurements were two Lark telemeter oscillators; the transmitters for the 217.55 and 219.45 Mc tests were two G. R. 857-A oscillators. Relative field intensity was indicated by two APR-1 receivers fed by receiving antennas. These receivers were calibrated as detectors and located upon another building at a distance of ninety feet from the Lark antennas. Antenna locations were chosen to minimize the extraneous reflections in the antenna field, and resonant standpipes were shielded to render them nonresonant. The APR-1 receiving antenna for the 72 to 76 Mc band was a half-wave dipole mounted upon an eight-foot pole. The 215 to 222 Mc receiving antenna was a half-wave dipole with a corner-reflector, mounted eight feet high. In each case the antenna fed the two receivers in parallel with attenuator pads inserted to prevent interaction between the receivers.

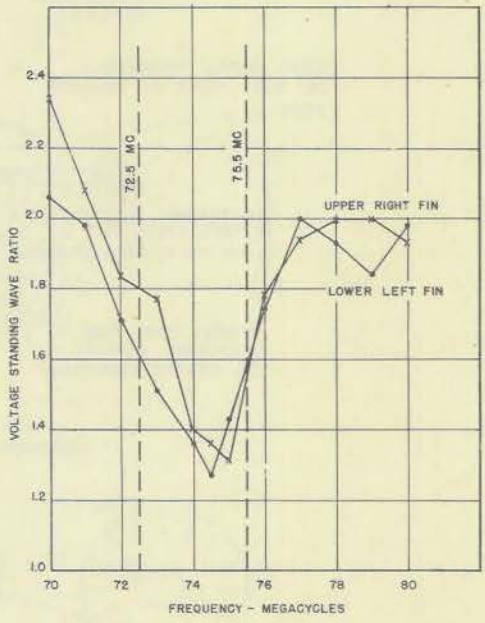

Fig. 4 - V.S.W.R. vs Frequency for the 72 to 76 Mc Lark KAQ-1 Telemetering Antenna Operated as Two Independent Quarter-Wave Antennas, Measured on 50-ohm Slotted Section Through 13 Feet of 52-ohm Cable

RESULTS OF MEASUREMENTS ON THE 72 TO 76 Mc INDEPENDENT QUARTER-WAVE ANTENNAS

Figure 4 shows good bandwidth and impedance matching for the subject antennas connected

as in Figures 1 and 2. This installation eliminates the transformer and two tuning condensers used heretofore, and thereby gives greater bandwidth.

Figures 5 through 18 show radiation patterns for simultaneous operation of the subject antennas with 72.5 Mc on one radiator and 75.5 Mc on the other. Patterns are shown for the receiving dipole vertical and horizontal, and for the Lark telemeter fins vertical, horizontal, and in flight position. The Lark wings act as reflectors in all cases and give excellent coverage to the rear.

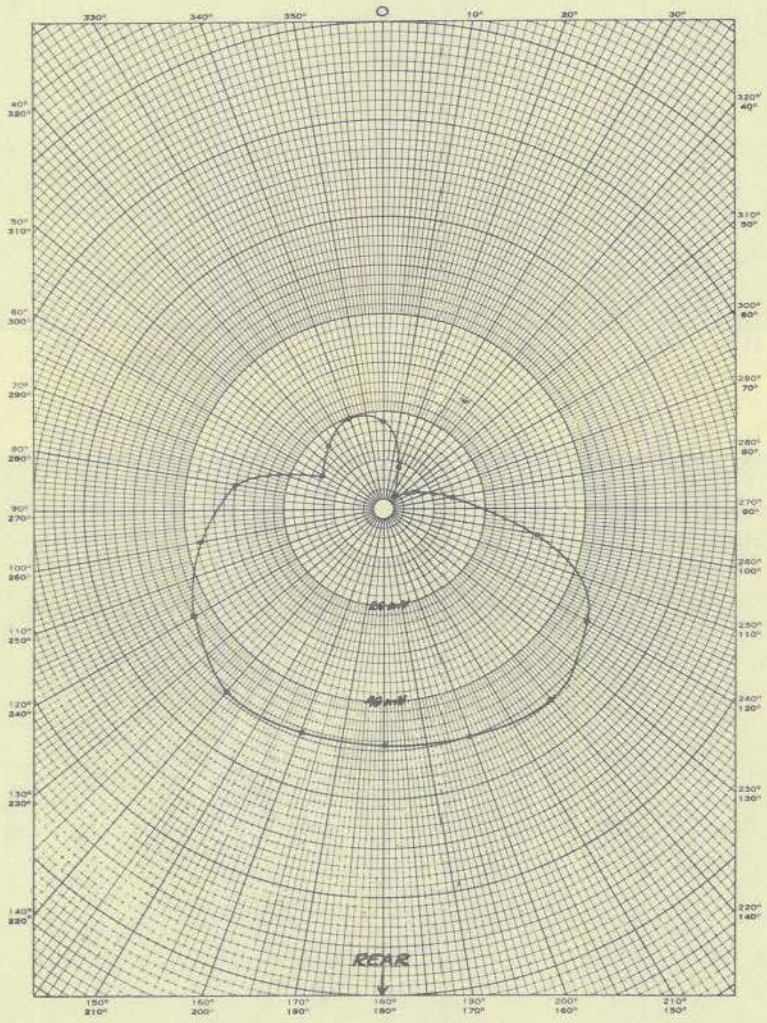

Fig. 5 - Horizontal Antenna Pattern of Lark in Flight Position; 75.5 Mc Fed to Upper Right Fin (72.5 Mc Simultaneously Fed to Lower Left Fin); Receiving Dipole Vertical

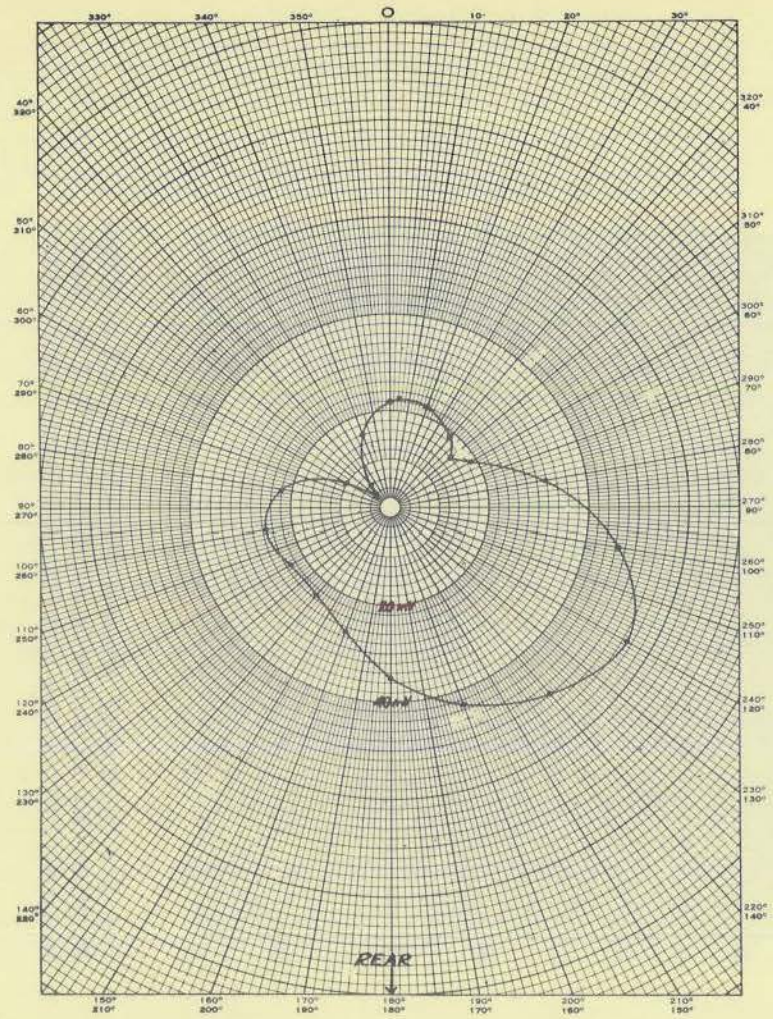

Fig. 6 - Horizontal Antenna Pattern of Lark in Flight Position; 75.5 Mc Fed to Lower Left Fin (72.5 Mc Simultaneously Fed to Upper Right Fin); Receiving Dipole Vertical

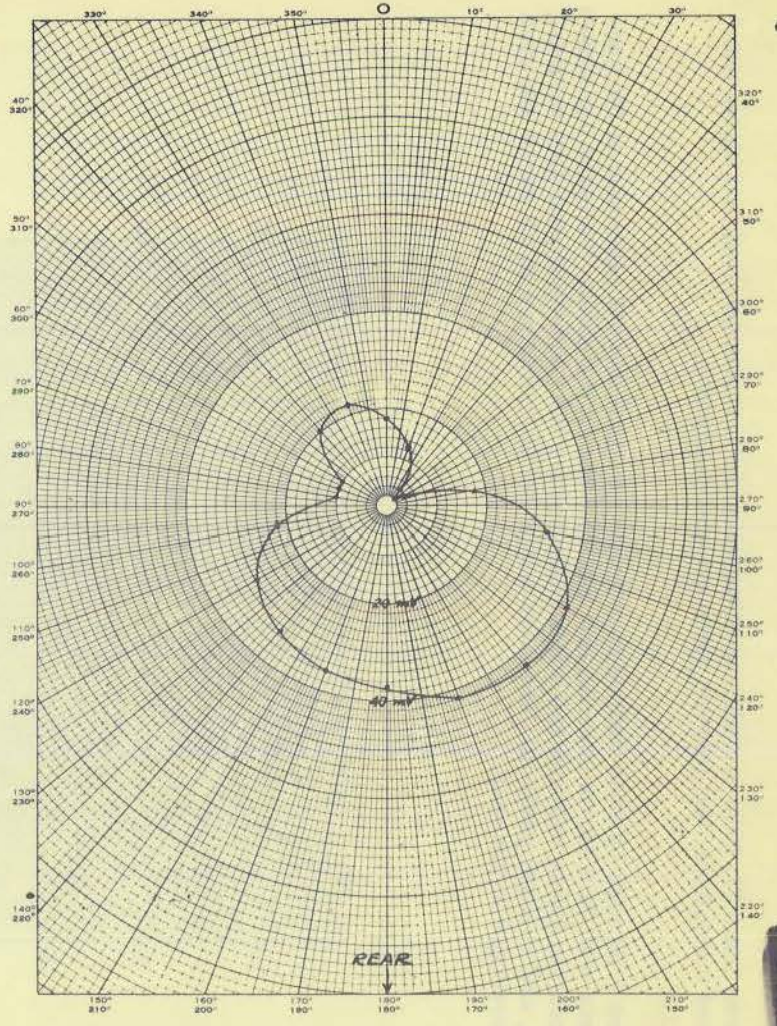

Fig. 7 - Horizontal Antenna Pattern of Lark in Flight Position; 72.5 Mc Fed to Upper Right Fin (75.5 Mc Simultaneously Fed to Lower Left Fin); Receiving Dipole Vertical

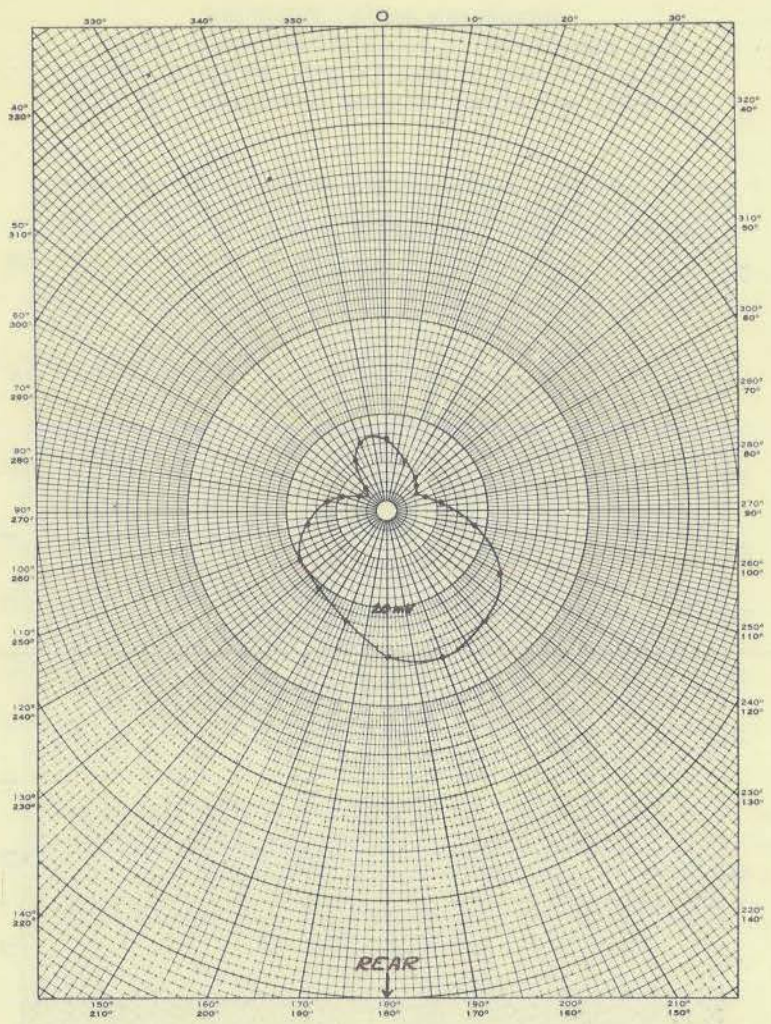

Fig. 8 - Horizontal Antenna Pattern of Lark in Flight Position; 72.5 Mc Fed to Lower Left Fin (75.5 Mc Simultaneously Fed to Upper Right Fin); Receiving Dipole Vertical

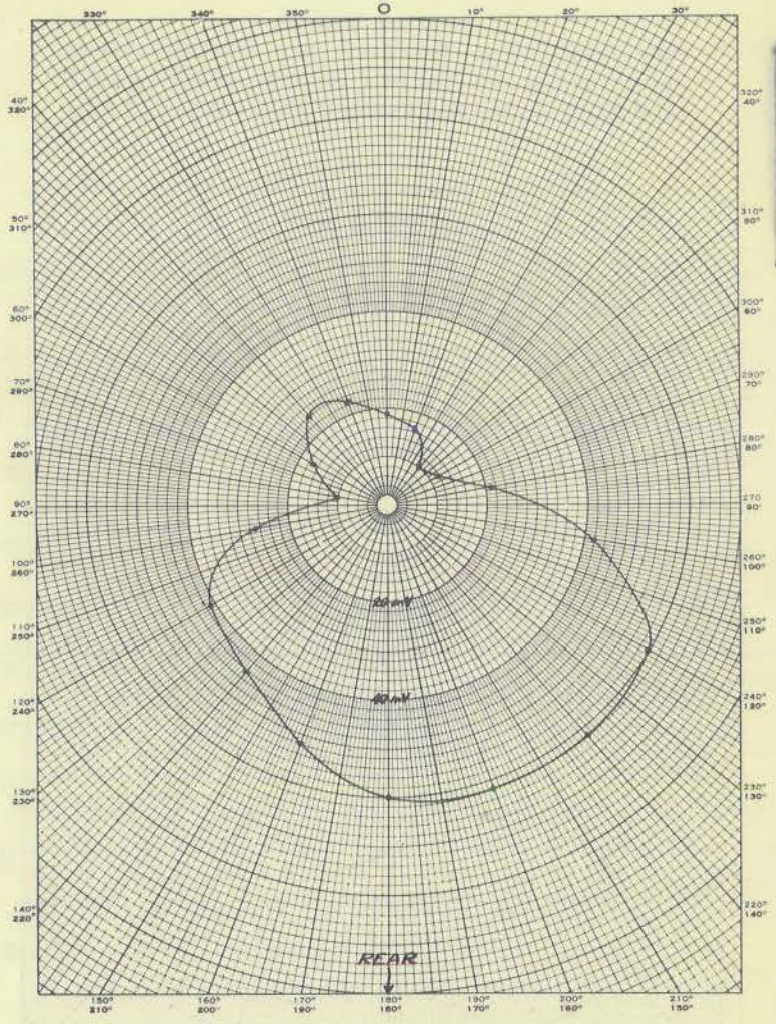

Fig. 9 - Horizontal Antenna Pattern of Lark in Flight Position; 72.5 Mc Fed to Upper Right Fin (75.5 Mc Simultaneously Fed to Lower Left Fin); Receiving Dipole Horizontal

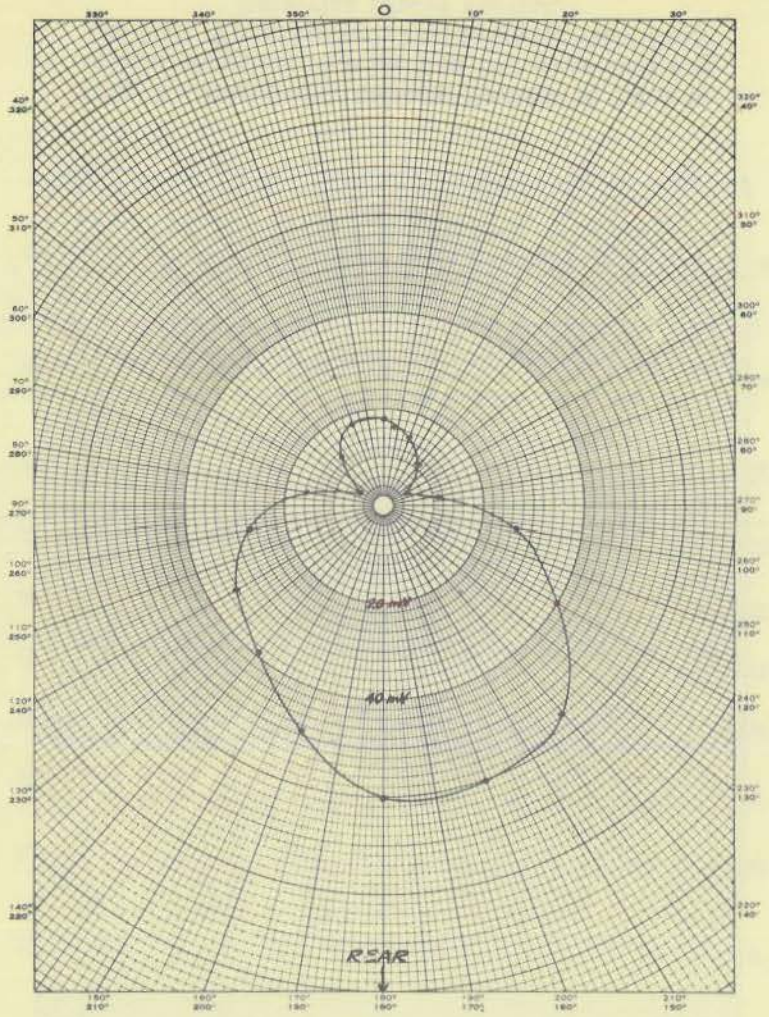

Fig. 10 - Horizontal Antenna Pattern of Lark in Flight Position; 72.5 Mc Fed to Lower Left Fin (75.5 Mc Simultaneously Fed to Upper Right Fin); Receiving Dipole Horizontal

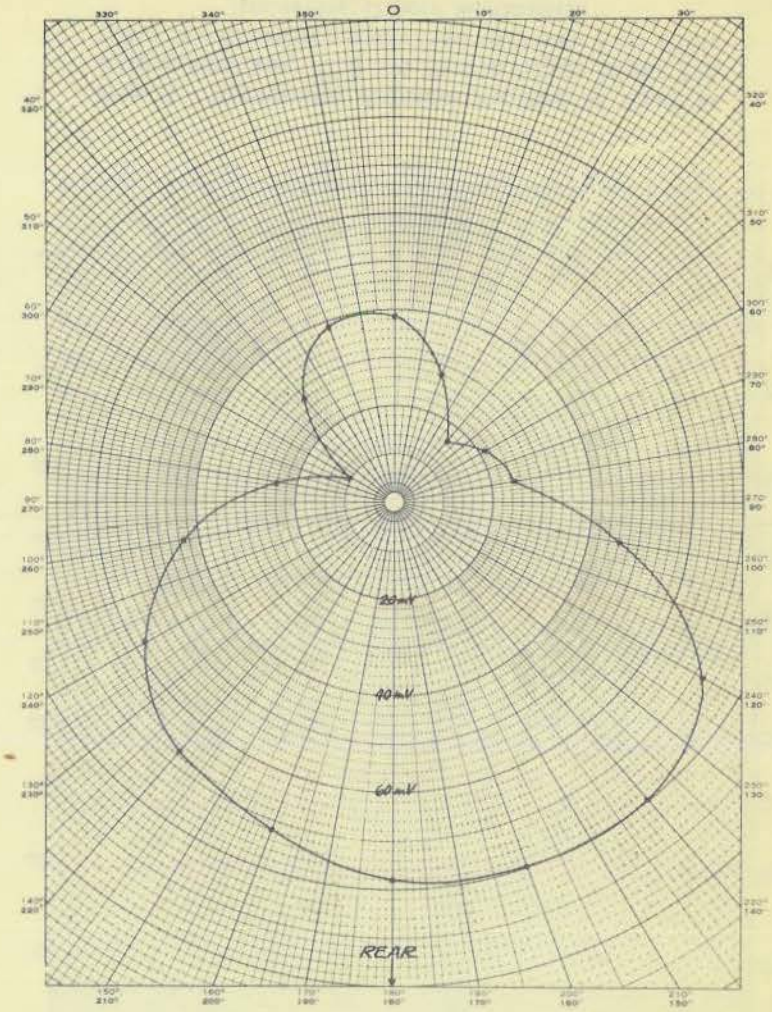

Fig. 11 - Horizontal Antenna Pattern of Lark with Fins Vertical; 75.5 Mc Fed to Upper Fin (72.5 Mc Simultaneously Fed to Lower Fin); Receiving Dipole Vertical

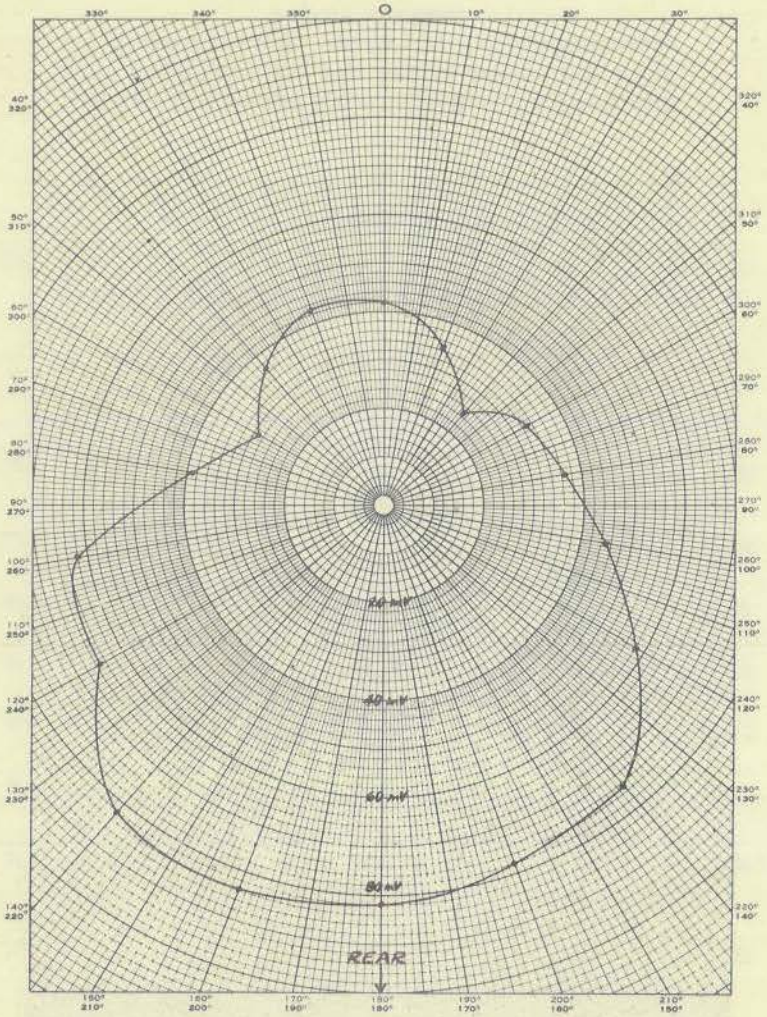

Fig. 12 - Horizontal Antenna Pattern of Lark with Fins Vertical; 75.5 Mc Fed to Lower Fin (72.5 Mc Simultaneously Fed to Upper Fin); Receiving Dipole Vertical

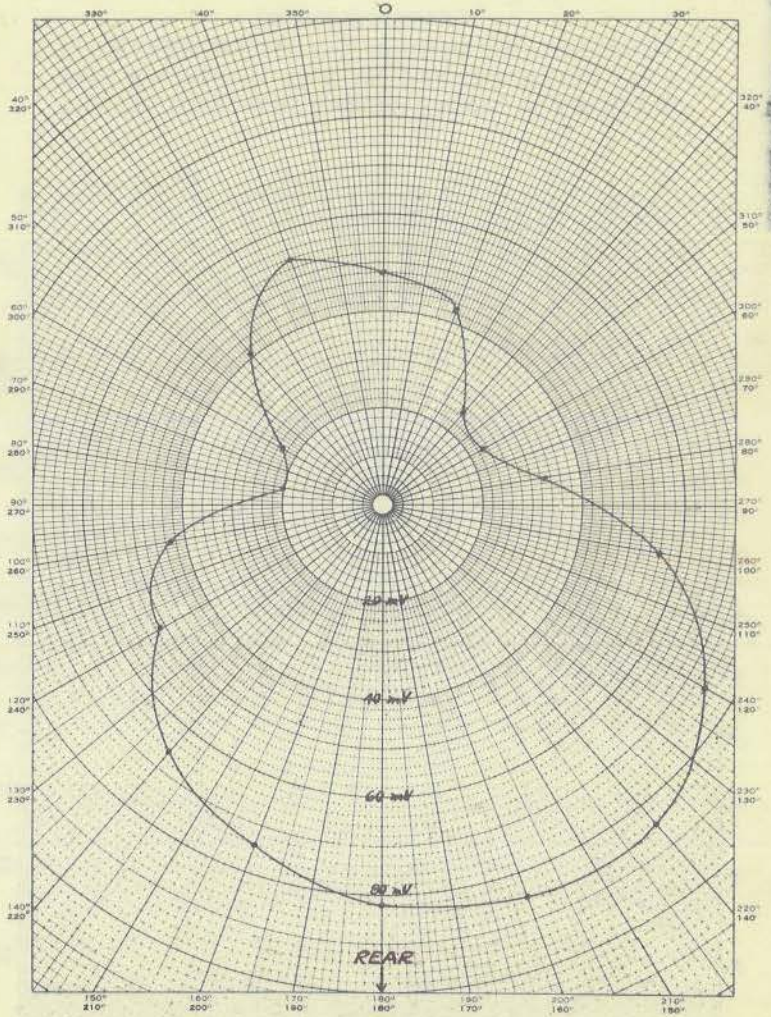

Fig. 13 - Horizontal Antenna Pattern of Lark with Fins Vertical; 72.5 Mc Fed to Upper Fin (75.5 Mc Simultaneously Fed to Lower Fin); Receiving Dipole Vertical

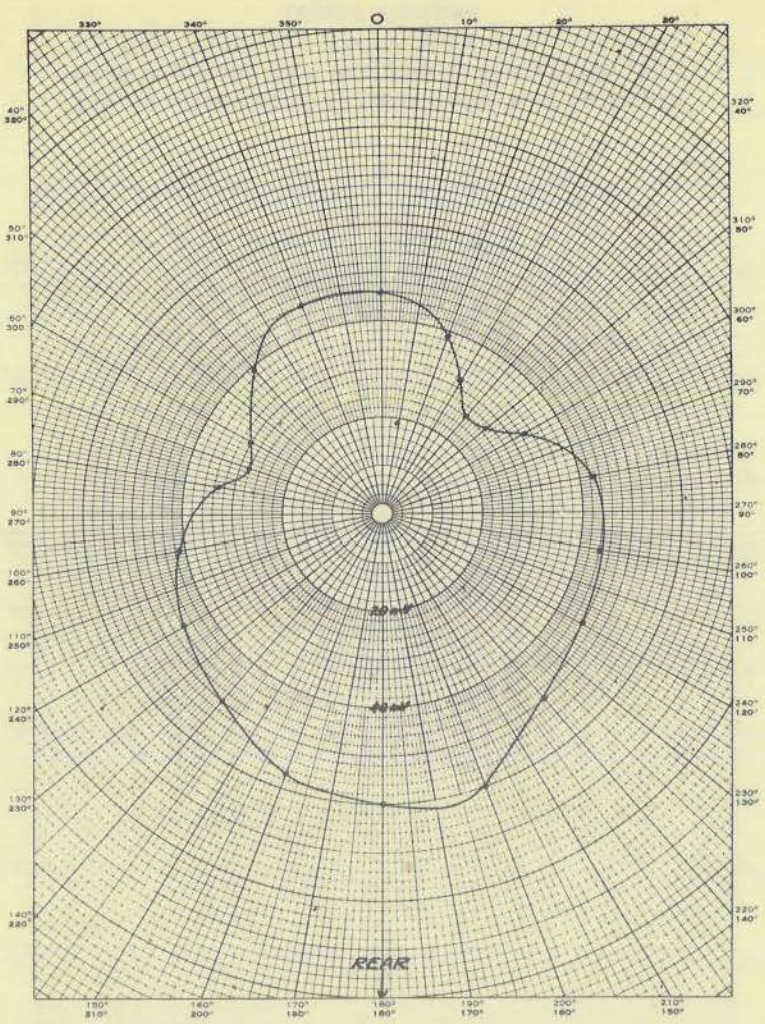

Fig. 14 - Horizontal Antenna Pattern of Lark with Fins Vertical; 72.5 Mc Fed to Lower Fin (75.5 Mc Simultaneously Fed to Upper Fin); Receiving Dipole Vertical

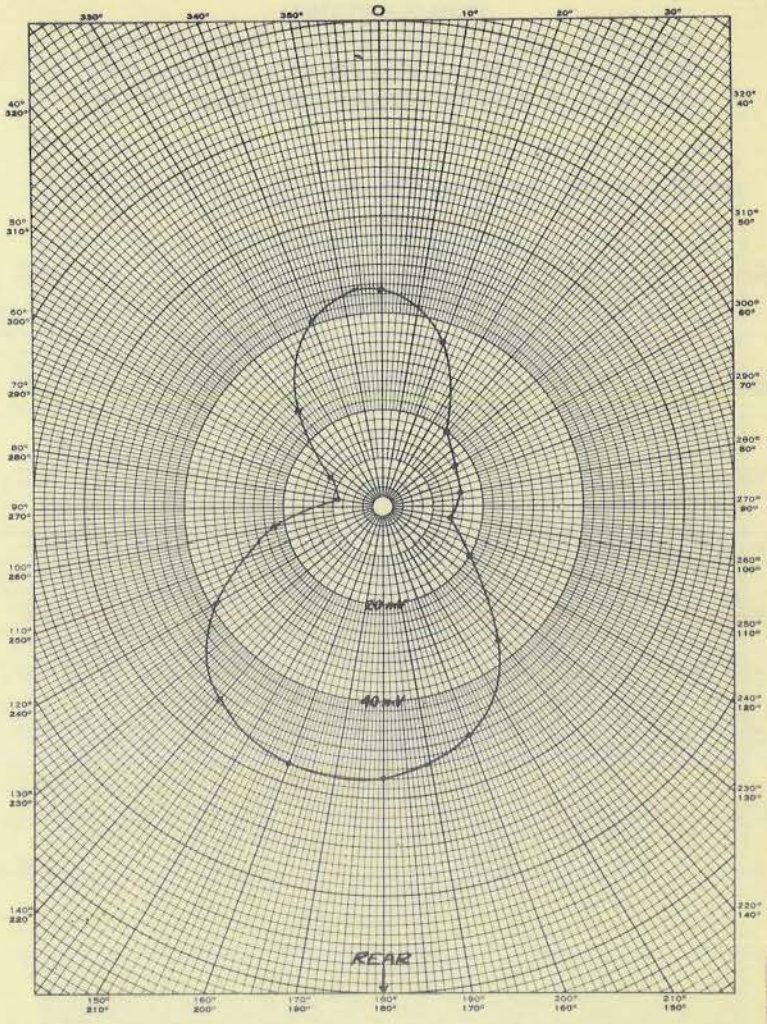

Fig. 15 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 75.5 Mc Fed to Left Fin (72.5 Mc Simultaneously Fed to Right Fin); Receiving Dipole Horizontal

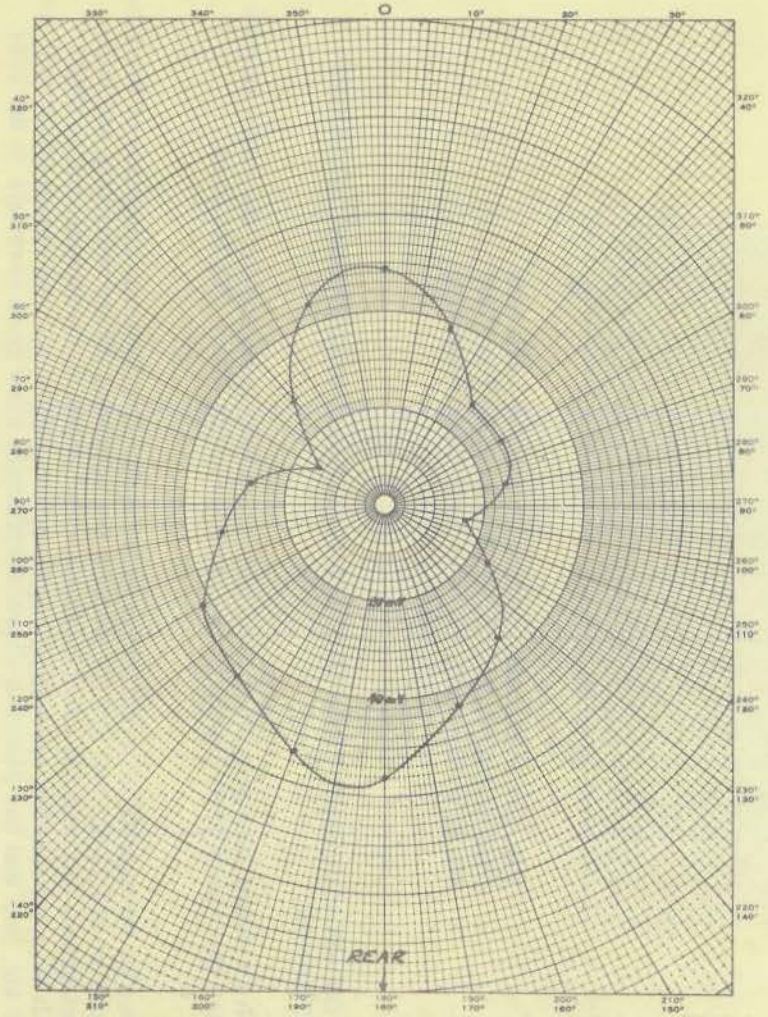

Fig. 16 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 75.5 Mc Fed to Right Fin (72.5 Mc Simultaneously Fed to Left Fin); Receiving Dipole Horizontal

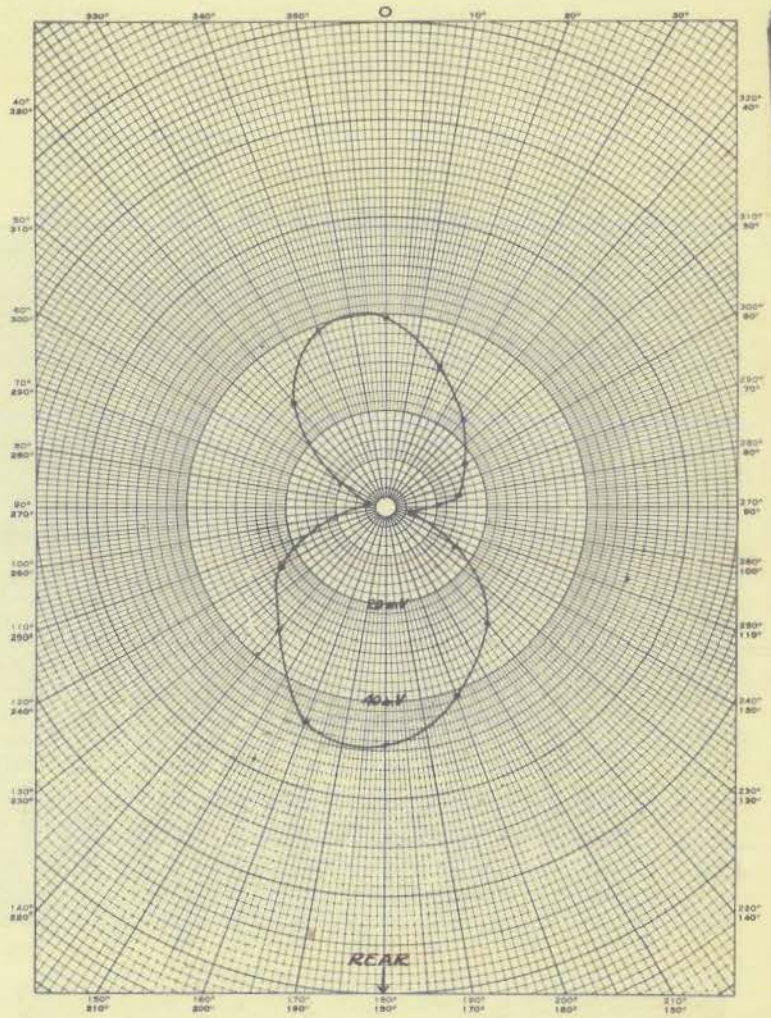

Fig. 17 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 72.5 Mc Fed to Left Fin (75.5 Mc Simultaneously Fed to Right Fin); Receiving Dipole Horizontal

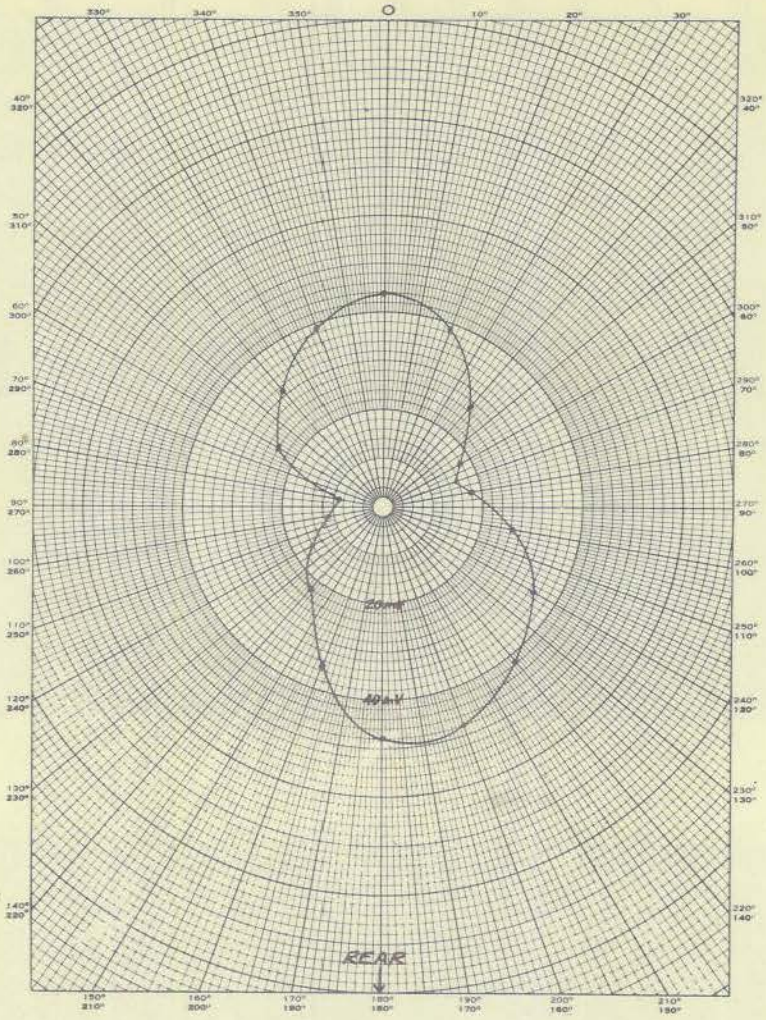

Fig. 18 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 75.5 Mc Fed to Right Fin (75.5 Mc Simultaneously Fed to Left Fin); Receiving Dipole Horizontal

RESULTS OF MEASUREMENTS ON THE 215 TO 222 Mc INDEPENDENT QUARTER-WAVE ANTENNAS

Figure 19 shows very good bandwidth and impedance matching for the above antenna system after the radiators had been cut to resonate in the 217 to 222 Mc band.

Figures 20 through 29 show radiation patterns for simultaneous operation of the subject antennas at 217.55 Mc and 219.45 Mc with the receiving dipole vertically and horizontally polarized, and with the Lark telemeter fins vertical, horizontal, and in flight position. It is noted that the Lark wings again act as reflectors, but not so effectively as at 72 to 76 Mc, and that the patterns characteristically show good coverage to the rear.

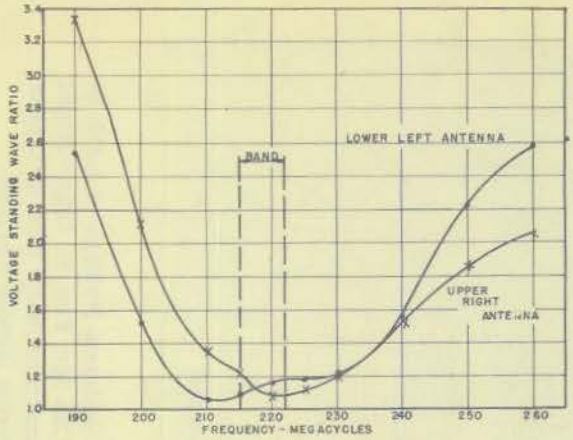

Fig. 19 - V.S.W.R. vs Frequency for the Lark KAQ-1 Telemetering Antenna Modified for Operation in the Range 215 to 222 Mc as Two Independent Quarter-Wave Antennas; Measured on 50-ohm Slotted Section Through 13 Feet of 52-ohm Cable

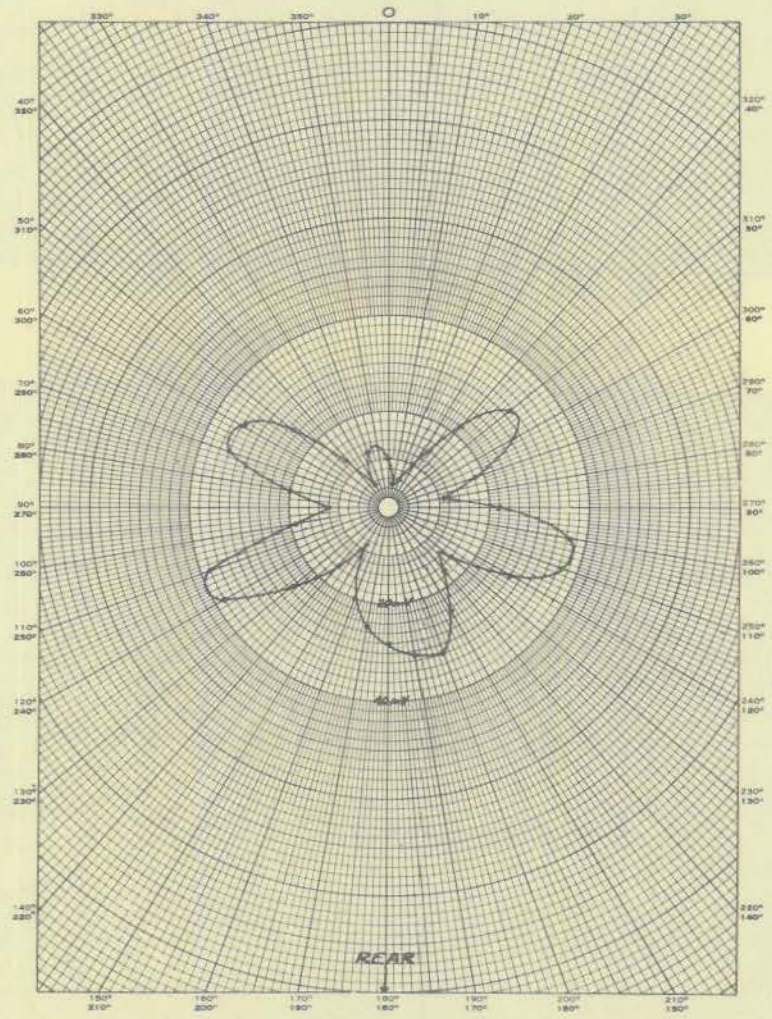

Fig. 20 - Horizontal Antenna Pattern of Lark in Flight Position; 219.45 Mc Fed to Upper Right Fin (217.55 Mc Simultaneously Fed to Lower Left Fin); Receiving Dipole Vertical

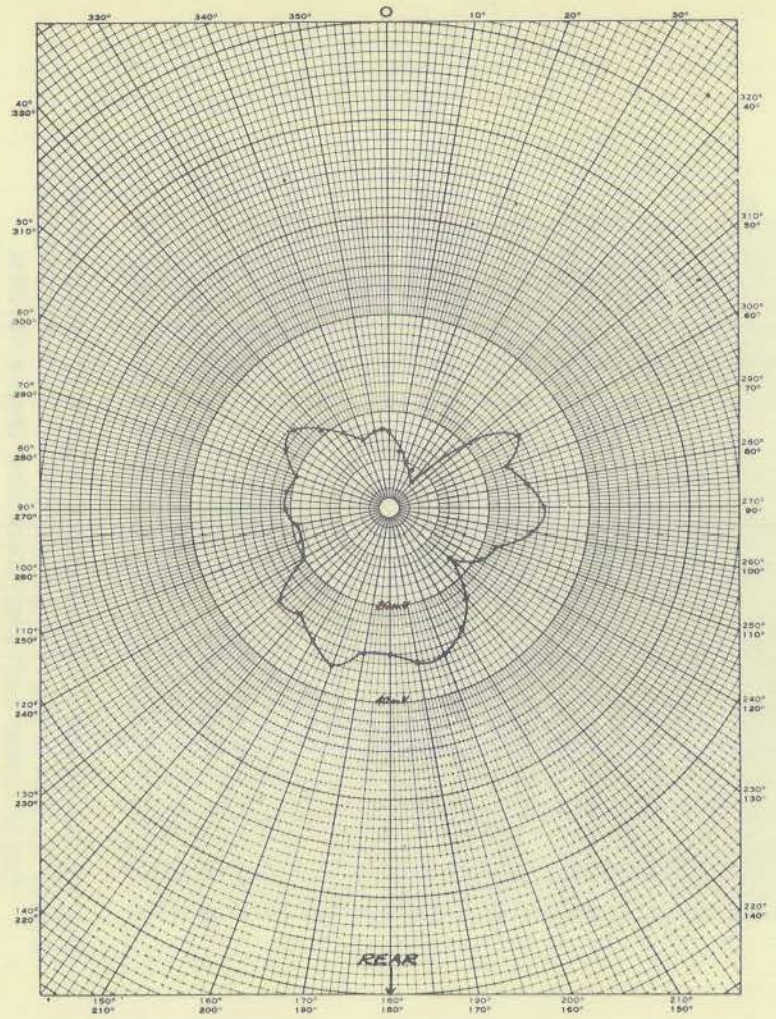

Fig. 21 - Horizontal Antenna Pattern of Lark in Flight Position; 219.45 Mc Fed to Lower Left Fin (217.55 Mc Simultaneously Fed to Upper Right Fin); Receiving Dipole Vertical

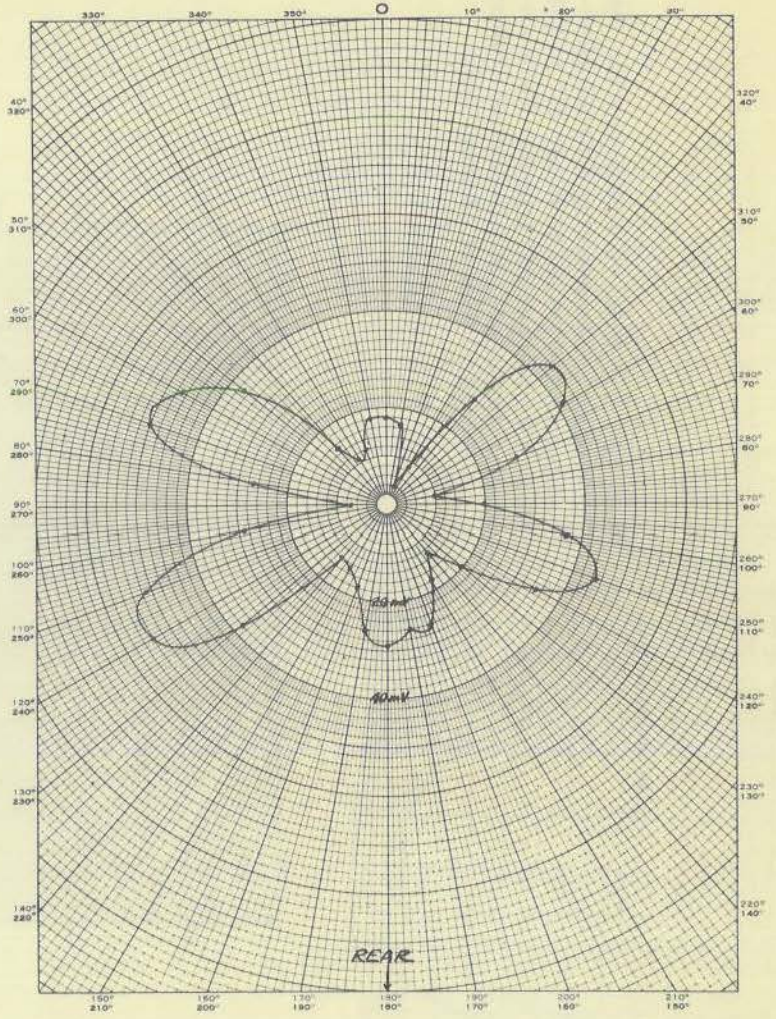

Fig. 22 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Upper Right Fin (219.45 Mc Simultaneously Fed to Lower Left Fin); Receiving Dipole Vertical

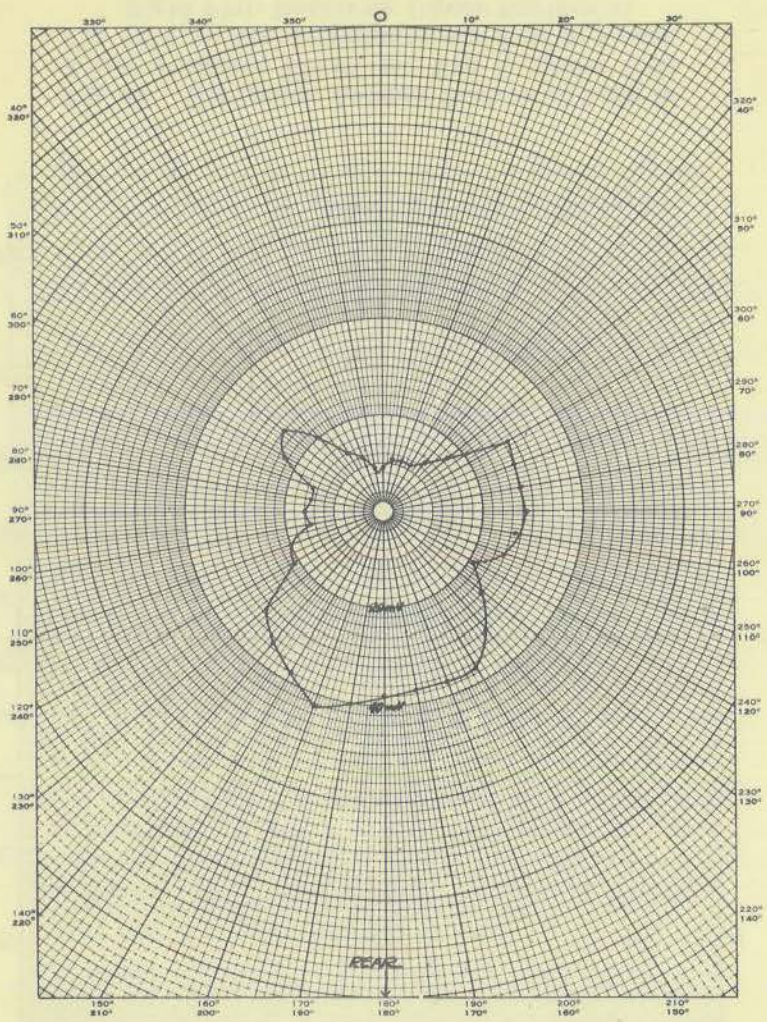

Fig. 23 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Lower Left Fin (219.45 Mc Simultaneously Fed to Upper Right Fin); Receiving Dipole Vertical

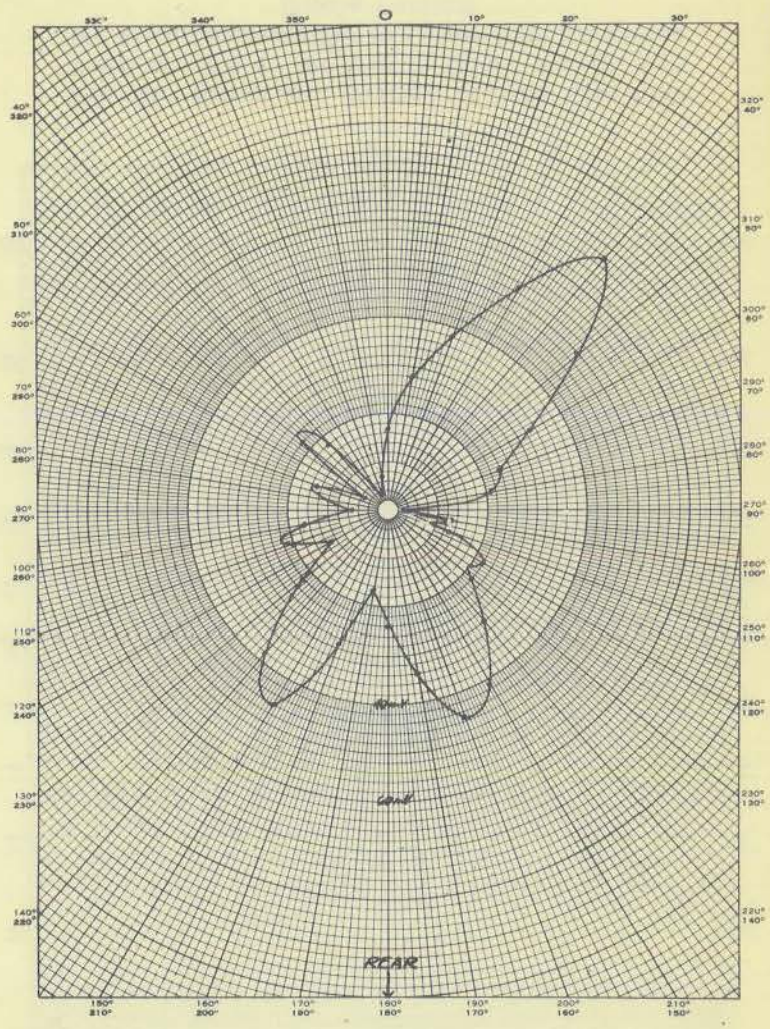

Fig. 24 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Upper Right Fin (219.45 Mc Simultaneously Fed to Lower Left Fin); Receiving Dipole Horizontal

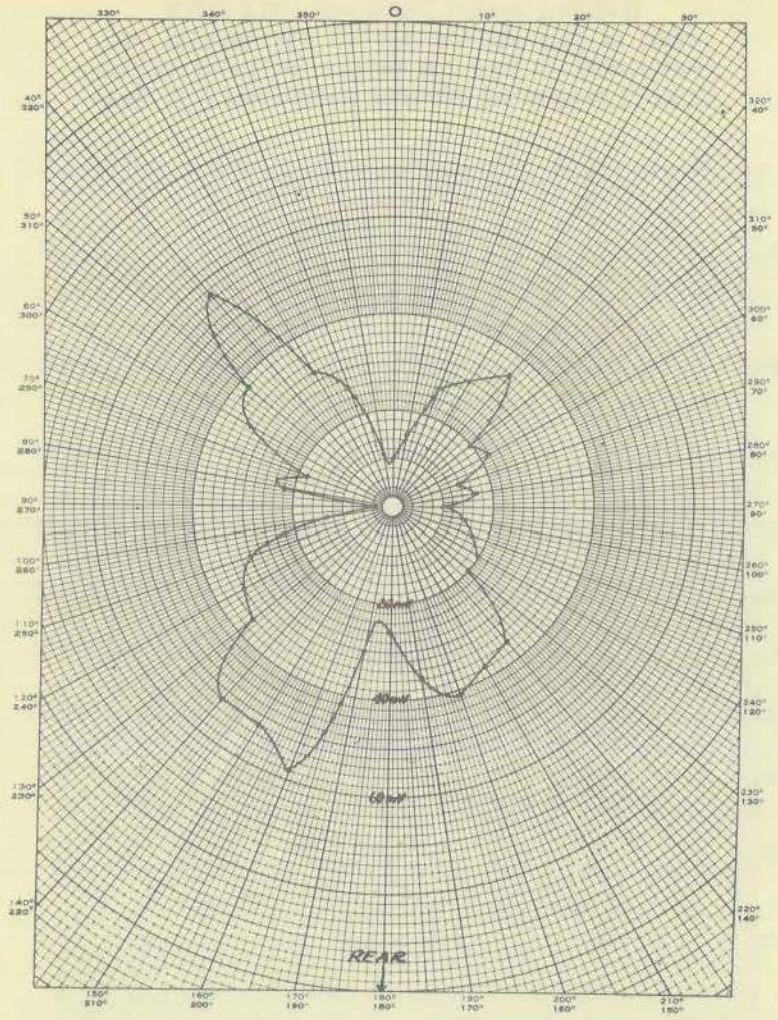

Fig. 25 - Horizontal Antenna Pattern of Lark in Flight Position; 219.45 Mc Fed to Lower Left Fin (217.55 Mc Simultaneously Fed to Upper Right Fin); Receiving Dipole Horizontal

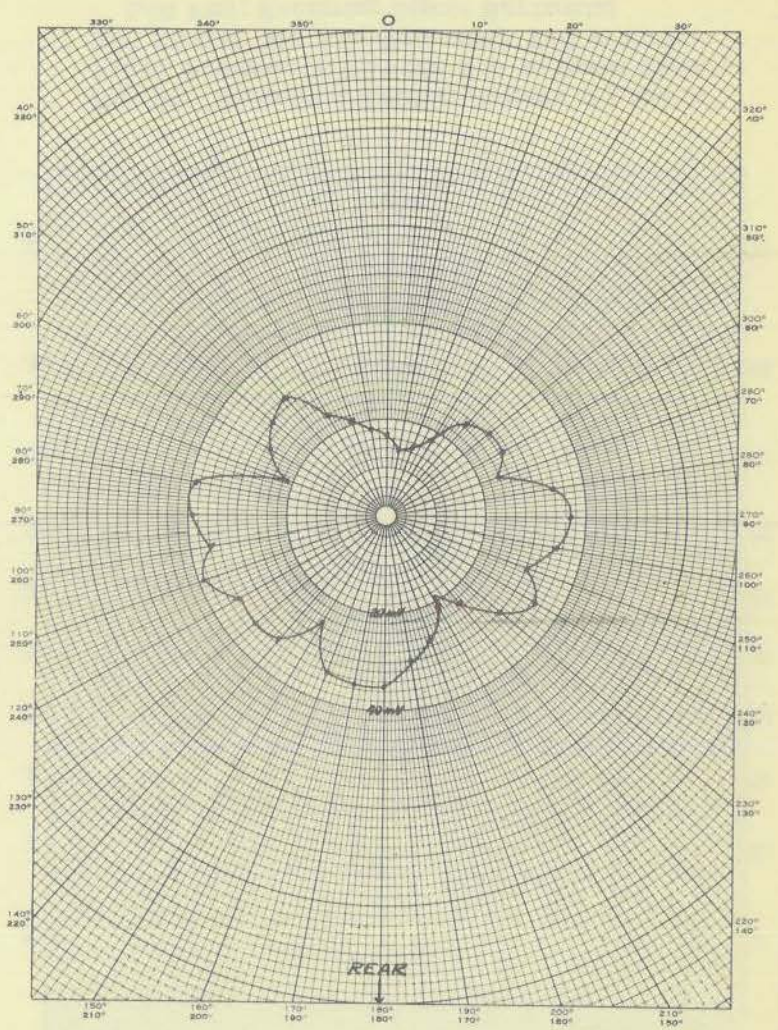

Fig. 26 - Horizontal Pattern of Lark with Fins Vertical; 219.45 Mc Fed to Upper Fin (217.55 Mc Simultaneously Fed to Lower Fin); Receiving Dipole Vertical

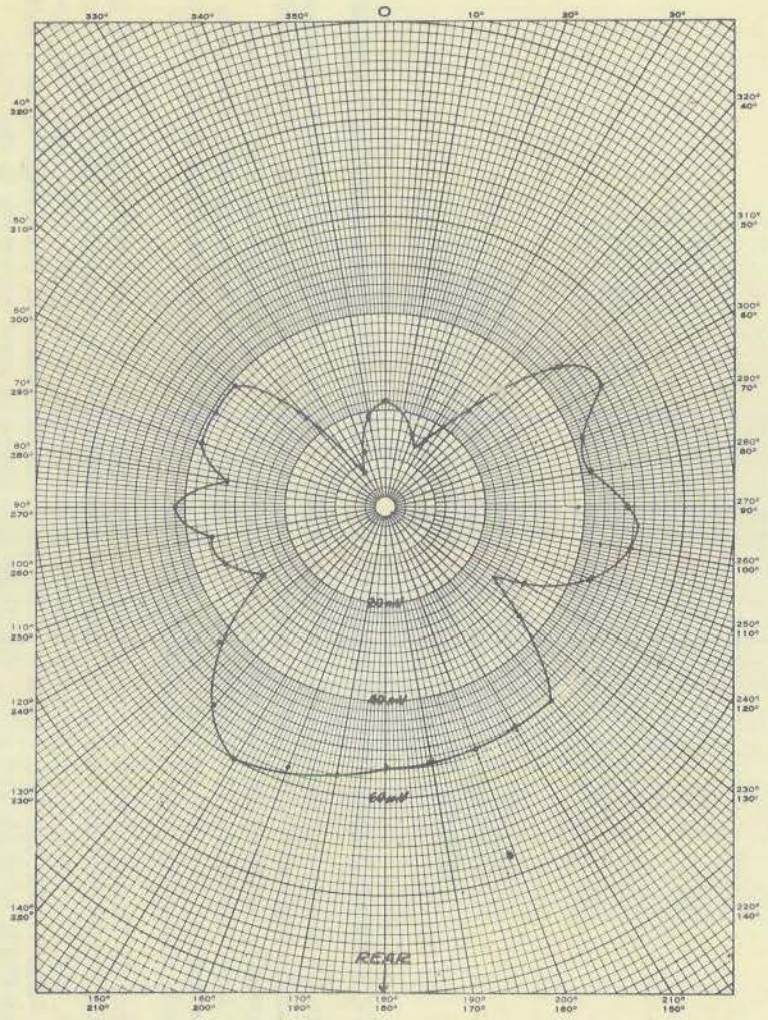

Fig. 27 - Horizontal Antenna Pattern of Lark with Fins Vertical; 217.55 Mc Fed to Lower Fin (219.45 Mc Simultaneously Fed to Upper Fin); Receiving Dipole Vertical

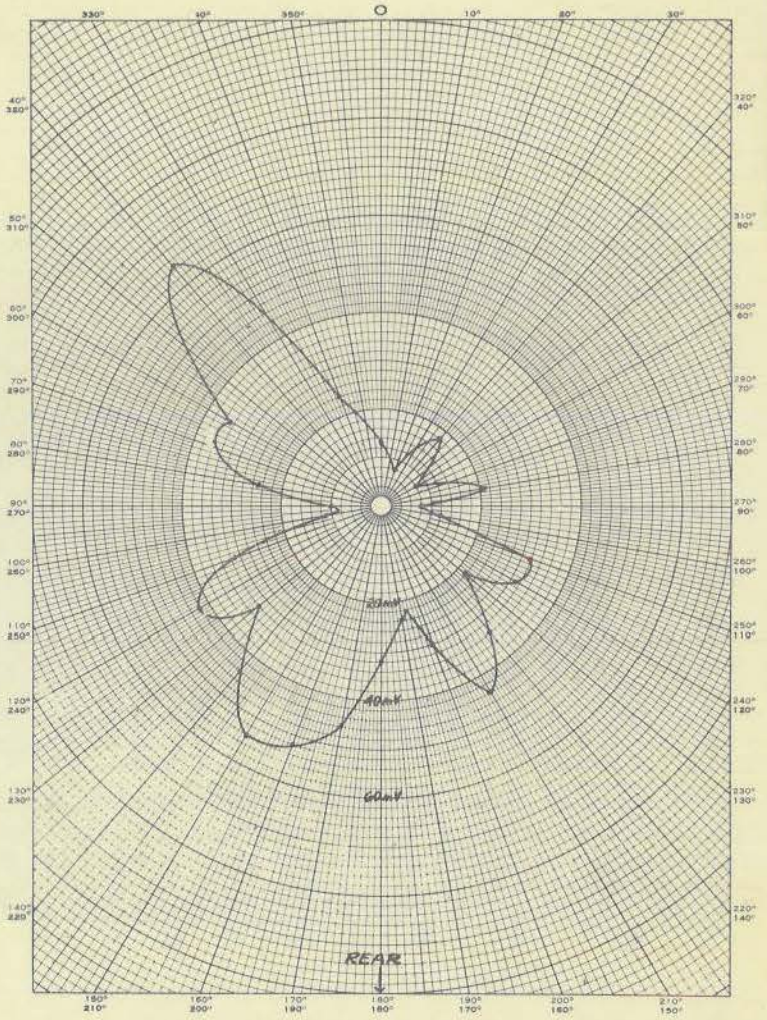

Fig. 28 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 219.45 Mc Fed to Left Fin (217.55 Mc Simultaneously Fed to Right Fin); Receiving Dipole Horizontal

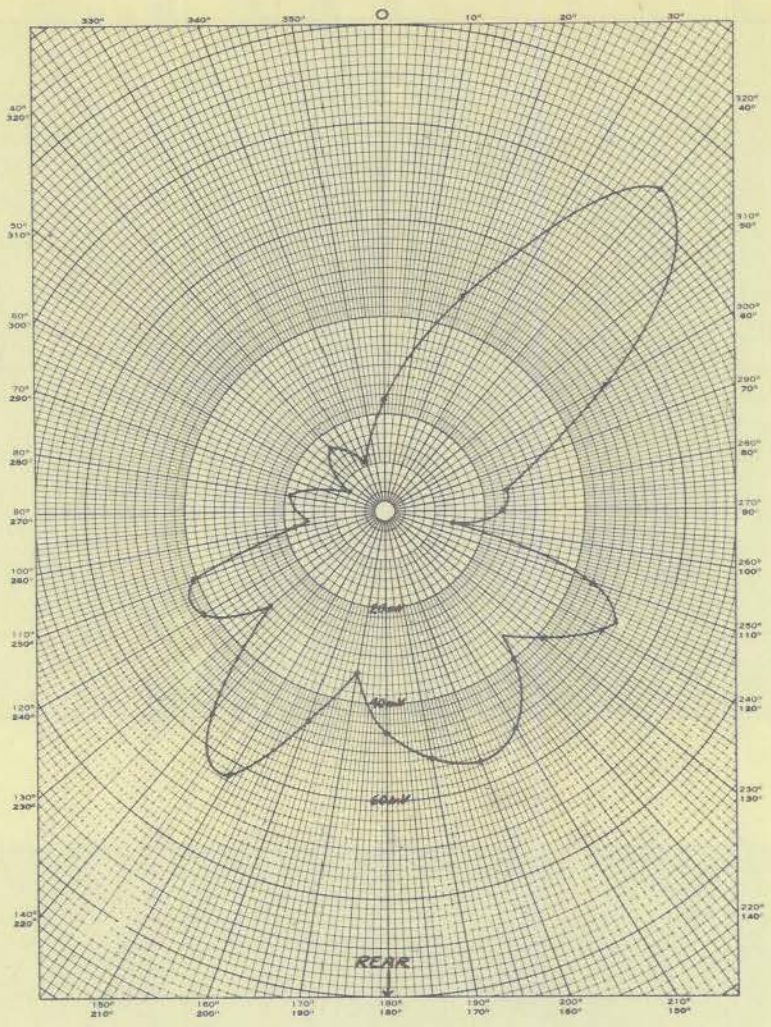

Fig. 29 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 217.55 Mc Fed to Right Fin (219.45 Mc Simultaneously Fed to Left Fin); Receiving Dipole Horizontal

RESULTS OF MEASUREMENTS ON THE 215 TO 222 Mc SINGLE HALF-WAVE ANTENNA

Figure 30 shows fair bandwidth and impedance matching for the independent radiators fed as a single half-wave antenna by means of an adapter tee (See Figure 3). This match was improved by introducing a matching transformer between the antenna and the line. The delay line, introduced to improve the radiation patterns, did not seriously affect the impedance match. The variations from a single resonance characteristic in these curves are probably caused by the 13-ft cable length.

Figures 31 through 39 show radiation patterns for this antenna operating at 217.55 Mc. Figures 32, 34, 36, and 38 show great improvement over the corresponding cases, Figures 31, 33, 35, and 37. This improvement was effected by introducing the 180^{0} delay line between the adapter tee and one radiator. For the case of a vertical receiving antenna and the bird-in-flight position and using the delay line there is good coverage to the rear.

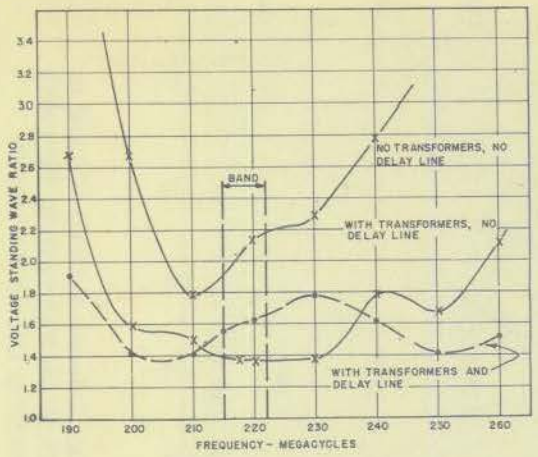

Fig. 30 - V.S.W.R. vs Frequency for the Lark Telemetering Antenna Modified for Operation in the Range 215 to 222 Mc as a Single Half-Wave Antenna; Measured on 50-ohm Slotted Section Through 13 Feet of 52-ohm Cable

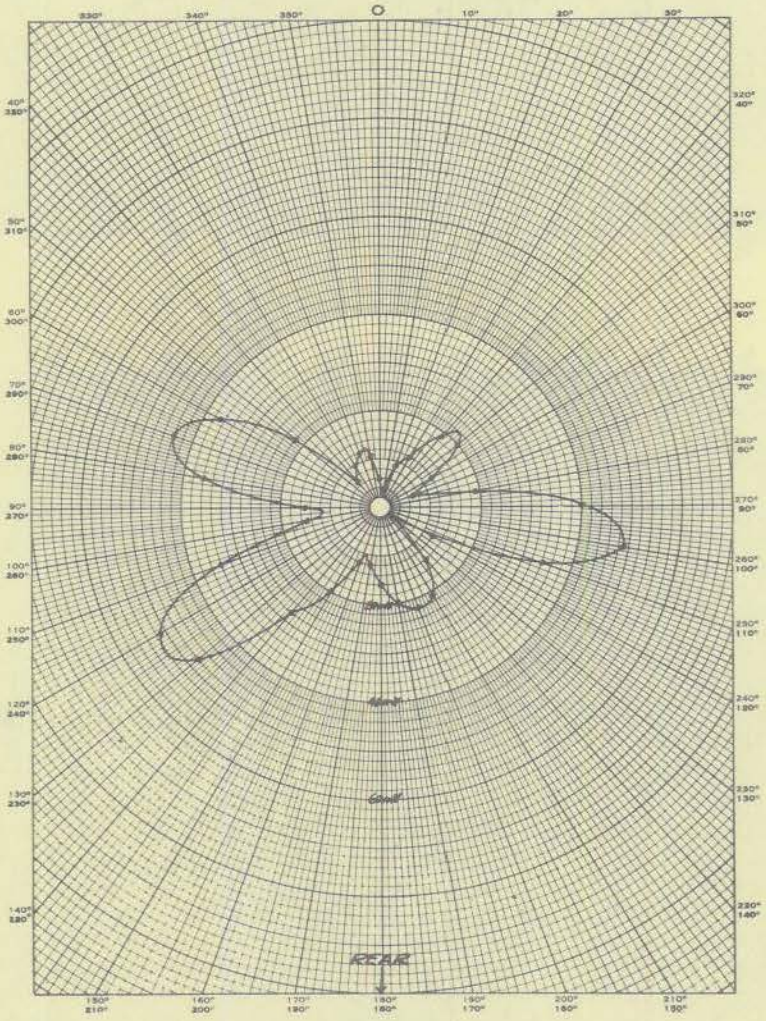

Fig. 31 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Both Fins with No Delay; Receiving Dipole Vertical

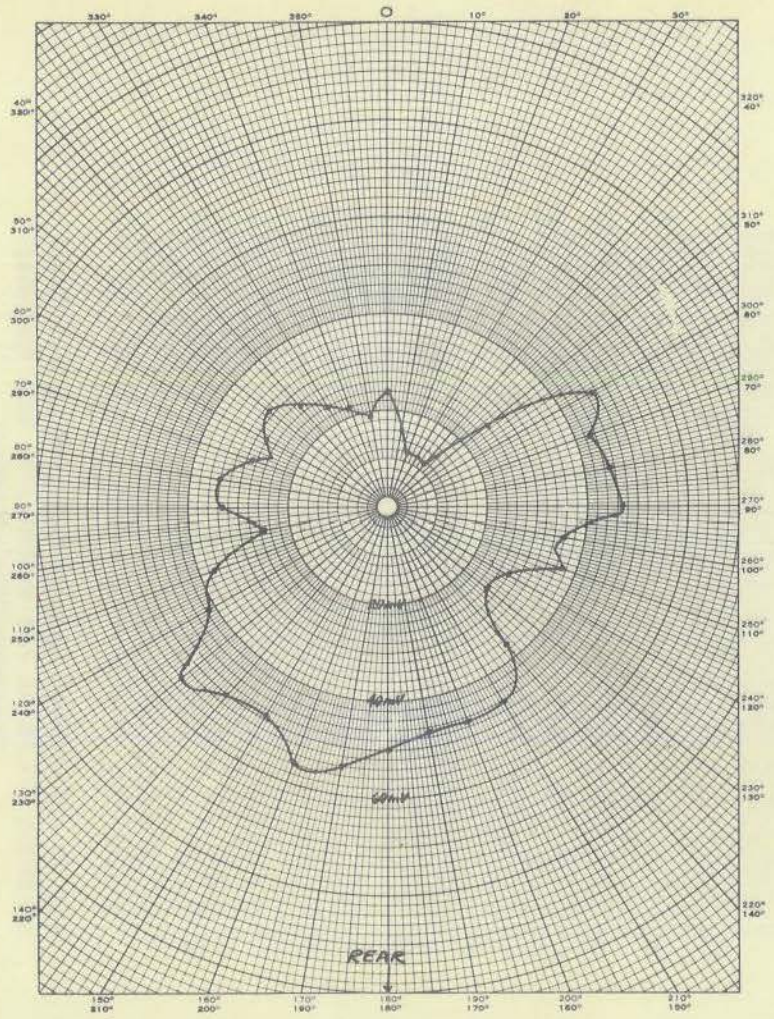

Fig. 32 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Both Fins, with Delay in Upper Right; Receiving Dipole Vertical

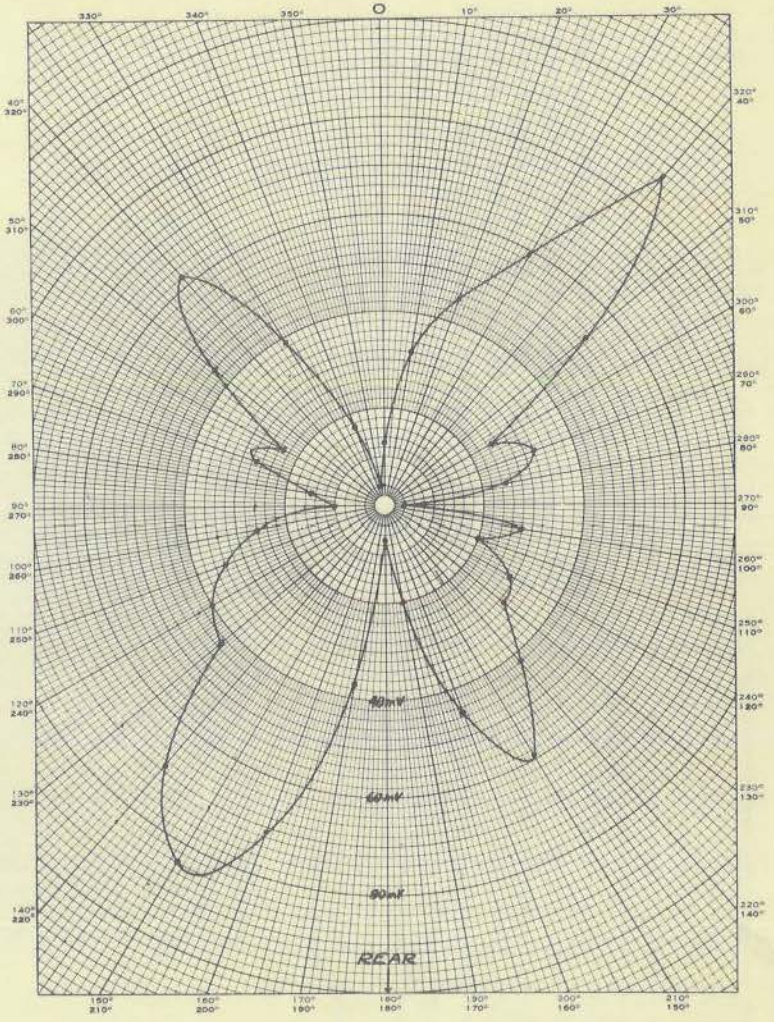

Fig. 33 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Both Fins with No Delay; Receiving Dipole Horizontal

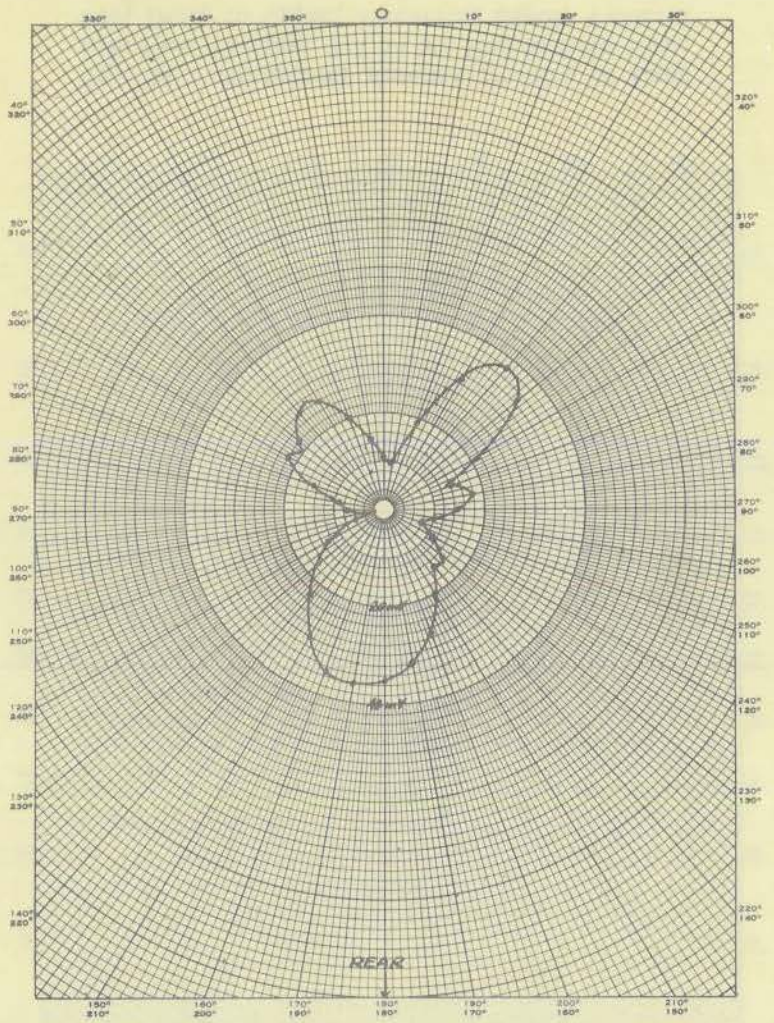

Fig. 34 - Horizontal Antenna Pattern of Lark in Flight Position; 217.55 Mc Fed to Both Fins, with Delay in Upper Right; Receiving Dipole Horizontal

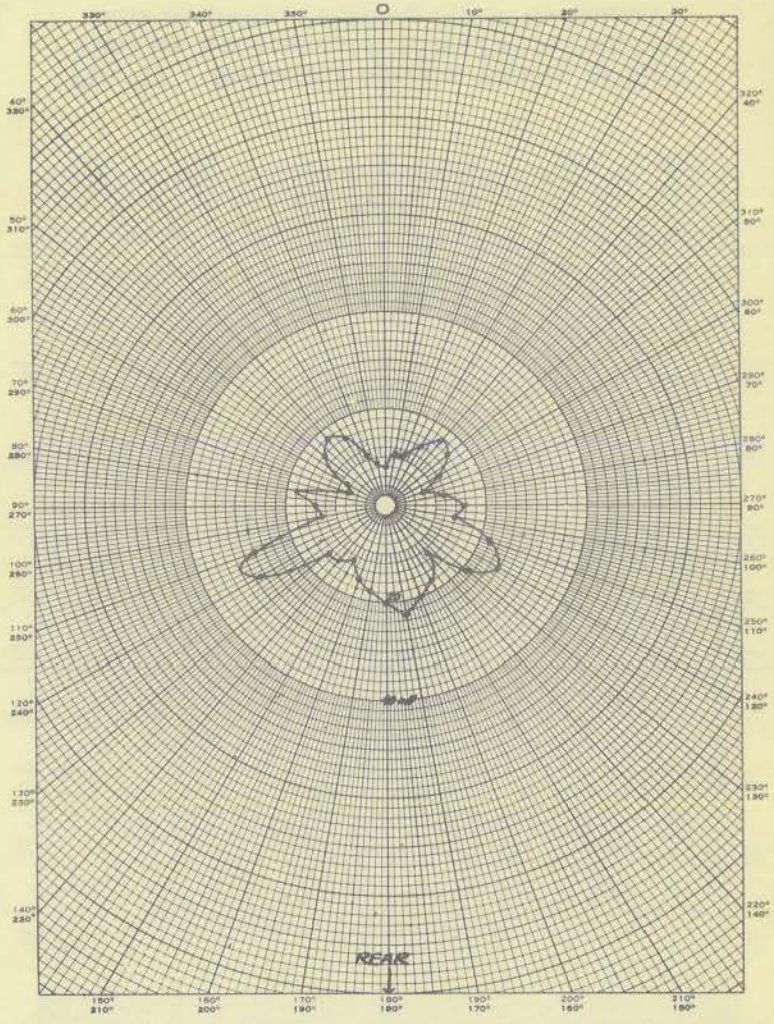

Fig. 35 - Horizontal Antenna Pattern of Lark with Fins Vertical; 217.55 Mc Fed to Both Fins with No Delay; Receiving Dipole Vertical

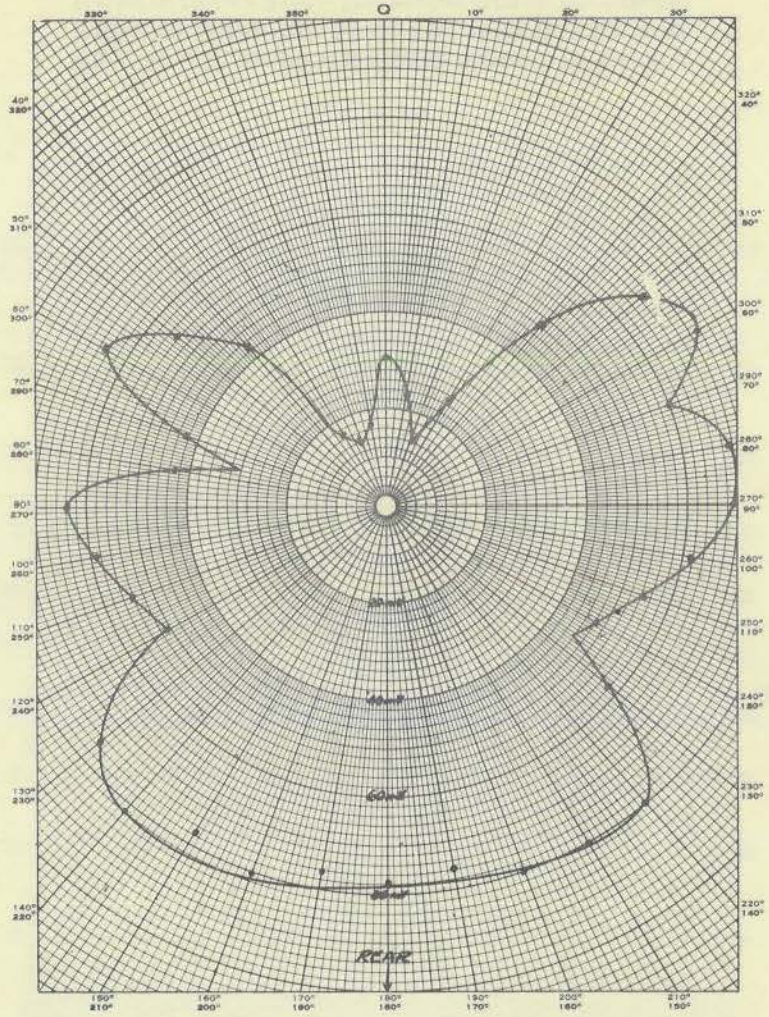

Fig. 36 - Horizontal Antenna Pattern of Lark with Fins Vertical; 217.55 Mc Fed to Both Fins, with Delay in Upper; Receiving Dipole Vertical

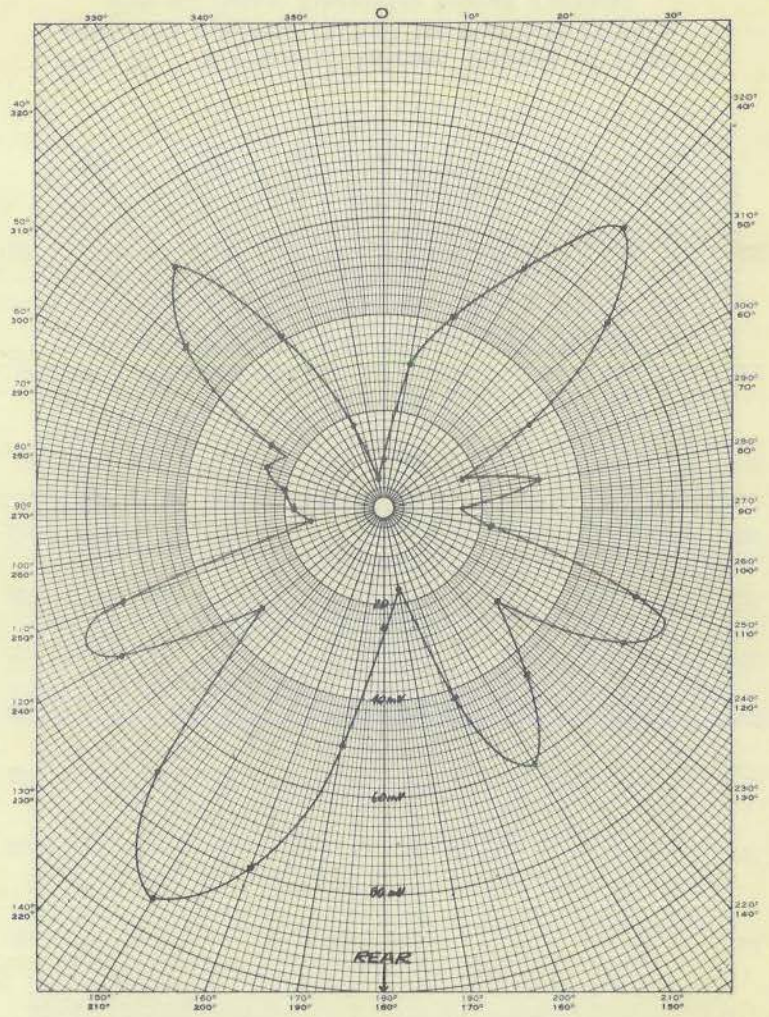

Fig. 37 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 217.55 Mc Fed to Both Fins with No Delay; Receiving Dipole Horizontal

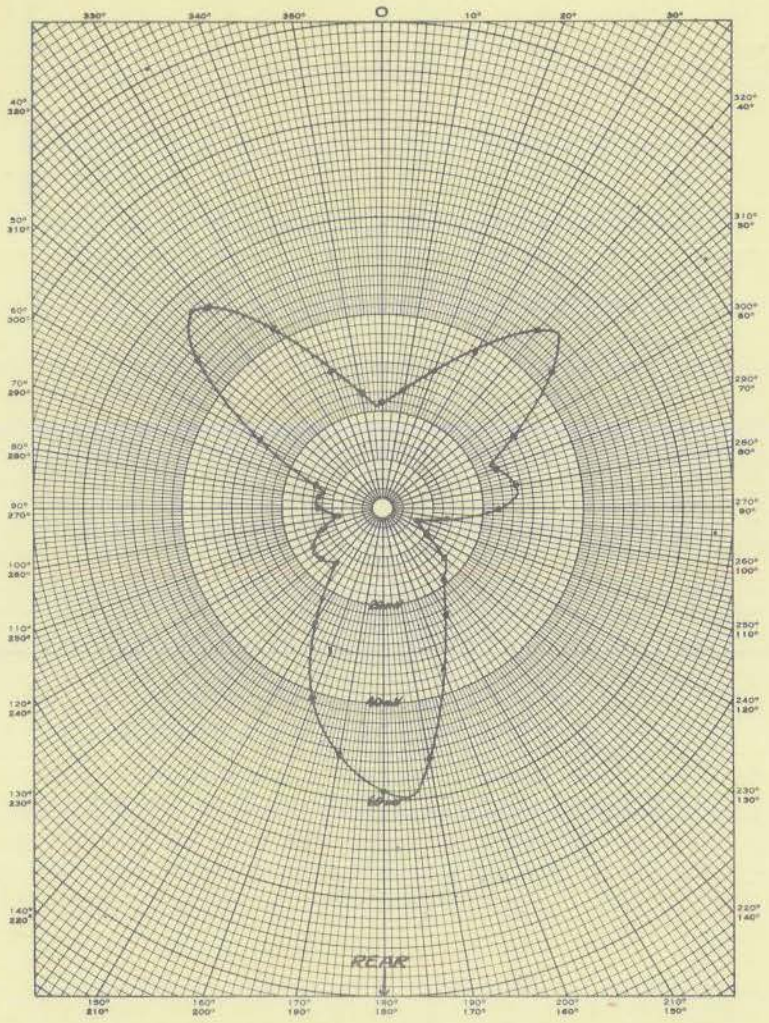

Fig. 38 - Horizontal Antenna Pattern of Lark with Fins Horizontal; 217.55 Mc Fed to Both Fins, with Delay in Right; Receiving Dipole Horizontal

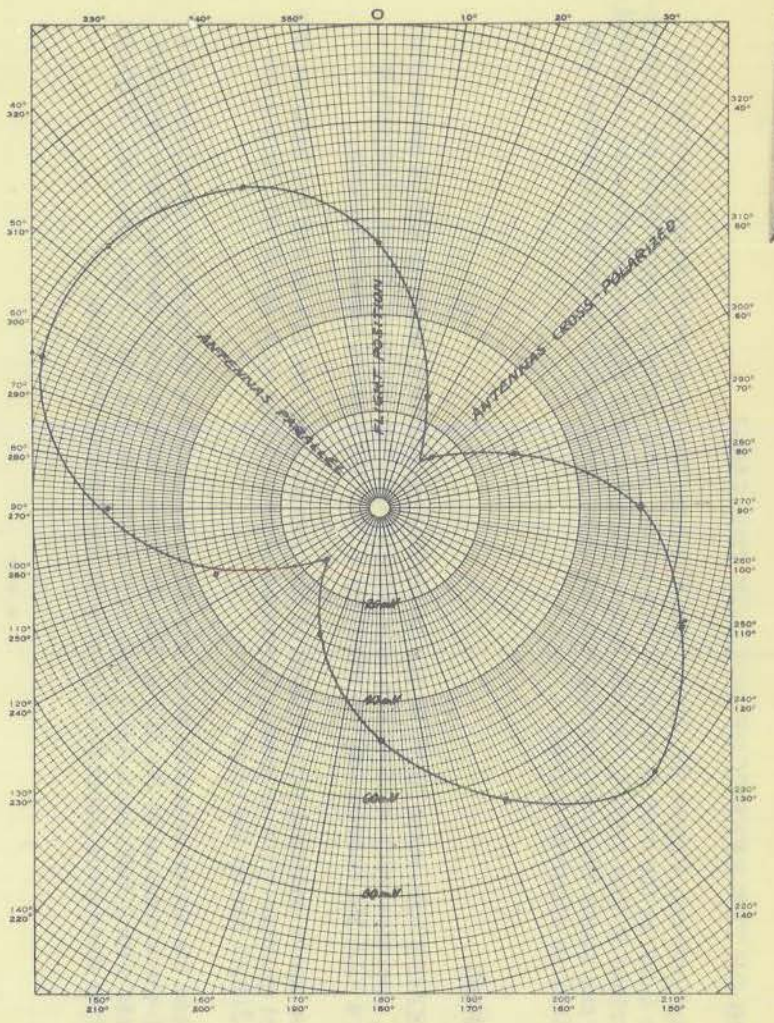

Fig. 39 - Field Strength vs Roll Angle at Rear of Lark; 217.55 Mc Fed to Both Fins, with Delay in Upper Right; Receiving Dipole Vertical

DISCUSSION OF THE EFFECT OF ROLL OF THE KAQ-1

The last pattern, Figure 39, shows the effect on the received field strength to the rear of the Lark as the bird is rolled to any angle. Roll patterns were taken for each antenna described in this report, and the same characteristic figure-of-eight was recorded. A 45° roll can cause the transmitting and receiving antennas to be cross-polarized with a serious loss in received signal.

CONCLUSIONS

1. A KAQ-1 half-wave 72 to 76 Mc telemetering antenna, when modified as herein described, operates very well as two independent quarter-wave antennas when one is excited by a 72.5 Mc source and the other by a 75.5 Mc source simultaneously.

2. The above antenna, when modified for operation in the 215 to 222 Mc band as two independent quarter-wave antennas, operated satisfactorily with 217.55 Mc on one antenna and 219.45 Mc on the other.

3. When the above antennas were modified by feed line changes for operation as a single half-wave antenna in the 215 to 222 Mc band, satisfactory results were obtained at 217.55 Mc with a half-wave delay line in series with one half of the antenna. Without the delay line deep nulls appeared directly to the rear of the Lark.

* * *

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