Progress reports on CB and MZPI radar equipments, July - September, 1949

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REPORT ERA-176

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LABORATORIES

OF

THE NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

PROGRESS REPORT

ON

CB AND MZPI RADAR EQUIPMENTS

JULY - SEPTEMBER 1949

OTTAWA

OCTOBER 1949

Report ERA-176

Secret

Laboratories

of

The National Research Council of Canada

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PROGRESS REPORT

on

CB and MZPI RADAR EQUIPMENTS

July - September, 1949

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COUNTER-BOMBARDMENT RADAR EQUIPMENT

Purpose

The purpose of this equipment is to locate mortars, within any ten-degree sector, out to a range of at least 5,000 yards. For all other purposes for which this radar may be useful, a maximum range of 25,000 yards will be available.

Status on June 30th, 1949

The block diagram on the following page indicates the status of the project on June 30th, 1949.

Progress during July-September, 1949

R-F Head

Further modifications and noise measurements have been carried out on the i-f unit and preamplifier. The i-f noise figure is now 3.5 db, which is considered satisfactory. The bandwidth is 18.2 mc between 3-db points.

Photographs of R-F Head

These views show in turn:

1. The complete head, with cover in position. The inverted trough along the side is required to accomodate an air outlet for the magnetron cooling system.

2. End view, with pulse-forming components, magnetron boot, inverse diode and pulse transformer visible.

3. Side view, with the 60-mc i-f amplifier strip and part of the i-f preamplifier. The TR and ATR switches may be seen in this view on the right-hand side.

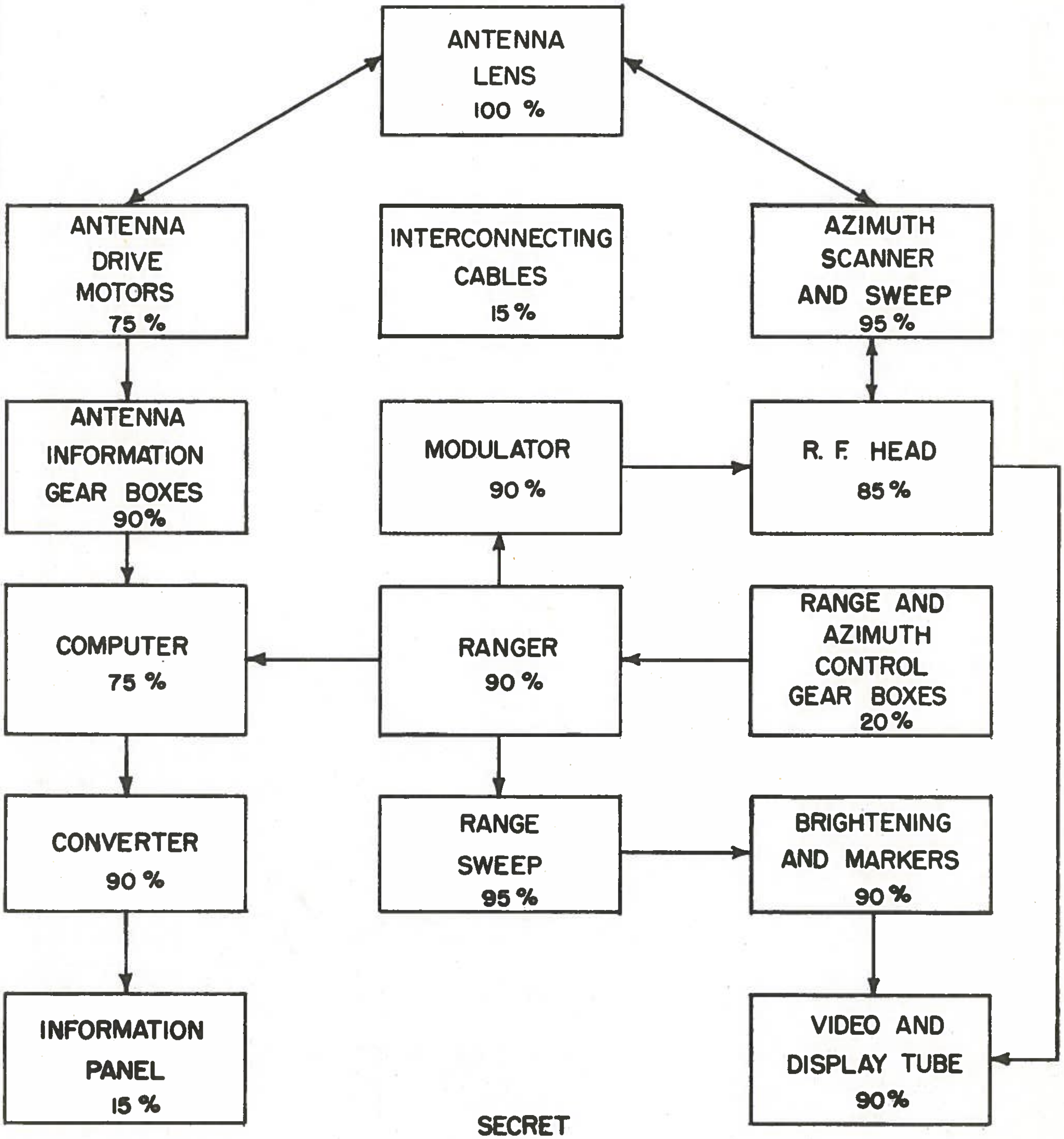
4. Side view, with the AFC and AFC i-f chassis visible. The local oscillator and receiver mixer can be seen on the left-hand side.

Transmitter

An output pulse transformer has been designed and built for an optimum pulse-width of 0.1 microseconds. Power measurements indicate that the transformer gives about 10 per cent more power than the MIT 232/FW2 design previously used, the latter transformer being suitable primarily for pulse widths between 0.25 and 1.0 microseconds. The magnetron frequency spectrum is satisfactory, corresponding to an r-f pulse width of 0.11 microseconds.

STATUS OF CB RADAR PROJECT AT THE END OF JUNE, 1949

The degree of completion of each unit of the Field Trials Model is indicated approximately as a percentage.



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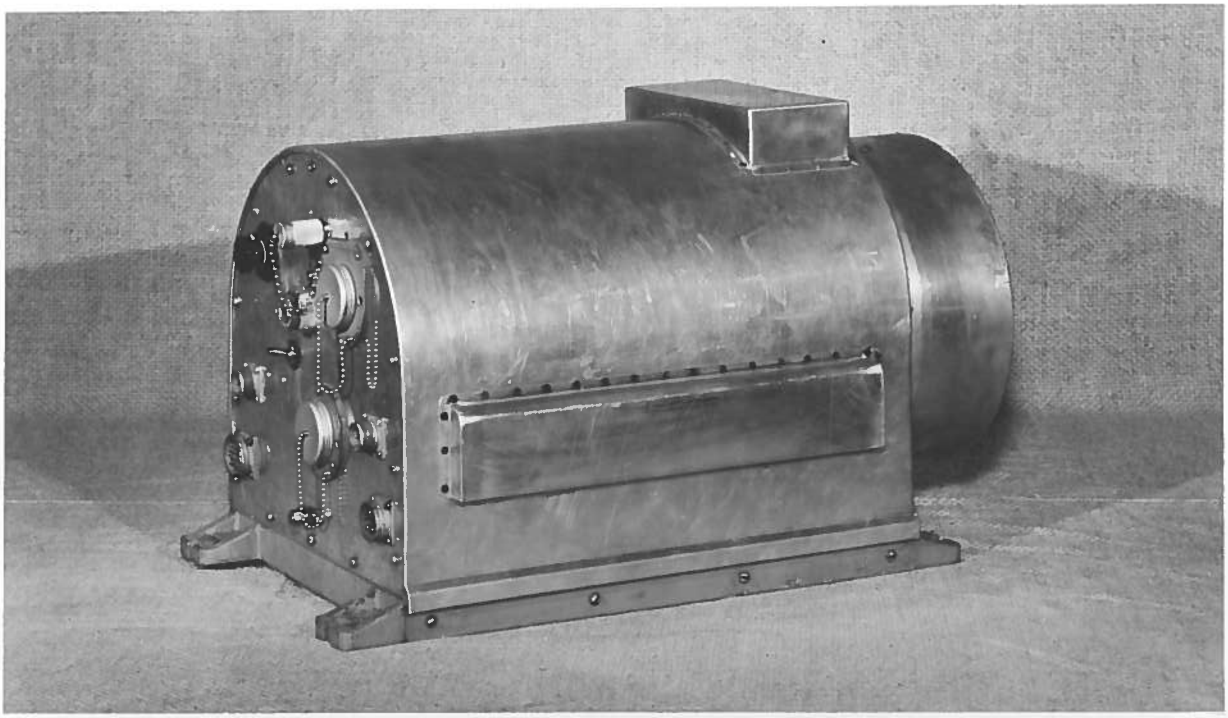
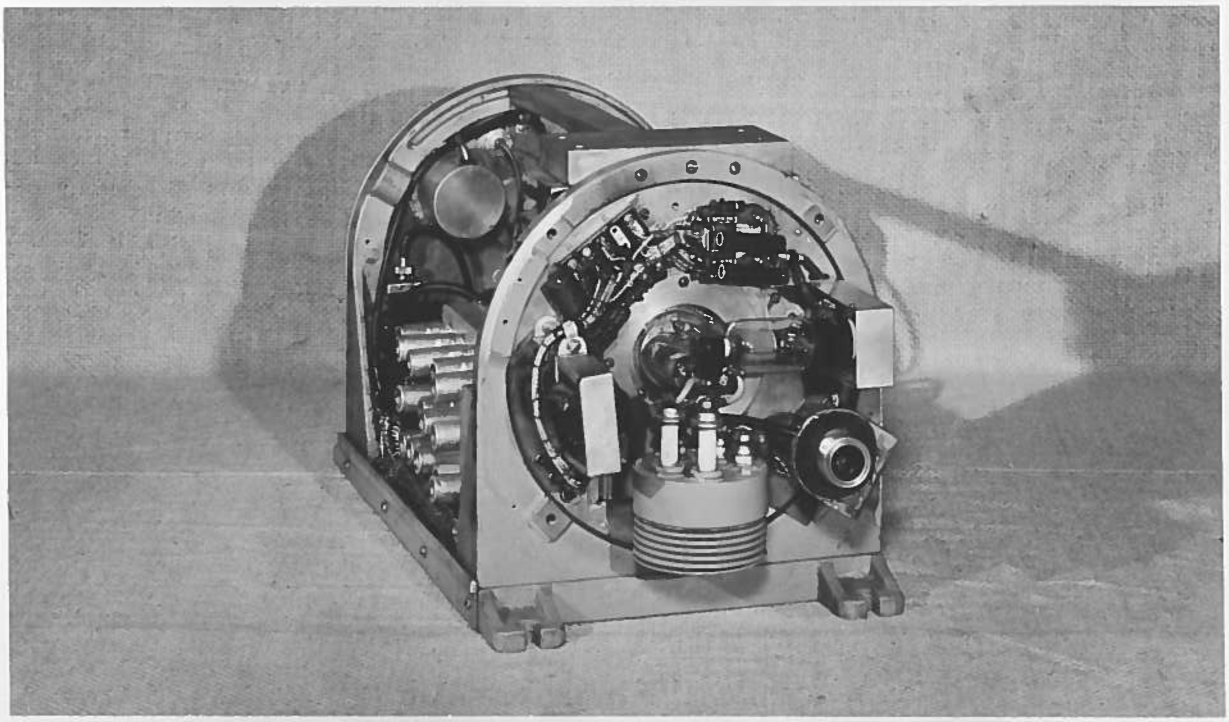


cover in place



Transmitter End-cover removed

R-F Head (CB Equipment)

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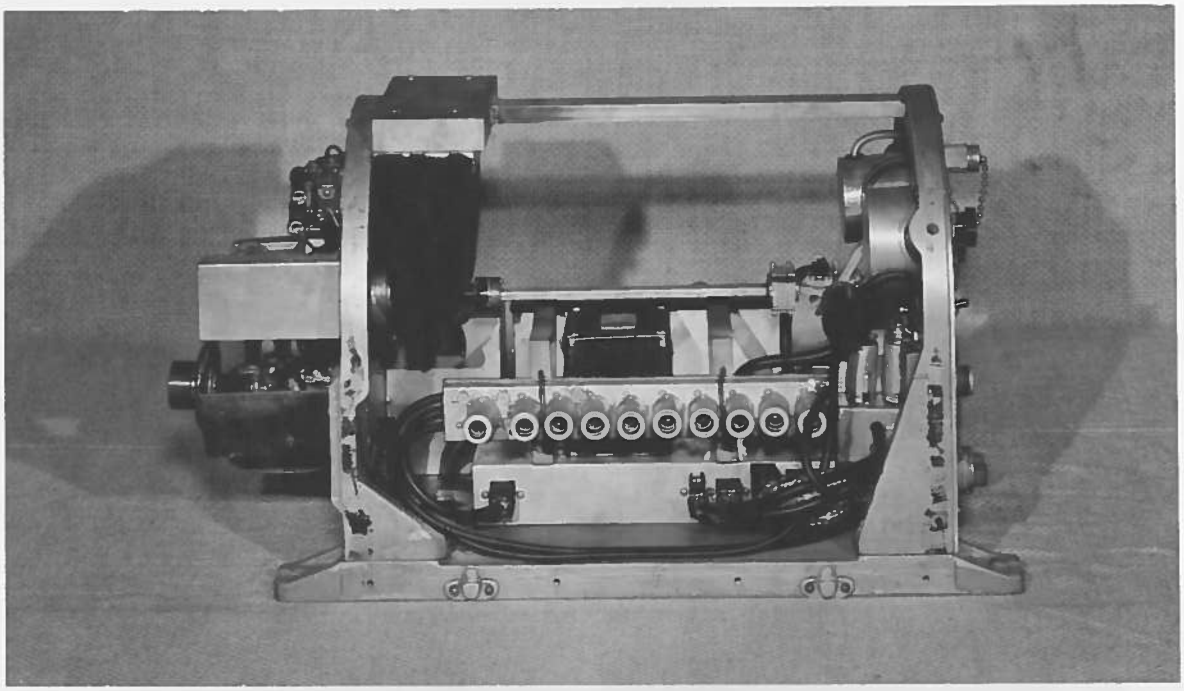
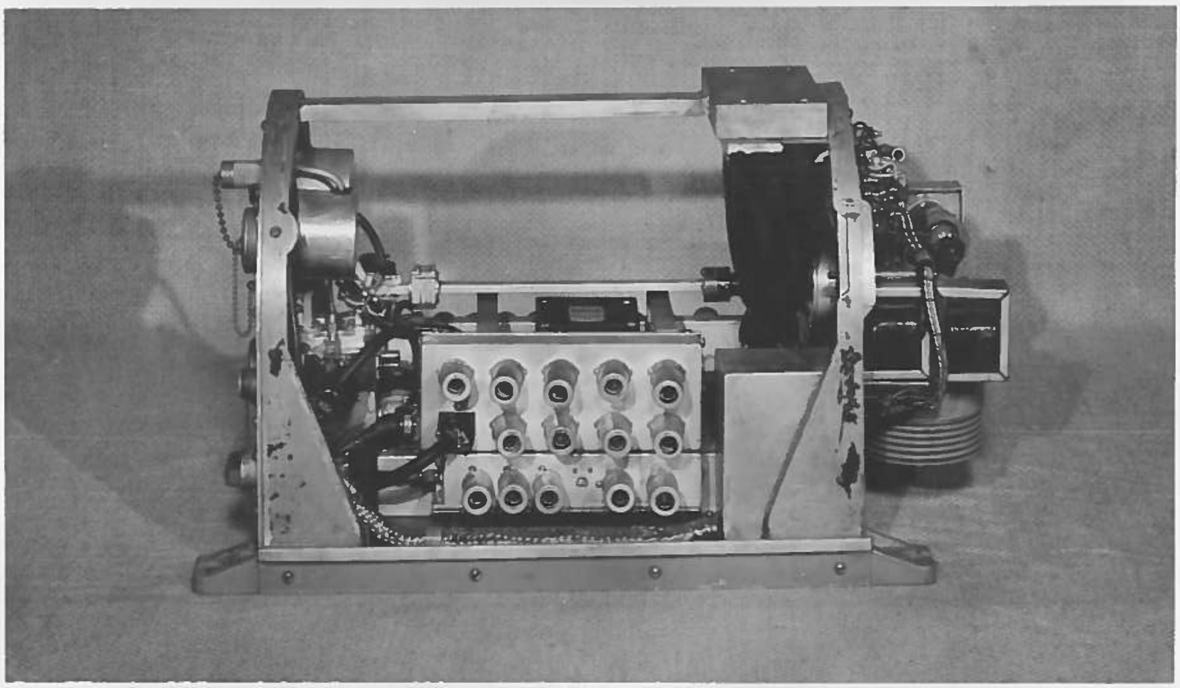


I-F side



AFC side

R-F Head (CB Equipment)

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Modulator

A second (U.S. Army AN/TPQ-2) modulator has been modified and tested to give a pulse width of 0.1 microseconds. This unit will be used as a spare.

Video

A video amplifier for the type-B display, with improved physical layout, has been built and is now in use.

Monitor and Test Set

Two 400-cycle sets and one 60-cycle set are undergoing test.

Interconnecting Cables

Most of the connectors and cables have been received but they have not yet been made up. The wiring of most of the connecting boxes and relays has been completed.

Extrapolating Computer and Co-ordinate Converter

A prototype of the elevation computer is being wired.

The dual-channel servo amplifiers have been further simplified by eliminating the pre-set control, adding a second tube and removing the saturable reactor. Wiring of these amplifiers is almost complete. A new single-channel amplifier unit, less critical with respect to waveform, has been designed as a substitute for the Bendix magnetic amplifier.

The link multiplier, made by Canadian Arsenals, Limited, has been received and adjustments are being made to it in the shop. The layout of the control panel and computer unit is well advanced and some subassemblies have been completed.

Photographs included in this report show a number of interior views of the co-ordinate converter, as well as an exterior view with the cover in place.

Information System

The information system is shown diagrammatically on the following page. The radar beam is approximately 0.6° x 0.6° and sweeps out two fan-shaped beams, each of which is approximately 0.6° wide in the vertical plane and 10° wide in the horizontal plane, separated by a vertical angle of 1.7°. The angle of elevation (θ) is measured from the horizontal to the lower beam. In flight, the

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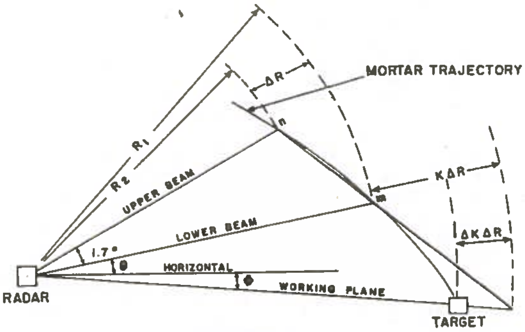
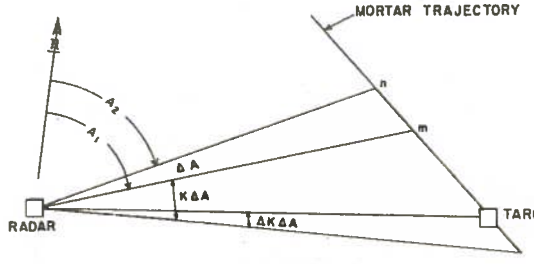
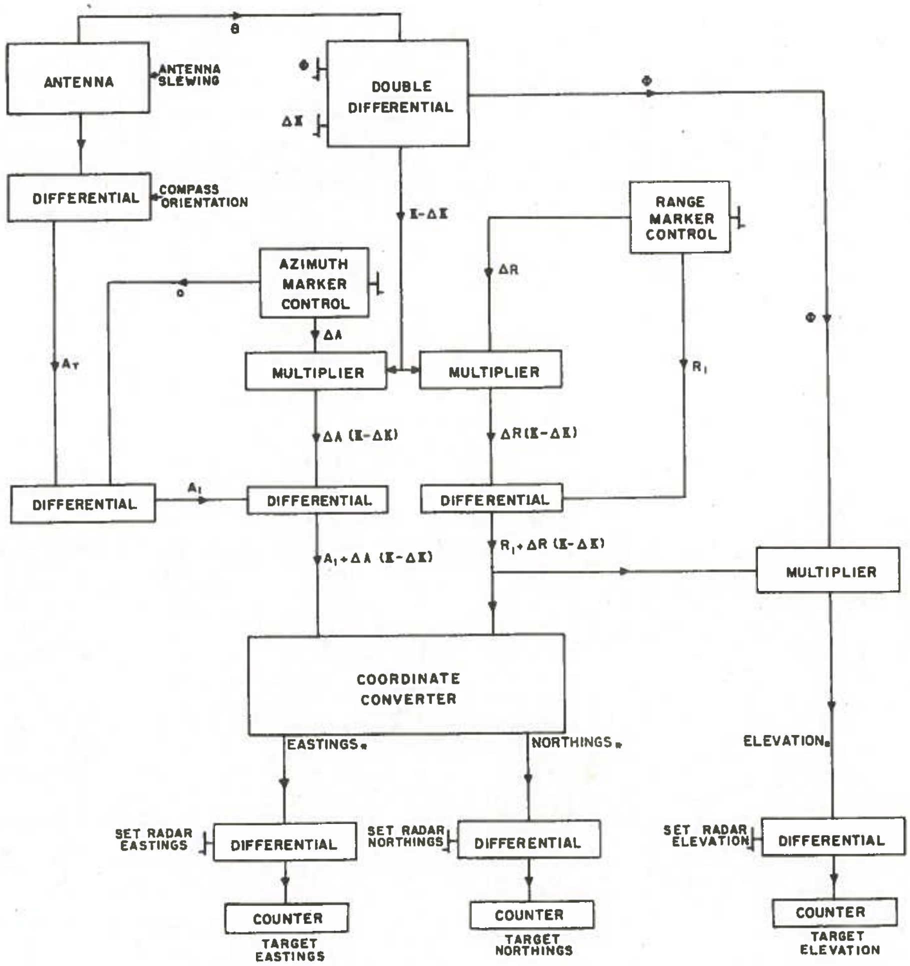


Elevation



Plan



A = Azimuth
A_T = True Antenna Azimuth
a = B-Scope Azimuth
R = Range
$K = \frac{\theta + \Phi}{1.7}$
$\theta < 6°$
m and n = Lower and upper beam intercepts respectively

* With respect to Radar position

CB Information System
Block Diagram

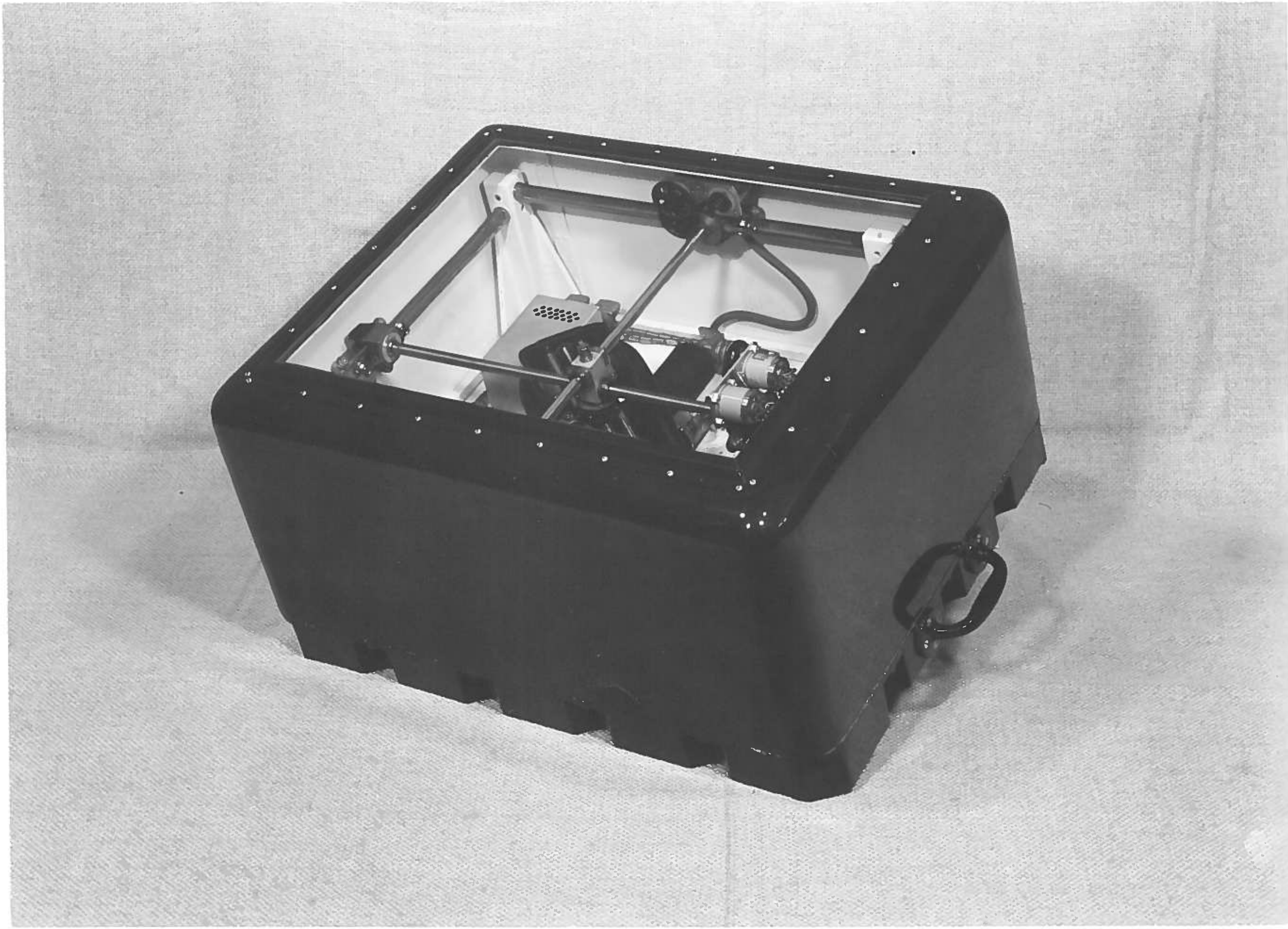
mortar bomb passes through the two beams in succession and produces two echoes, Echo No.1 (lower beam) and Echo No.2 (upper beam). These echoes appear on a type-B display having range as ordinate, with an expandable scale, and azimuth as abscissa over an angle ±5° from the centre of the antenna swept beams. The range information is fed directly into the system while the azimuth marker information, a, is added to true antenna azimuth to give the true azimuth of the beam intercept. Antenna azimuth with respect to carrier heading is corrected to true antenna azimuth by means of a differential controlled by radar or visual fixes or by compass reading.

Operation consists of placing an electronic marker on Echo No.1 (R_1 and A_1), engaging a clutch, and moving the marker to Echo No.2 (R_2 and A_2). Thus R_1 and A_1, $\Delta R = (R_1-R_2)$ and $\Delta A = (A_1-A_2)$ are fed into the system as shown in the diagram.

From a knowledge of the ground contours, the operator sets in the working plane angle (angle ϕ below or above horizontal) which, when added algebraically to the angle θ in a differential and divided by 1.7°, gives a quantity $K = \frac{(\theta+\phi)}{1.7}$. When K is multiplied by ΔR and added to R_1, this quantity provides a means of extrapolating from the located points on the trajectory back toward the source of the bomb. An arbitrary quantity $-\Delta K$, is provided which may be used to correct the linear extrapolation to the parabolic trajectory for any assumed muzzle velocity and angle of projection.

$\Delta A(K-\Delta K)$ and $\Delta R(K-\Delta K)$ are obtained in multipliers and added to A_1 and R_1, respectively, to give the target position in polar co-ordinates. The co-ordinate converter changes this information to rectangular co-ordinates, to which are added the eastings and northings of the radar map position, giving target position as a map reference. It may be noted that the small difference in range due to any difference in elevation between radar and target is neglected in the co-ordinate converter.

To obtain elevation (in feet above sea level) of the target, the angle ϕ is multiplied by target range, $R_1 + \Delta R(K-\Delta K)$, and the product is added to radar elevation (in feet) to give target elevation in terms of the map contours.



CB Coordinate Converter (assembled)

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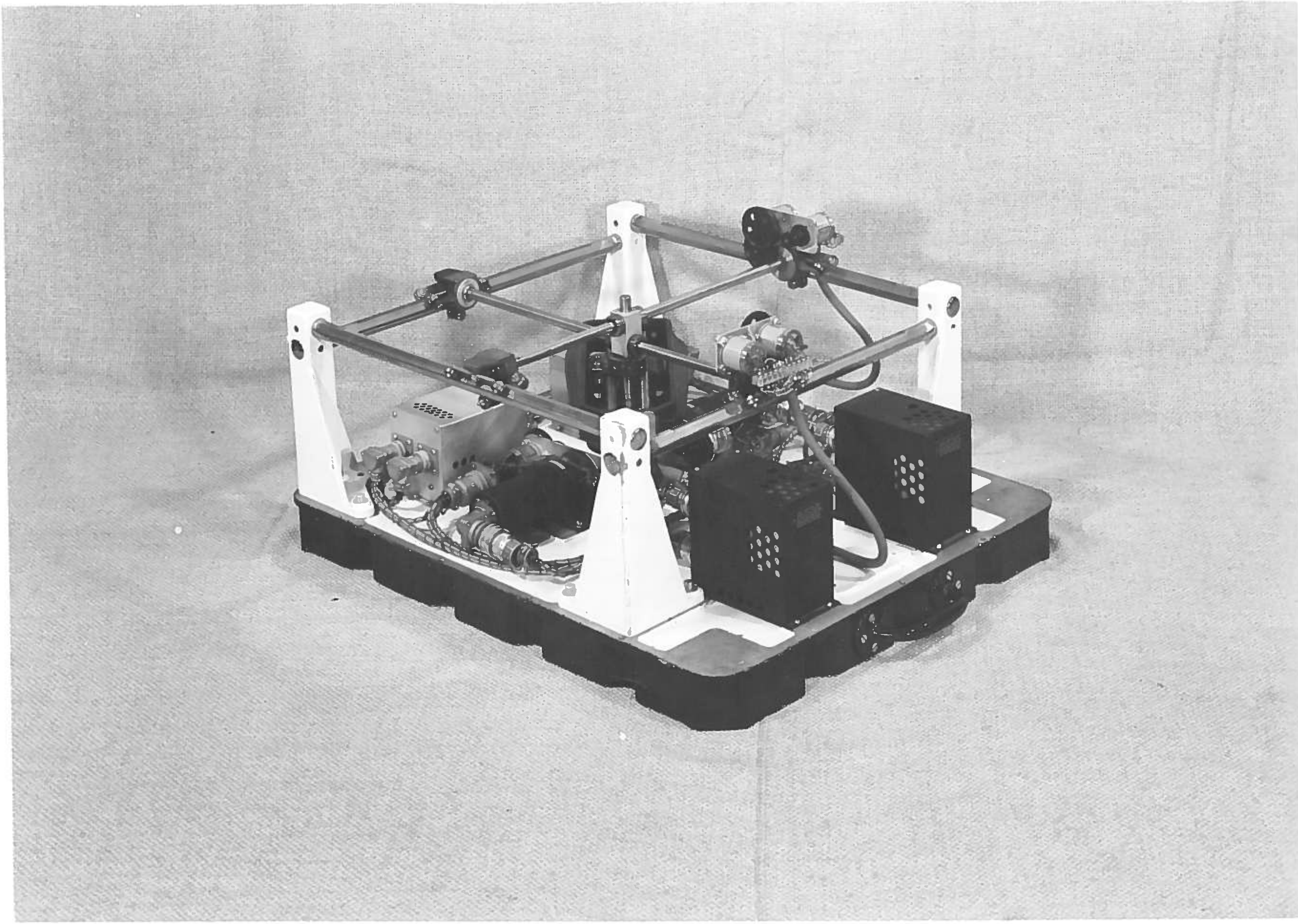

CB Coordinate Converter (cover removed)

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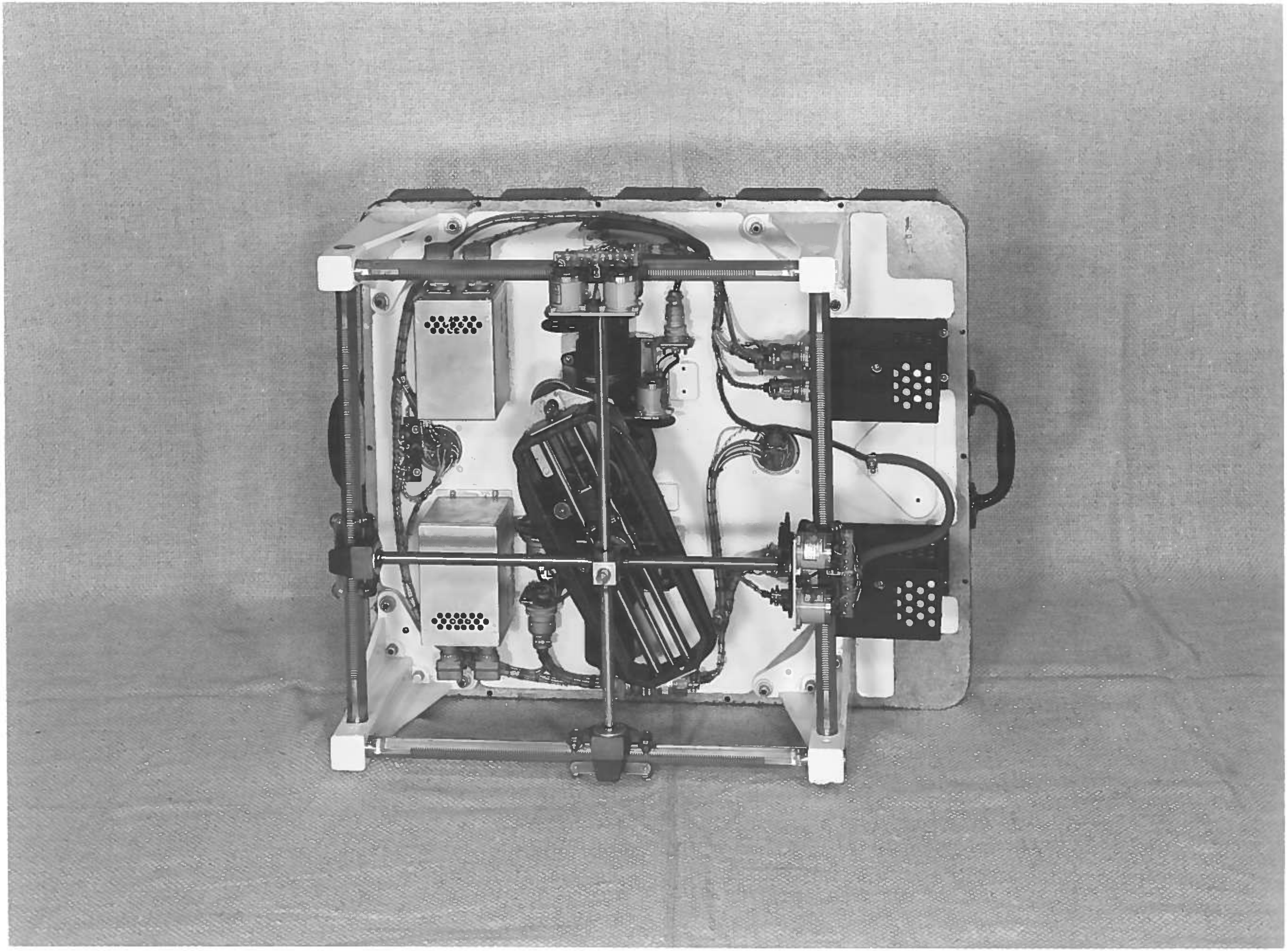

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CB Coordinate Converter
top view

MICROWAVE ZONE POSITION INDICATOR, Mk.II
(Modified A.A. No.4, Mk.6)

Summary

As part of the program to increase the range of this equipment, an antenna of greater power-handling capacity is required. The prototype antenna will consist of a 2 by 14 foot section of a parabolic cylinder fed from a slotted wave guide. Beam positions will be determined by means of a hydraulic rocking mechanism.

Progress

(a) Mechanical

Major activity during the period under review was confined to two items:-

(1) "Debugging" the hydraulic rocking mechanism.

(2) Modifying the wave-guide feed system to suit later requirements of the Microwave Section.

Hydraulic Rocking Mechanism

Early experiments with the hydraulic rocking mechanism, as originally designed, led to the suspicion that the major trouble was lack of power in the solenoids operating the pilot valve. This lack of power was evident even when the solenoids were operated at 100% over-voltage (which led to serious switching difficulties).

The solenoids were therefore removed, and a temporary arrangement installed whereby the pilot valve could be operated by a hand lever. With this setup, the antenna followed the position of the lever with no appreciable lag or backlash, thus indicating that the main piston and pilot valve itself were quite satisfactory.

As there was ample hydraulic power available, it was decided to operate the pilot valve by a small three-position hydraulic cylinder. This consisted of a two-diameter cylinder with dual pistons. Flow of oil to either end, or between the dual pistons, is controlled by standard Vickers solenoid operated valves. This design has been found to perform very satisfactorily.

Wave-guide System

After initial tests of the antenna by the Microwave Section, various minor modifications were made to the wave-guide system to increase its power-handling capabilities. These changes involved moving the wave-guide array back two inches, changing its angle from 45° to 31°, and replacing a 45° bend with a curved section. For mechanical assembly reasons a choke coupling was also added within the king pin. In co-operation with the Microwave Section a complete new wave-guide system has been drawn up which, it is hoped, will have very considerably greater power-handling capabilities.

(b) Electrical

Breakdown tests under reduced air pressure at 0.75 megawatts have indicated that the original rotating coupler would not transmit more than about 1.7 megawatts peak power. Tests on the re-designed coupler are well under way and present indications are that it will have a considerably higher power-handling capacity and a better match. It is hoped to achieve a bandwidth of 3%.

On receipt of the Raytheon QK-169 magnetron it was found that this tube required pressurizing in the wave guide to prevent voltage breakdown. This necessitated the inclusion of a window in the wave guide. A quartz window was constructed and measurements of its match, bandwidth and loss are being made. Power-handling capacity cannot be determined satisfactorily until a high-power modulator, now on order, is delivered.

MZPI Antenna – three-quarter view from rear

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MZPI Antenna in travelling position

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