Progress report on CB and MZPI radar equipments October - December 1949

National Research Council of Canada. Radio and Electrical Engineering Divison

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REPORT ERA - 179

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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

OCTOBER - DECEMBER 1949

OTTAWA

JANUARY 1949

Report ERA-179

Secret

Laboratories

of

The National Research Council of Canada

Radio and Electrical Engineering Division

PROGRESS REPORT

on

CB and MZPI RADAR EQUIPMENTS

October-December, 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 September 30th, 1949

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

Progress during October-December, 1949

R-F Head

The entire r-f head was coupled to a small paraboloid dish for test purposes, and echoes were displayed on the A- and B-scopes in the laboratory. The test revealed that the over-all gain of the receiver should be increased to provide an adequate margin of gain. The appropriate modifications are being made.

Due to the use of very short pulses some difficulty was experienced in locking the AFC unit. This was overcome by the addition of i-f stages. Further work will be done to make AFC adjustment less critical.

An improved magnetron-input pulse transformer is to be built and the parts have been fabricated or purchased. The experimental model will be retained as a spare.

Modulator

Cathode followers have been added to the triggering circuits of both the operational and spare modulators to improve stability.

Control Panel

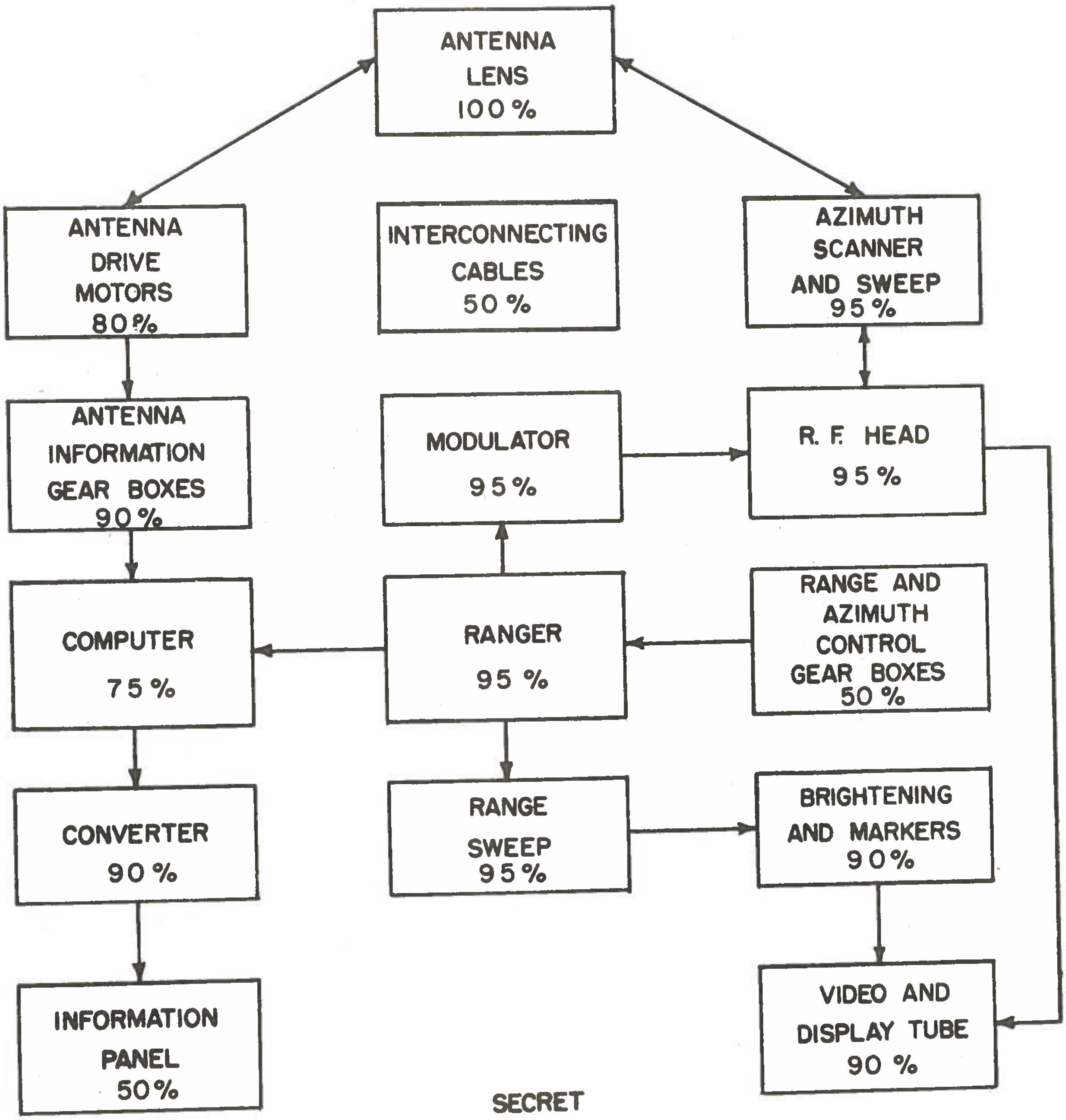
A control panel, incorporating time delays and interlocked relays to permit push-button operation of the modulator and r-f head, was designed and is being wired.

Video Amplifier

A video amplifier for the type-A display, of similar physical design to that used in the 'B'-scope amplifier, has been built and is now in use.

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

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



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Display Unit

A new rack and chassis has been drawn up and is under construction. It will incorporate suitable filters and switching for the operation of the type-A and type-B displays.

Ranger

A new chassis layout is being designed for the packaging of the ranger. It will consist of drawer-type chassis, comprising up to 12 tubes each, easily accessible for maintenance. Minimum dimensions consistent with good practice are being used.

Extrapolating Computer and Co-ordinate Converter

The Computer will be, in the main, a part of the Computing Controller which also includes the Information Panel. All engineering design is complete. About 80% of the drawings have been made and approximately 60% of the components have been fabricated. As a whole, this part of the project is about 75% complete. The dual-channel amplifiers have been completed and tested, as have the new torque amplifier units. The $K\Delta A$, $K\Delta R$ and elevation multiplier amplifier, designed as a possible option to the link multiplier, has been wired and is being tested. Tests are being performed as sub-assemblies are received from the shop and adjustments are being made as required.

CB Simulator

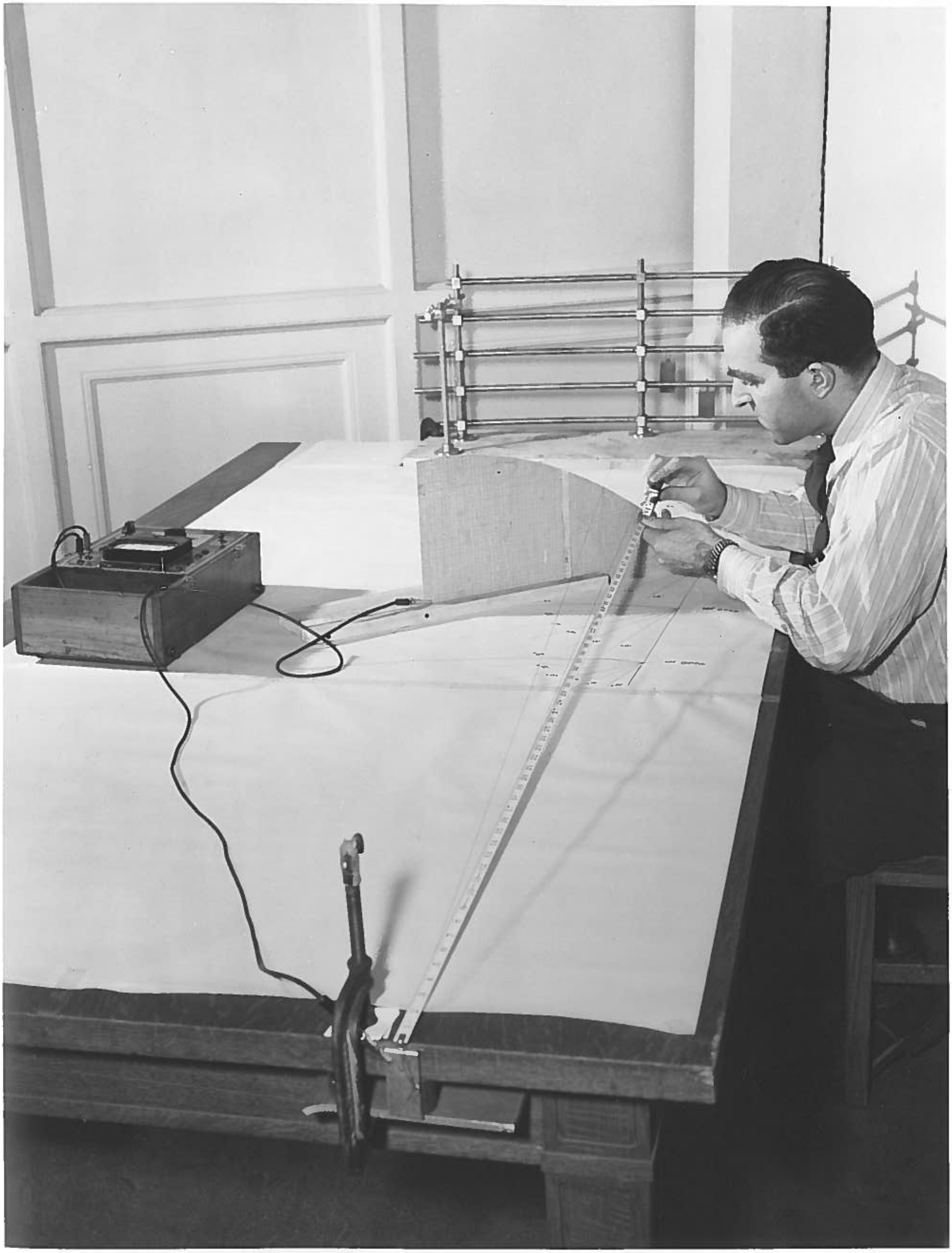
It was known that the quantity $\frac{\text{angle of sight}}{\text{split angle}} = K$, when used in computing the mortar position, results in considerable error, and no correction factor, ΔK, suitable for introduction into the CB mechanism could be obtained analytically. The CB simulator (see photos)was constructed to facilitate the solution of the mortar problem for a great variety of radar beam intersections of the mortar trajectories. Data pertaining to these intersections are being plotted and analyzed to obtain the correction factor.

The accompanying pictures show the essential components. At one end of the table is a point representing the radar position, at which are attached two piano wires under tension, representing the radar beams, and an ordinary metal tape for measurement of range. The table is covered with paper marked off at ranges from 4,000 yards to 8,000 yards, to a scale of 1 inch = 100 yards. The"beam-setting framework" consists of aluminium rods with adjustable clamps, and the horizontal rods are adjusted so that adjacent pairs subtend an angle equal to the beam split-angle at the radar point. Each of these rods is calibrated in azimuth from an arbitrary zero. Trajectories representing various mortar velocities and angles of projection were cut from aluminium and provided with a support.

To obtain data, a trajectory is positioned on the table and the wires are moved along the framework until contact is made (determined by the ohmmeter) with the trajectory. The angle of sight is known, azimuths may be read from the scales, and ranges may be read by means of the tape as shown.

To date, a large number of readings have been taken and comparison with analytical results indicates that the accuracy is generally within ±2 yards in range and ±1 minute in azimuth.

The results are being plotted and analyzed to obtain the required correction factor.



MORTAR PROBLEM SIMULATOR
GENERAL VIEW SHOWING RANGE-MEASURING TECHNIQUE

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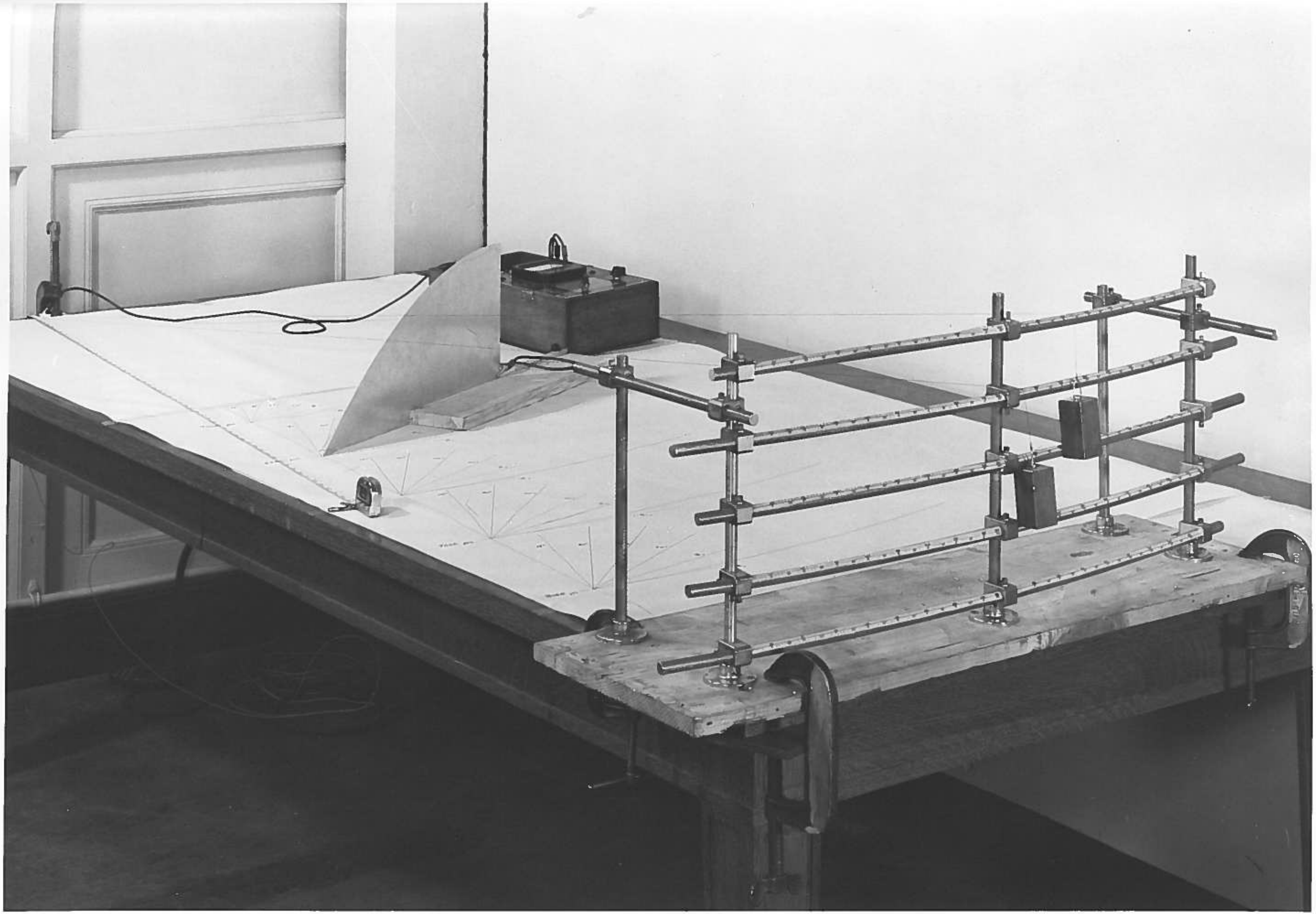

MORTAR PROBLEM SIMULATOR
GENERAL VIEW SHOWING BEAM-SETTING FRAMEWORK IN DETAIL

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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

By the beginning of the period under review the whole rotating structure was fitted to the trailer. This structure includes the main frame bolted to the king pin, the wave-guide array, rocking reflector and the associated hydraulic operating cylinder, hydraulic pump, accumulator, etc.

It was found necessary to throttle the hydraulic pilot valve to slow down the change-of-position time to around 1/10 second, the figure used in designing the reflector. Extensive dynamic strain gauge tests were carried out to check the actual stresses in the reflector structure with the calculated values. As a result of these tests minor modifications were made to the reflector hinge arrangement. The completed trailer was then turned over to the Microwave Section.

Hydraulic Rocking Mechanism

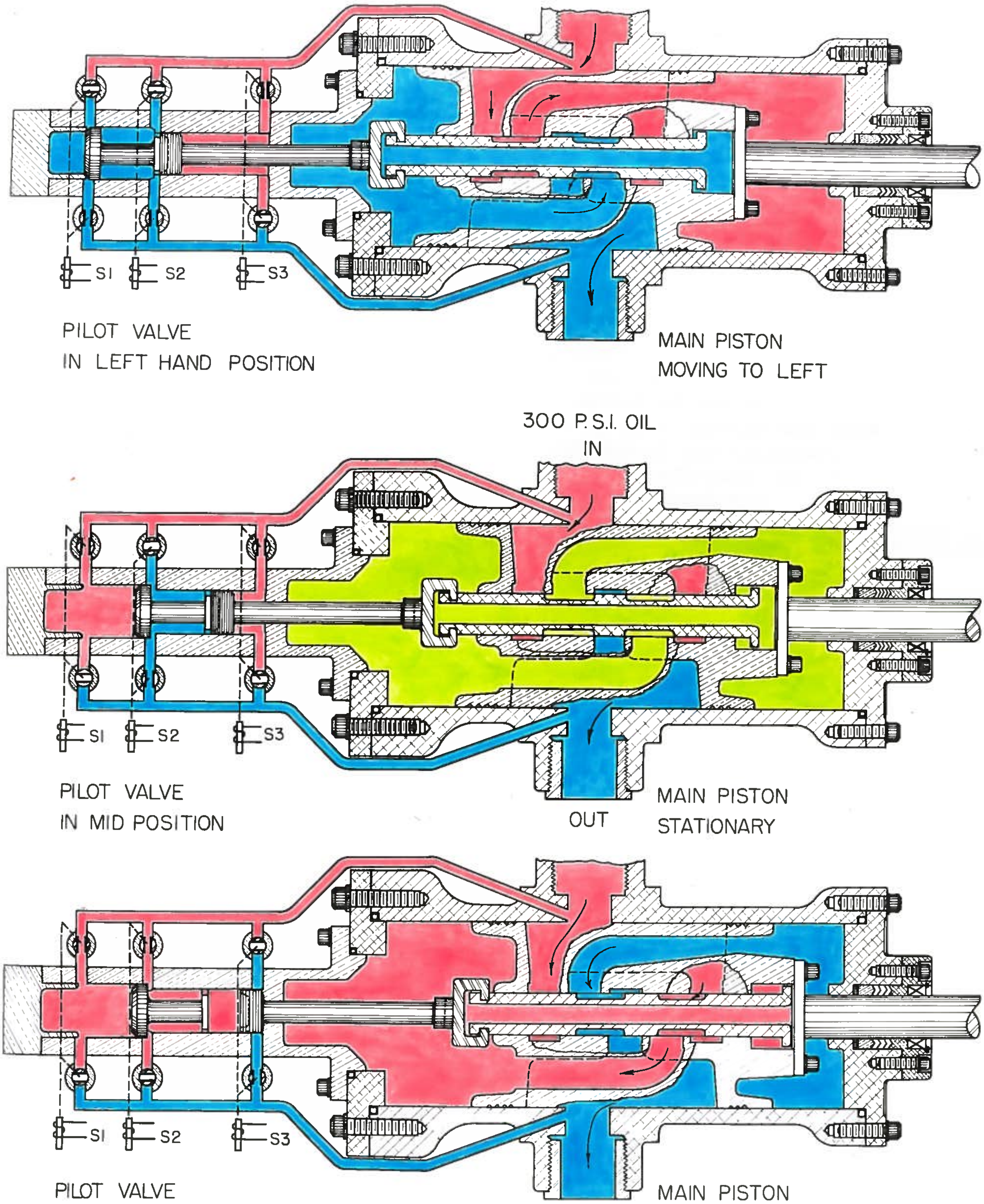
The mechanism (see figure) consists of three major parts:

(1) the solenoid-operated hydraulic pilot valve shown to the left on each diagram;

(2) the main valve rod in the center of the operating piston connected mechanically with the pilot valve piston;

(3) the operating piston connected by push rod and link motion to the antenna reflector; the main valve rod and operating piston form an hydraulic servo system wherein the main piston automatically follows any motion of the main valve.

The pilot valve assembly takes up one of the three positions shown in the three diagrams, depending on which position of the



NOTE 300 LB PRESSURE OIL
INTERMEDIATE PRESSURE OIL
EXHAUST OIL

SCHEMATIC DIAGRAM OF HYDRAULIC OPERATING MECHANISM

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reflector is desired. The main piston and valve, however, always come to rest relative to each other as shown in the middle diagram. In either the top or bottom diagram the piston would immediately be forced to follow the main valve until it reached the equilibrium position. This makes the piston self-cushioning. The closer it approaches equilibrium, the smaller the passage left for oil to flow and hence the slower the motion.

The top diagram shows solenoids S_1 and S_2 de-energized and S_3 energized. This allows the high-pressure oil - shown in red — to push the two pistons of the pilot valve to the left, with a force of 150 pounds available. This movement of the pilot valve pulls the valve rod in the center of the main piston to the left, allowing high-pressure oil to flow through the cast passages in the piston to the right-hand end of the cylinder. At the same time, passages are open from the left-hand end of the cylinder, through the valve and out, to exhaust the oil, shown in blue at the center of the piston. Actually, the passages in the piston are not all in one plane, as shown. The high-pressure oil inlet, and a corresponding space on the opposite side for balancing purposes, are in the plane of the paper. At right angles to these are the exhaust-oil passage and its balancing space. In planes at 45° to the above are located the passages connecting the ends of the piston with the valve — one pair of cored passages for each end.

The oil grooves in the valve rod are circular, and the valve is hollow so as to balance the valve hydraulically.

Under the conditions shown in the upper diagram, the high-pressure oil at the right-hand end would move the piston to the left. If the valve remains stationary, this movement automatically closes off the high-pressure oil supply to the right-hand end, and when the piston reaches its mid-position, the valve and piston are in the relative positions shown in the middle diagram. In this position both ends of the cylinder are at the same pressure, an intermediate pressure determined by the amount of leakage past the valve.

Under actual operating conditions, the piston and valve relative to each other would be as shown in the middle diagram whenever the piston is not moving.

If the main valve were stationary, with the piston to the left with respect to the valve, as in the lower diagram, then the oil would flow from the inlet at the top, through the valve and cored passage to the left-hand end of the cylinder. This would force the piston to the right, the oil displaced from the right-hand end flowing out through the center of the valve to the exhaust oil pipe at the bottom of the unit.

With solenoids S_1 and S_3 energized and S_2 not energized, the pilot valve positions itself as shown in the left-hand side of the center diagram. Oil pressure on the larger left-hand piston (which is separate from the right-hand unit — see lower diagram) forces it against a step part-way along the cylinder. At the same time oil enters the right-hand side and forces the smaller piston to the left until it rests against the first. As the left-hand piston is larger in diameter, the right-hand piston cannot push it away from the step and a positive mid-position is obtained.

If solenoids S_1 and S_2 are energized and S_3 is not energized, the pilot valve will take up the position in the lower diagram. The right-hand pilot piston will be forced to the extreme right, moving the main valve also to the right. Thus, whenever the solenoids on the pilot valve are energized for a different antenna position, the pilot valve rapidly snaps into its new position and the main piston follows, coming to rest smoothly approximately 1/10 second later. Should there be any wind load on the antenna the piston would be moved slightly with respect to the valve, allowing oil to flow to the end of the cylinder opposing the wind load. This would have a possible force of up to 4,000 pounds to resist movement, since the piston is 4 1/4" in diameter and operates at 300 pounds per square inch. The solenoids have been so arranged that with the power removed from all three, the antenna assumes the low-beam position. As it will probably be operated in this beam more often, this minimizes power consumption of the solenoids.

(b) Electrical

The rotating coupler has been completed, except for breakdown tests which are awaiting the high-power English Electric modulator. These tests will determine whether it will be necessary to pressurize the coupler. A voltage standing wave ratio of less than 1.1 over a 3.1% band has been obtained.

The receiver is being redesigned in the hope of achieving a 3- or 4-db improvement in the noise figure. The results of present work are encouraging. Flight tests of the antenna will be undertaken as soon as the new receiver is finished.

DISTRIBUTION

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