Progress report on CB and MZPI radar equipments January - March 1951

National Research Council of Canada. Radio and Electrical Engineering Division

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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

PROGRESS REPORT

ON

CB AND MZPI RADAR EQUIPMENTS

JANUARY - MARCH 1951

OTTAWA

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Report ERA-205

Secret

National Research Council of Canada

Radio and Electrical Engineering Division

PROGRESS REPORT

on

CB and MZPI RADAR EQUIPMENTS

January-March, 1951

COUNTER-BOMBARDMENT RADAR EQUIPMENT

A new main i-f amplifier strip of three quadruples was constructed to replace the old strip of three triples which had insufficient gain. The new amplifier strip had a measured gain of 81 db, a bandwidth of 21 mc, and was quite stable.

Early in January the improved i-f amplifier and a new pre-video amplifier were installed in the CB set. Considerable improvement in over-all gain and apparent signal-to-noise ratio was realized, resulting in a much better display.

An i-f amplifier strip with 10-mc bandwidth was constructed for purposes of comparison, but was found to be unstable. Several variations of construction were tried in order to discover the source of instability. An i-f preamplifier chassis of more "sanitary" layout was begun.

The equipment was demonstrated to a group of visitors representing the United Kingdom, the United States, and the Canadian Army. Among the U.S. delegates were several engineers in charge of a similar project at Camp Evans. The response from 3-inch mortar bombs was better than that from 4-inch bombs. This effect had been observed earlier and was confirmed by experience at Camp Evans. Results with the bomb approaching at 45° to the radar site were poor. This again was supported by Camp Evans experience. Cross-fire at 90° gave satisfactory results within the range of 3,000 yards used. Field conditions prevented moving the mortar to a greater range. In general, results were representative of those given in Report ERA-197, with a clearer presentation due to the receiver modifications noted above. The use of the velocity computer was demonstrated for the first time and this instrument gave results of the desired accuracy.

Considerable discussion followed the demonstration, and a useful interchange of ideas and general information on the U.S. and Canadian Mortar Locators took place.

It was felt that the change in frequency from 1.25 cm to 1.87 cm would be desirable from the standpoint of new tube development. Only a small improvement is to be expected due to the shift from the water-vapour absorption band (1.25 cm), except under conditions resulting in excessive reduction in range, even on 1.87 cm.

It was agreed that a velocity correction is highly desirable.

After the demonstration the equipment was brought in to the Metcalfe Road Field Station for further work on the receiver and computer.

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

The following work was carried out on the electrical components of the radar:

Intermediate-frequency Preamplifier

The cascode receiver has been rebuilt to use as many as possible of the sub-assemblies and production techniques which were used on the original receivers. Fig.1 is an underside view of this receiver, with the original receiver included for comparison. Synchronous single-tuned bifilar-wound coils were used as in the original receiver.

The question of specially selecting the tube in the first stage of this receiver was raised, and for this reason the i-f noise factor was measured on approximately one hundred type-6AK5 tubes. The results are shown in Fig.2. The effect of variations in i-f noise factor is to vary the over-all noise factor, and, consequently, the range of the radar on a given target. The last curve in Fig.2 converts i-f noise factor to relative range of the radar. An i-f noise factor of 1.5 db has been chosen to give 100 per cent range. The per cent change in range for any other noise factor may be read from the curves. (These curves cannot be used to compare crystals.)

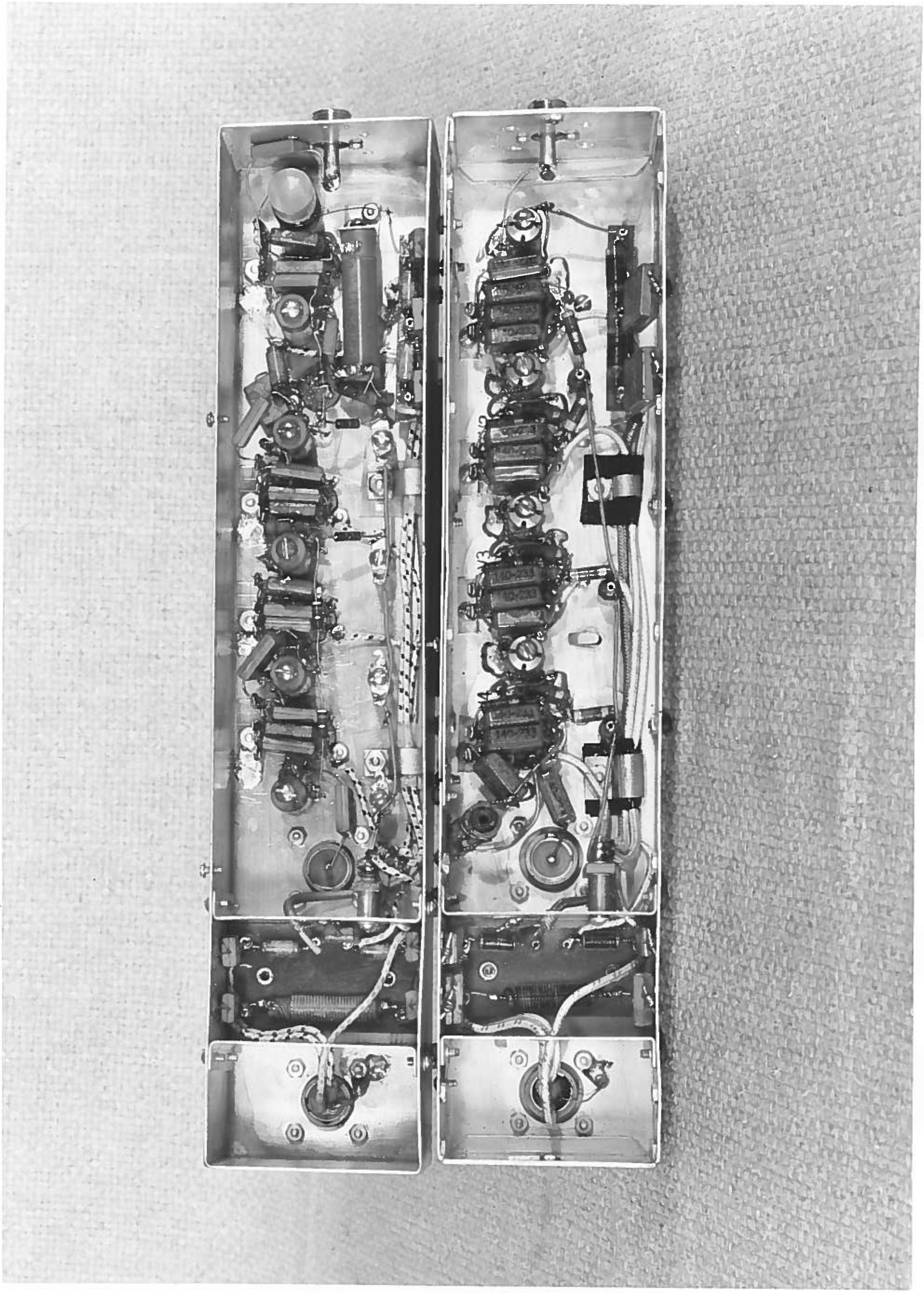
It would appear that the effect of 6AK5 variation is small, and probably does not justify the use of specially selected tubes.

Receiver Test Gear

As a continuation of the checking of test apparatus commenced during the last quarter, an NRC "bifilar" receiver of the type shown on the left in Fig.1 was taken to Canadian Arsenals. Noise factor measurements were made with their test apparatus, and excellent agreement was obtained with NRC measurements.

BTH Magnetrons

After proper aging, three of the four magnetrons received from the British Thomson-Houston Company, Limited, delivered 1.5 megawatts reliably and 2 megawatts with some arcing. The fourth magnetron was slightly inferior. Operation is very critically dependent on the output transition.



Cascode Receiver Mk. II (Using Type - 6AK5 Tubes) Original Receiver (Using Type-6AC7 Tubes)

Fig. I

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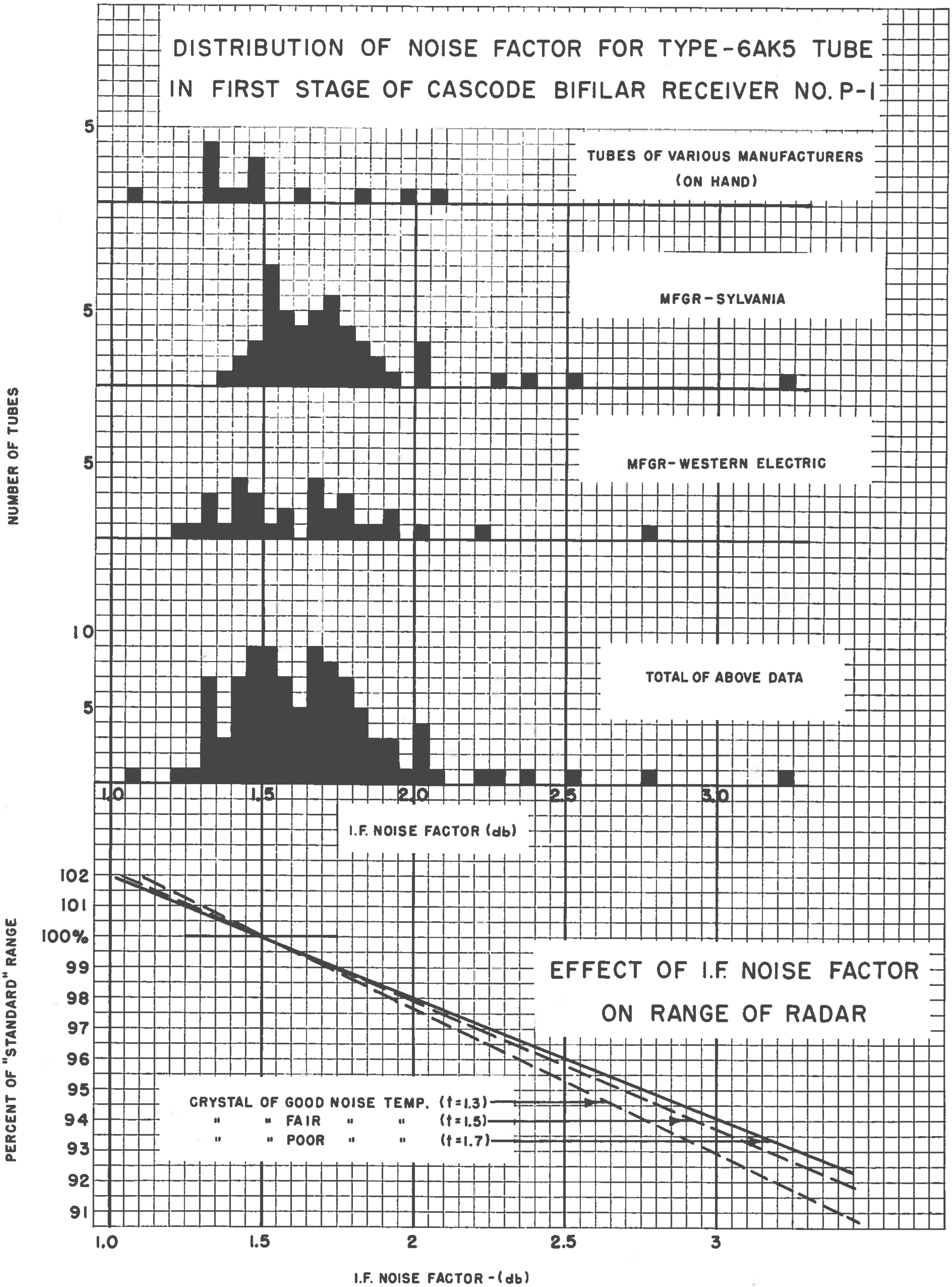
DISTRIBUTION OF NOISE FACTOR FOR TYPE-6AK5 TUBE
IN FIRST STAGE OF CASCODE BIFILAR RECEIVER NO. P-1
TUBES OF VARIOUS MANUFACTURERS
(ON HAND)
MFGR-SYLVANIA
MFGR-WESTERN ELECTRIC
TOTAL OF ABOVE DATA
NUMBER OF TUBES
5
5
5
10
5
1.0
1.5
2.0
2.5
3.0
I.F. NOISE FACTOR (db)
EFFECT OF I.F. NOISE FACTOR
ON RANGE OF RADAR
PERCENT OF "STANDARD" RANGE
102
101
100%
99
98
97
96
95
94
93
92
91
CRYSTAL OF GOOD NOISE TEMP. (t=1.3)
" " FAIR " " (t=1.5)
" " POOR " " (t=1.7)
1.0
1.5
2
2.5
3
I.F. NOISE FACTOR - (db)

FIG. 2

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The following precautions are desirable:

(a) a well matched load,
(b) a solid, low-inductance ground on the anode,
(c) an energy-sink to prevent excessive currents when the magnetron arcs,
(d) well controlled filament voltage,
(e) filament-voltage reduction as the power is applied,
(f) reduction of the pulse rise time to 150 kilovolts per microsecond,
(g) a three-minute time-delay relay in the high-voltage circuit.

Split Reflector

When the radar is used for its normal function of transmitting target information to gun-laying radars, there could be some advantage in broadening the high beam, at the expense of range performance on the "nose" of this beam*. This is because an approaching high-flying target might in some circumstances fly "out of" the high beam before a gun-laying set could be put on the target.

One of the methods proposed to achieve this effect is to hinge the reflector longitudinally one-third of the distance from the bottom. A mock-up of the antenna was constructed and antenna patterns were measured. Appreciable widening of the beam was obtained, but it was decided that the resulting advantage would not justify the additional mechanical complexity in practice.

Low-level Tests of Polarization Duplexers

The Mk.I Polarization Duplexer was assembled with a mixer, magnetron, T/R cavity, 30-mc i-f receiver, and local oscillator. Various type-1N21B crystals were inserted, and the standing-wave ratio of the complete system was determined. In all cases the voltage standing-wave ratio was better than 1.4, corresponding to a maximum mismatch loss of about 0.1 db, which is negligible.

High-level Tests of Polarization Duplexer

Owing to the impossibility of obtaining polarizing tubes commercially, Pyrex tubes were constructed in our tube laboratory. The filling was identical to that of the British type-CV294 pre-T/R tube. These were installed in the Mk.I Polarization Duplexer and

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* See coverage diagram, Fig.4 of NRC Report ERA-193.

operated at a peak power level of 1.5 megawatts. Excessive loss occurred and some tubes melted. It was concluded that different filling and tube material (for example, quartz) must be tried.

In order to measure T/R leakage power, a dummy crystal was constructed consisting of a thermistor mounted in a crystal cartridge. Leakage power was found to average 120 microwatts at a peak power of 2 megawatts with a pulse length of 1.5 microseconds and a PRF of 380 pulses per second. Instability was observed, which indicated improper functioning of the magnetron. In order to provide adequate crystal protection, it would be highly desirable to reduce this figure to below 90 microwatts. One measurement on the existing MZPI set gave 97 microwatts, at a peak power of 0.6 megawatts, a pulse length of one microsecond, and a PRF of 590 pulses per second.

Polarization Duplexers — General

Work was started on a Mk.II and a Mk.III Polarization Duplexer. The Mk.II Duplexer has a rectangular waveguide input in order to simplify layout problems. Mk.II and Mk.III have a reduced circular waveguide diameter to prevent propagation in the TM_{01} mode.

Range Delay Chassis

Flight trials using the cascode receiver revealed that a modification of the range sweep would be desirable, since large aircraft could be followed until they reached the edge of the tube.

In order to extend the maximum range to 200,000 yards, a phantastron delay chassis was designed and installed in the sweep and calibration chassis of the radar. This circuit delays the start of the range sweep. At the request of the Directorate of Armament Development, a similar modification was made to the Canadian MZPI set undergoing trials in the United States.

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