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WIDE RANGE TUNING METHODS AND TECHNIQUES

APPLICABLE TO SEARCH RECEIVERS

QUARTERLY PROGRESS REPORT NO. 11, TASK ORDER NO. EDG-4
Period Covering January 1, 1954 to March 31, 1954

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Project 1970

CONTRACT NO. DA-36-039 sc-15358
SIGNAL CORPS, DEPARTMENT OF THE ARMY
DEPARTMENT OF ARMY PROJECT NO. 3-99-04-042
SIGNAL CORPS PROJECT 29-194B-0

April, 1954

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ABSTRACT

The progress of the Electronic Defense Group on Task EDG-4 is reviewed for the quarter ending March 31, 1954. Magnetic cores made by Task EDG-6 are being tested, and the type J core found to have drifting properties. Barkhausen noise in ferroelectric capacitors is being measured on the recently completed equipment. Double hysteresis loops were found in titanate ceramics. A negative capacity amplifier was investigated. The progress on voltage tunable magnetrons is outlined.

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1. PURPOSE

This report reviews the progress made by the Electronic Defense Group in the study of wide range tuning methods and techniques applicable to search receivers during the first quarter of 1954.

2. PUBLICATIONS AND REPORTS

Dr. L. W. Orr delivered a paper entitled, "Wide Band Amplitude Distribution Analysis of Voltage Sources" at the IRE Convention on March 25, 1954. This paper was based on EDG Technical Report No. 22, October, 1953.

Mr. H. Diamond attended the Symposium on Ceramic Dielectrics at Rutgers University on March 10, 1954.

Mr. William Parker was added to the staff as a part time employee on March 2, 1954.

Dr. J. M. Luttinger of the Physics Department was contacted regarding theoretical consultation in ferroelectric materials and agreed to give assistance if time permitted.

3. FACTUAL DATA

3.1 Use of Ferromagnetic and Ferroelectric Materials in the Tuning of RF Components

3.1.1 Ferromagnetic Materials. (L. W. Orr and L. C. Beavis)

3.1.1.1 Magnetic Ferrite Core Tests in the 1-10 Megacycle Region.

Most of the effort in this quarter has been the analysis of behavior of type J cores produced under Task 6. These cores at first appeared to have much promise for magnetic tuning because their magnetic properties seemed quite insensitive to the final firing temperature over a limited temperature range.

In comparing the measured values of μ_1 and Q for these cores taken just after processing, and later after shipment to the North Campus, a very poor check was obtained. It was later discovered that this type of core had drifting magnetic properties which accounted for the discrepancy, making this core type unsuitable for magnetic tuning. It is believed that the drift in μ_1 was caused by the presence of ferrous iron ions. The problem of eliminating the ferrous ions is now being studied under Task 6.

3.1.1.2 Low-Q Measurements.

A workable method for making low-Q measurements on ferrite cores has been partly developed for frequencies up to about 5 mc. There has not been much work done on this during the quarter because of the priority of higher Q measurements on the type J cores.

3.1.1.3 Ferrite Cores in the 100 Megacycle Range.

The cores tested in this frequency range have been confined to a class of VHF cores produced by Task 6. These were found unsuitable for magnetic tuning because of the very small tuning range obtained.

3.1.2 Ferroelectric Materials Study. (M. Winsnes and W. Parker)

3.1.2.1 Barkhausen Noise Measurements in Ferroelectric Specimens. The equipment described in the previous progress report has been completed and several specimens have been investigated. It has been possible to make quantitative noise measurements of the gated noise as a function of the phase of the applied ac field.

In general, the Barkhausen noise found in titanate ceramics increases with temperature and with increasing peak field. It varies over the cycle having a maximum roughly at the coercive point in the polarization loop. Technical Report No. 32 will be written on this work when the investigation is more complete.

3.1.2.2 Literature Survey. (H. Diamond) A survey has been made of the current literature on ferroelectric materials. There has been a rapid advance in development of new ferroelectric materials. Certain materials other than barium-strontium titanates appear to have desirable properties. These may prove useful in dielectric tuning and frequency modulation.

Although piezoelectric effects have not been observed to date in our investigation, several authors have noted these as undesirable in dielectric tuning and amplifier applications. A simple method of detecting piezoelectric resonances was discussed in the recent Symposium on Ceramic Dielectrics, Rutgers University, March 10, 1954.

3.1.2.3 Effect of Electrode Plating. (H. Diamond) Two methods of applying silver electrodes to titanate specimens were investigated. In the first method, a thin coating of General Cement Silver Print No. 21-2 is painted on and dried in an oven. In the second method, a very thin pure silver layer is deposited by the high-vacuum evaporation technique.

When using pure crystals of barium titanate, the vacuum plated electrodes gave lower losses and steeper sided P-E loops than the silver painted electrodes. This was tried on commercial samples of titanate ceramics. In this investigation, twenty-five ceramic samples were measured at frequencies ranging from 60 cycles to 1 megacycle. The vacuum plated electrodes gave lower losses in every case than either the commercial plating (furnished on ceramic capacitors or silver painted electrodes. In cases where the ceramic is rather thin, a considerable improvement is obtained with the vacuum plating.

3.1.2.4 Double Hysteresis Loops. When samples of certain commercial ceramics were furnished with vacuum plated electrodes, they exhibited double hysteresis loops.[1] The loops showed no abrupt change over a temperature range of 10°C to 50°C. This rather unusual behavior was not explainable on the basis of presently known theories which predict a sharp transition at the Curie temperature. The effect is being investigated further.

3.1.3 Electric Tuning.

3.1.3.1 Negative Capacity Amplifier. (L. W. Orr, H. Diamond, and L. Beavis) A negative capacity amplifier[2] was constructed in an attempt to increase the tuning range of an electric tuned oscillator. This unit has a negative input capacity, and by using it as part of the tank circuit of an oscillator working near 1 mc it was hoped that the tuning range could be increase by decreasing the minimum (high field) capacity of the variable ceramic element.

Q-meter measurements of the negative capacity circuit alone showed favorable operation up to about 2 megacycles. At frequencies above 3 mc the input conductance turned negative, and the unit tended to oscillate strongly.

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[1] Electronic Defense Group Quarterly Progress Report No. 10, Task No. 4, January, 1954.

[2] MIT Radiation Laboratory Series, Vol. 19, Appendix A, p. 767, McGraw-Hill, 1949

In the 1 mc region, the unit was given a preliminary test when placed in an oscillator tank circuit. The results were not satisfactory since the combination seemed to be unstable.

The properties of the negative capacity amplifier as a circuit element will be described more fully in Technical Report No. 31 (to be issued).

3.1.3.2 VHF Electric Tuned Oscillators. (H. Diamond) Work in this area was suspended during the quarter pending delivery of special capacitors required for the investigation.

3.2 Investigation of Techniques for Signal Detection and Frequency Determination

3.2.1 Voltage-Tunable Magnetrons. (R. Bradley) Work in the last quarter consisted of constructing and assembling the necessary equipment to place the magnetron in operation. A permanent magnet assembly, not mentioned in the previous report, was constructed to eliminate the electromagnet and its controls. The new magnet provides a field of 3.3 kilogauss.

The emphasis of this quarter has been on the assembling of noise measuring equipment (see Fig. 1). The magnetron output is fed through a length of lossy coaxial cable and a variable attenuator to a crystal mixer, where it is mixed with the output of a klystron signal source (Hewlett-Packard 616A Signal Generator or other). The mixer incorporates a crystal current monitor, and its output is passed through a step attenuator to a 200 mc IF amplifier. The amplifier output is detected with a crystal rectifier and a microammeter indicating the magnetron output. Although individual components are operating satisfactorily for the most part, only preliminary test runs of the system have been made. A suitable noise source has yet to be obtained.

Crystal rectifiers and an oscilloscope are used to monitor the output of the magnetron and klystron local oscillator. A coaxial wavemeter is used to determine the frequency of the magnetron and klystron outputs.

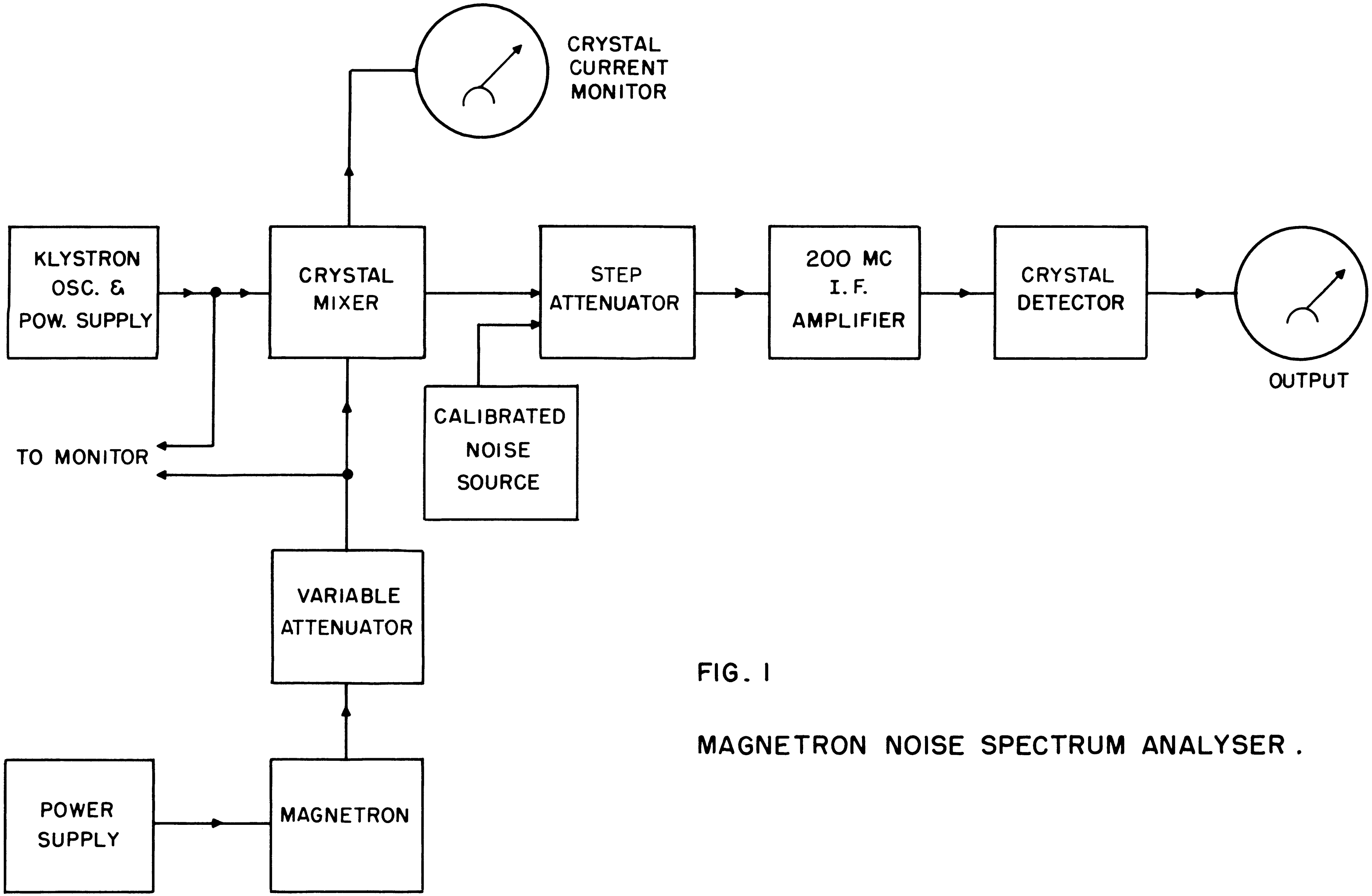

FIG. 1

MAGNETRON NOISE SPECTRUM ANALYSER.

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The equipment is to be used in a point by point analysis of the magnetron output frequency spectrum under various operating conditions.

4. CONCLUSIONS

Except for the completion of the development of low-Q measuring techniques, which does not appear to have any immediate application, the major objectives of the quarter were accomplished, and the remaining work is proceeding satisfactorily.

5. PROGRAM FOR NEXT INTERVAL

5.1 Ferromagnetic and Ferroelectric Tuning

An interim report, Technical Report No. 29, "Ferroelectric Materials", will be written to summarize the findings to date of this continuing investigation.

Technical Report No. 30 "Ferromagnetic and Ferroelectric Tuning" will be written giving a comprehensive evaluation on the basis of presently known data.

The negative capacity amplifier as a circuit element will be further investigated and the results summarized in Technical Report No. 31.

The investigation of double loops and effects of plating methods will continue on titanate ceramics, as well as the Barkhausen noise study.

The study of VHF electric tuned oscillators will continue pending delivery of special thin ceramic capacitors. Efforts will be made to extend the upper frequency limit.

5.2 Voltage-Tunable Magnetron

A program to determine the feasibility of voltage-tunable magnetrons in search receivers is now being outlined. This will include the effect of various parameters on noise figure. The first part of the program will consist of measuring the off-carrier noise spectrum of an unmodulated cw magnetron, and the necessary equipment for this is now complete.

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