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ATTENTION: AFAL-WRP
Wright-Patterson AFB, Ohio 45433

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This is the ninth monthly progress letter on Contract F33615-73-C-1174 and covers the period 15 November - 15 December 1973

Progress during this reporting period has been made on three fronts: computer programs, resistive sheets and near field effects.

Computer programs

Program RAML is now essentially complete and a test copy (i.e., a deck of FORTRAN source cards) has been forwarded to AFAL for testing on the CDC computer there. RAML is a generalized program which incorporates electric and magnetic sheets for either E- or H-polarization in addition to a surface impedance boundary condition, and is the "extension" of program TWOD which will permit us to combine the features of several previous programs, as well as to include new capabilities not available in these older programs.

Due to minor differences between the IBM and CDC computer systems (RAML was developed on the IBM system at Michigan), a few changes had to be made. The CDC compiler, for example, does not have a built-in subprogram for the cotangent function and this had to be remedied by specifically inserting a cotangent subroutine into the program. While these defects were being repaired at AFAL, further testing of RAML was being carried out at Michigan. Special cases were run which could be compared with the results of previous programs, such as RAMD and REST, and we are now satisfied that RAML does all that is expected of it. A copy of the final version has been sent to AFAL and we shall be using RAML extensively in the next reporting period.

Earlier in the contract we found that it was extremely helpful to have available the phase of the scattering as well as the amplitude, and such a provision was designed into program RISK. Program RISK is a modified version of REST and was used extensively to study resistive sheets for E-polarization. The success of having phase data at hand in this program impelled us to modify program RAMD in a similar fashion. The modification is a minor one and the necessary cards have been transmitted to AFAL.

Other programs, or modifications of programs, include programs RASP and RAMF. As pointed out below, we have virtually exhausted the possibilities of cross section reduction using resistive sheets and the need now arises for more control of the sheet properties. One control option is to permit the sheet to have a reactive component in addition to a resistive one, but program RISK accommodates only real (purely resistive) properties. In order to include complex impedances along electric sheets we have modified the program, and the new program is called RASP. Program RASP can do everything previously done by programs REST and RISK and a copy of it has been sent to AFAL.

Program RAMF was developed to study near field effects and permits us to place a line source near a conducting two-dimensional obstacle. RAMF compares the near scattered field with the far field and is based upon the impedance boundary condition integral equations presented in our most recent Interim Report. The program has been used but little in comparison with the others, but has yielded quite useful information, as discussed below.

In summary, the following programs are now in the hands of AFAL:

- RAML, a generalized program that handles electric and magnetic sheets, and includes the surface impedance boundary condition over an inner core;
- RAMD, an impedance boundary value program that now prints out phase as well as amplitude;
- RASP, a program for electric sheets having both resistive and reactive parameters;
- RAMF, a near field program for metallic obstacles.

Resistive sheet study

An intensive study of resistive sheets has been completed during this reporting period. From a sequence of computer runs involving linear, parabolic and cubic distributions along a sheet placed in front of an ogival cylinder, we have isolated the dominant components of the scattered field. There seem to be only two, one each associated with the leading and trailing edges of the sheet. For a fixed sheet width, increasing the leading edge resistance decreases the leading edge contribution but it increases the contribution from the rear of the sheet. This is true for all distributions studied, although the rear edge return may be weaker for higher order distributions.

As a result, the total cross section decreases to a minimum value with increasing edge resistance then begins to rise again. This behavior is sketched qualitatively in Figure 1. The result is that the net scattering can be reduced no more than is available at the optimum resistance value. If more reduction is desired, there is no way to obtain it except to use a wider sheet. If the reduction must be accomplished using a sheet no wider than a given value, then the performance will be limited to the minimum level as indicated in Figure 1.

These statements apply only to purely resistive sheets and may not necessarily hold if the sheet is permitted to be slightly reactive. To explore the possible advantages of such sheets we have modified program RISK as described above. In the coming months we plan to exercise the program, concentrating on the higher order distributions which seem to have been most favorable.

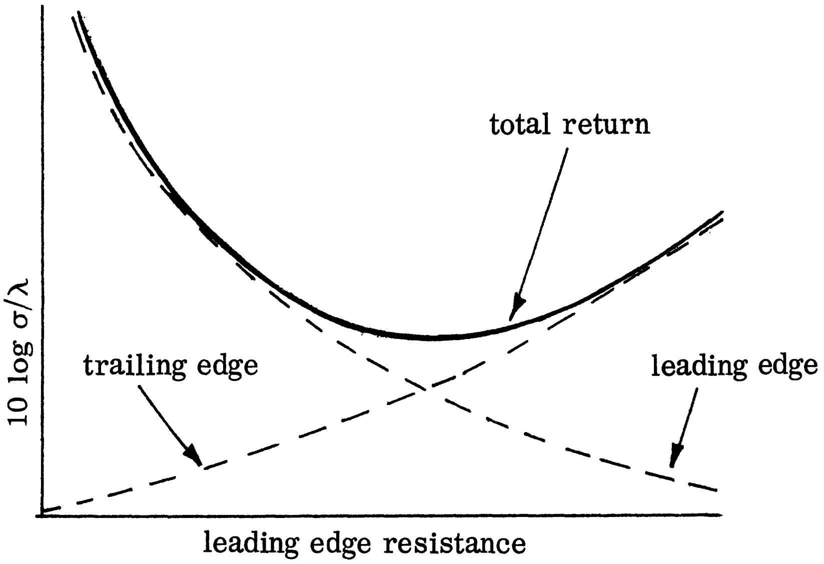


Figure 1.

Near field studies

The near field program RAMF was not used heavily during this reporting period, but several interesting configurations were examined. Among the cases studied were isolated circular cylinders, arrays of small cylinders, flat plates and ogival cylinders. Although the standard far field requirement $R = 2L^2/\lambda$, where L is the maximum body dimension and R is the necessary range to the target, is often a good criterion for accurate measurements, there are instances when it is not. For example, circular cylinders 4 wavelengths or more in diameter can be measured with an accuracy of 0.5 dB at the standard far field distance, but smaller cylinders cannot; the error increases as the cylinder shrinks in size.

Of particular concern is the error that can be incurred for ogival cylinders $3\lambda$ wide; we have found that at the standard range a 3 dB error can be made and that if the measurements are made at only half the far field distance, it can be as large as 4 dB. In order to obtain better than 0.5 dB accuracy, the range must be fixed at 4 times the normal distance, a rather stringent requirement. This may explain why cross sections measured both at AFAL and The University of Michigan were consistently lower than the predicted levels. The study of these near field errors is being pursued and we hope to offer an explanation of their origin.