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THE EFFECTS OF HIGH LEVEL GAMMA RADIATION ON TELEMETERING R. F. LINKS

SCTM-6-53-52

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ABSTRACT

A report on an experiment conducted at Los Alamos by members of Division 5222, Micro-time Systems, of Sandia Corporation on October 3, 1952.

Case No. 474.0

January 22, 1953

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PREPARATION

Early in September of 1952 our organization was notified by Los Alamos that they expected the arrival of a 30 kilo-curie source around the end of that month. Our interest in the source centered on a desire to determine the effect of high levels of radiation on our telemetering package. Experience in the past had been that our transmitter cut off prior to being mechanically disrupted. This had led to the theory that the cut-off was due to ionization in and around the package produced by the radiation from the nuclear reaction.

The operation of our telemetering package involves the discharge of a condenser that impresses a 3,000 volt pulse on the plate of the final amplifier. Experiment has shown the normal length of this pulse to be on the order of 7 millisecond. Further experiments with a radiation source of 6,800 C of RaBa and 7,800 C of RaLa has shown that this pulse length decreases, presumably due to the radiation of the source. It was postulated that a more active source would produce a definite cut-off or, in effect, would short out the transmitter.

A week prior to the expected arrival of the source, the materials to be tested and related test equipment were taken to Los Alamos. During this trip, procedures for the experiment were worked out to the satisfaction of all concerned. The only limiting factors were the physical set-up at Tensite, standard methods and procedures of the group at Tensite, and normal safety practices. None of these presented any major problem.

It had been decided in our group to expose each unit of our package individually. These were the exciter, the amplifier, the modulator, and the junction box. In this manner we might find to what extent each unit is affected by radiation.

The sketches on Page 6, Fig. 1 and Fig 2 show the manner in which the source is shielded during an experiment. It should be noted that the sketches show only those details in which we have interest. For example, cylindrical shield is not solid; but is, rather, a concrete and steel shell some 8 or 10 inches thick, enclosing two lead D's - one on either side of the opening. Access to the center for large components

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Sketches of shielding for 30 kilo-curie Gamma source. (ref page 5).

[Sketches not included on microfilm]

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is through an 8x10 inch slot that extends through the whole shield at floor level. A circular opening extends through the top to allow passage of the crane cable which raises and lowers the source.

The aluminum trough is anchored by 150 to 200 pounds of lead brick piled on its outer end. The aluminum angles on the other end guide the micarta slide over the hole in the floor to prevent its being caught and stopped.

Normally, the source is kept in a well shielded chamber some 15 feet below the work area. It is picked up, by remote observation and control, on a cable that is lowered from the upper chamber. It is then lifted into the cylindrical shield in the work area.

In the initial planning of procedure it was decided that no one be in the room with the cylinder when the source was up in it. This was out of respect for the 30 kilo curie figure. The original plan was that the components to be tested were to be mounted on individual micarta slides, cabled together into an operating package, and placed on the floor beside the protruding aluminum trough. One slide could then be placed in the trough (the source being in the chamber below the floor) and attached to the insertion cable. The upper chamber would then be vacated and the source raised into the cylinder. The insertion device, operated from outside the source room, would then move the micarta slide and package component into the cylinder and under the source.

The end of the shield opening that faced the door of the source room was bricked up with lead brick for obvious reasons. The package units were mounted on their slides in such a manner that the component was centered under the source when its micarta slide was butted up against the lead brick in the opposite end of the cylinder opening. The source could then be lowered to any point up to that where its container touched the unit under radiation.

The test procedure was then merely to "fire" the telemetering package with the source at various distances from the particular unit being tested. The pulse was observed on a Tektronix 511-D oscilloscope which got its signal from the detector of the standard receiver used in our operation. A Fairchild Polaroid Oscilloscope Camera was used to record the scope presentation.

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REPORT

When the source arrived at Los Alamos, it was found to be considerably less active than the 30-kilo-curies expected. Analysis or measurement at Tensite resulted in values of 5,300 curies of RaLa and 7,500 curies of RaBa. An intensity measurement showed 2,044 R per min. at 9. inches. Appendix I, page 13, shows the relation between the above values when an R value is calculated from the activity of the source. These calculations are made to check the accuracy of the method which is also used to correlate a particular stage of nuclear reaction with an R value. These latter calculations are in Appendix II, page 15.

These figures are, at best, only relative. The actual energy absorbed by various circuit elements would depend upon their composition and the materials between them and the radiation source.

Tabulated test data are in Table I, page 9. These show distances from the source, oscilloscope sweep speed, and the identifying numbers of the pictures. The pictures are on page 10.

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TABLE I

Distance*	Component	Picture Number
35. inches	Power Amp.	1
18. inches	Power Amp.	2
11. inches	Power Amp.	3
8. inches	Power Amp.	4
34. inches	Modulator	5
17. inches	Modulator	6
10. inches	Modulator	7
6. inches	Modulator	8
34. inches	Junct. Box	9
17. inches	Junct. Box	10
9. inches	Junct. Box	11
9. inches	Junct. Box	12
35. inches	Exciter	13
18. inches	Exciter	14
10. inches	Exciter	15
4. inches	Exciter	16

1. *Distance is that from the center of the source to the geometric center of the component.

2. All pictures are of 7. millisecond sweep, full scale.

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Pictures as noted in table on page 9, and as mentioned on page 8.

Pictures not included on microfilm reel

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CONCLUSIONS

As can be seen in the pictures on page10, the experimental results are negative. The observed pulses range from a minimum of 4.6 milliseconds in picture No. 3 to a maximum of 7.1 milliseconds in No. 6. The variations are of random nature and of no apparent relation to radiation intensity.

The question arises -- why was the pulse shortened in the previous test and not in this one? This cannot be answered in any absolute fashion, for any change in the package or in the test procedure could have been responsible. An example of the former is the substitution of a 3E29 tube for the 829-B formerly used in the final. The major difference between the two being that the 3E29 is the more highly evacuated tube, and one would expect less ionization within the tube due to radiation. An example of the change in test procedure is the irradiation of the package as a whole in the earlier experiment and of individual components in this case.

In regard to the tube substitution, the results might indicate a large effect in the final amplifier. In regard to the change in procedure, the results might indicate that the effect of radiation is composite and not to be taken as a single effect in a single component. These, of course, assume all other parameters being equal.

One other parameter, while not necessarily changed, is uncertain. The activity of the source used in the first experiment was not too well known The same information regarding the source was available, but the technique of handling and calibrating large sources appears to have been in the development stage around the time of the first test.

In view of these differences then, no objective comparison of the two tests can be made. The only conclusion to be drawn from this test is that any one of the Telemetering Package components can be depended upon to function as usual under radiation of an intensity corresponding to the 25th generation of bomb reaction development.

Appendix III consists of a generalized discussion of the interaction of radiation and the RF components tested.

Tests in the future will be directed toward answering the questions not satisfied up to this date.

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G. G. CURRY - 5222

Case No. 474.0
January 22, 1953

APPENDIX I

Source:

7,500 C RaBa	Tensite data
5,300 C RaLa	
2,044 R min^{-1} @ 9 inches	

According to the decay scheme of the Ba^{140} system and the above curie values:

RaBa - 7.27×10^{13}	γ	sec^{-1}	@	0.5	Mev
RaLa - 2.74×10^{13}	"	"	"	2.4	"
1.69×10^{14}	"	"	"	1.6	"
1.03×10^{14}	"	"	"	0.82	"
4.61×10^{13}	"	"	"	0.49	"
6.9×10^{13}	"	"	"	0.35	"

Relating R sec^{-1} to γ sec^{-1} of energy E Mev:

$$\frac{\mu\,(cm^{-1})\,N\,(\gamma\,sec^{-1})\,E \times 10^{6}(e\gamma^{-1})\,4.8 \times 10^{-10}(esu\ io\gamma^{-1})}{4\pi X^{2}(cm^{2})\qquad 32.5(e\gamma\ io\gamma^{-1})} =$$

$$= 4.12 \times 10^{-11}\,\frac{N.E}{X^{2}}\ esu\ cm^{-3}\ sec^{-1}$$

But 1 esu cm^{-3} = 1 R

$\therefore$ above = $4.12 \times 10^{-11}\,\frac{N.E}{X^{2}}$ R sec^{-1} @ X cm from source

N = No. of photons sec^{-1}

μ = absorp. coefficient of air = 3.5×10^{-5} cm^{-1}.

if 0.07 Mev < E < 3.0 Mev.

X = distance from source in cm.

R

@ X = 9 in = 22.8 cm.

$X^2 = 5.2 \times 10^2$ cm.

R sec^{-1} = 7.9×10^{-14} N.E

Ba - $7.9 \times 10^{-14} \times 7.27 \times 10^{13} \times 0.5$ = 2.87 R sec^{-1}

La - $7.9 \times 10^{-14} \times 2.74 \times 10^{13} \times 2.4$ = 5.2 R sec^{-1}

$7.9 \times 10^{-14} \times 1.69 \times 10^{14} \times 1.6$ = 21.4 R sec^{-1}

$7.9 \times 10^{-14} \times 1.03 \times 10^{14} \times 0.82$ = 6.66 R sec^{-1}

$7.9 \times 10^{-14} \times 4.61 \times 10^{13} \times 0.49$ = 1.79 R sec^{-1}

$7.9 \times 10^{-14} \times 6.9 \times 10^{13} \times 0.35$ = 1.91 R sec^{-1}

39.83 R sec^{-1}

60 sec min^{-1} x 39.8 R sec^{-1} = 2,390 R min^{-1}

This value includes neither absorption in the source container nor scattering. Assuming that the former is the greater effect, a quarter-inch of metal of μ ~.25 cm^{-1} will reduce 2390. to a value in close agreement with 2044.

APPENDIX II

Relating a stage of nuclear reaction to an R value:

Assuming:

Telemetering pkg. is 6. ft = 183. cm from pit center

γ's from pit ~ 1.9 Mev

3×10^{-3} γ fission^{-1} get through tamper, H. E., etc.

$$2{,}044 \text{ R min}^{-1} = 3.41 \times 10^{-7} \text{ R shake}^{-1}$$

$$\frac{4.12 \times 10^{-11} \times 1.9}{3.35 \times 10^{4}} \cdot N = 3.41 \times 10^{-7} \text{ R shake}^{-1}$$

$$N = 1.46 \times 10^{8} \ \gamma \text{ shake}^{-1}$$

$$\frac{1.46 \times 10^{8} \ \gamma \text{ shake}^{-1}}{3 \times 10^{-3} \ \gamma \text{ fis}^{-1}} = 4.87 \times 10^{10} \text{ fis shake}^{-1}$$

Neutron growth is given by:

$$n = n_o e^{\alpha t}$$

$$\text{if } n_o = 1 \quad n = e^{\alpha t}$$

$$\frac{dn}{dt} = \alpha e^{\alpha t} = \alpha e^{g} (\text{n shake}^{-1})$$

where

$$g = \alpha t$$

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There are ~ 2.5 neut fission^{-1}

$$2.5 \text{ n fission}^{-1} \times 4.87 \times 10^{10} \text{ fission shake}^{-1} = 1.22 \times 10^{11} \text{ n shake}^{-1}$$

$$\alpha \sim 2. \text{ shake}^{-1}$$

$$e^{\alpha t} = e^{g} = \frac{1.22 \times 10^{11}}{2} \text{ n shake}^{-1} = 6.1 \times 10^{10} \text{ n shake}^{-1}$$

$$g = \ln (6.1 \times 10^{10}) \qquad \text{where } \ln = \log_e$$

$$0.434\, g = \log_{10} (6.1 \times 10^{10})$$

$$0.434\, g = 10.787$$

$$g = 24.8 \approx 25\text{th generation}$$

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APPENDIX III

The effect of radiation on the package may be studied from two different points of view. As mentioned before, it is possible to calculate a Roentgen value, an instantaneous value, for a particular stage of the nuclear reaction. (See Appendix II, page 15) Normally, this would be the value sought in such calculations. Because of the very short time involved in the whole reaction, it may be wiser to look upon the radiation effect as cumulative.

There is an effect only because the radiation ionizes the air surrounding the package and the materials of the package itself. This ionization, (and here only the ionization in air is considered) is discharged or dissipated by recombination of positive and negative ions or by the collection of ions on charged surfaces wherever an electro-static field terminates. Both of these actions require time, and, while no values of the time involved in the former case are available here, the recombination requires more time than the collection of ions. This is true, of course, when the two actions are competing and is based on the assumption that, if it were not true, ionization chamber instruments would not be as reliable as they are.

In the case of the collection of ions, it is not difficult to calculate the tim involved in a particular situation. Assuming ionization occurs between two surfaces, one at ground potential and the other at plus 1000 volts, separated by 2. cm. of air. The average negative ion, one produced mid way between the two surfaces, will take on the order of 10^{-9} sec. to get to the positive surface. If the electric field is less intense by virtues of lower potential and/or greater separation of surfaces, the time involved is greater. Conversely, higher potentials and/or less separation of surfaces will decrease the time. Similar actions take place throughout the volume of the package where ever an electric field exists.

Therefore, it is theorized that the action and effect of radiation on our package is complex in nature; that is, it cannot be traced to any one locale or component in the package. It is a summation of effects such as leakage currents between charged surfaces even in such things as mic or ceramic condensers. Since the time involved (10^{-9} seconds as calculated above) is small, the ionization currents or leakage currents in effe begin as soon as radiation strikes the package, but they increase on a cu that follows the Time-Intensity curve of radiation. The final effect of the radiation is then the effect of many individual occurrences integrated fro t_o to t_x, where t_x is the cut-off time.

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