TENTATIVE

DISCLOSURE

FROM

CARBIDE AND CARBON CHEMICALS COMPANY (U)

CCID NO. 638

AEC CASE NO.: S-12 761

INVENTORS: Everitt P. Blizard and John W. T. Dabbs

SUBJECT: METHOD AND APPARATUS FOR DETERMINING RADIATION INJURY (U)

OBJECT: To provide a method and apparatus for determining the biological injury at a given time due to exposure to radiations at previous times.

DESCRIPTION:

Fig. 1 is a schematic diagram of an instrument designed to accomplish the above-stated object.

It is generally accepted by persons skilled in the art that a given total radiation dose can have vastly different biological effects depending upon the time schedule on which it is administered. In general, the injury attributable to a dose is proportional to the magnitude of the dose and to some function of the elapsed time since the dose. Certain other conditions, such as the amount of injury previously sustained, may also affect the injury.

At present there are no proven relationships between injury and the time interval, although some such relationships have been proposed. The choice of the function clearly must be predicated upon some "model" for biological damage and recovery, and cannot be simply the result of "curve" fitting. One of the more simple "models" of damage is that described by H. A. Blair (Reports UR-206 and UR-207). In this model, it is assumed that an injury is made up of two parts, one irreparable and the other reparable. The latter decreases exponentially with time after administration of the dose. The incremental injury δI from an increment of dose δD may be expressed as: $\delta I = Ak\delta D + Bk\delta D e^{-\beta T}$, where k = a constant relating injury to dose

T = elapsed time since administration of the dose

A = fraction of injury which is irreparable

B = fraction of injury which is reparable

β = recovery coefficient of the reparable injury

The total injury is just the sum of the incremental injuries:

$$I = \sum \delta I$$

Preliminary study of information published by [illegible]

[redacted]

Propulsion Medical Advisory Group (ANP-MAG) and of studies by radiobiologists indicate that the constants of the above equation are of the magnitude:

$A = 1/10$

$B = 9/10$

$\beta = 0.7$ (This implies that the half-life of the reparable injury is about one year.)

This permits the basic equation to take a simpler form:

$$\delta I = k\left[0.1\delta D + 0.9\,\delta D(2)^{-T}\right]$$

It should be pointed out that this injury determination in no way competes with the more specific biological tests. Since it is desirable to estimate biological damage when it is small enough that none can be detected by medical means, the subject method may be useful to give an indication of injury which may be seriously aggravated by subsequent exposure to radiation. In particular, the subject method would indicate the proper weight to be attached to irregular dose schedules such as incidental large doses, or alternately, long periods of absence from radiation doses.

In order to utilize the subject method of injury determination, a practical method of performing the calculations is necessary. To this end, the instrument shown in Fig. 1 has been designed and successfully demonstrated. A source of DC voltage is applied across a potentiometer R_1. This potentiometer is calibrated in terms of dose (in any appropriate scale). The voltage (E_1) developed between the tap of potentiometer R_1 and a common point is applied across a series circuit comprising a second potentiometer R_2 and a fixed resistor R_3. The fixed resistor R_3 is 1/10 the value of the combined resistances R_2 and R_3 because of the constant A of the above-derived equation.

The second potentiometer R_2 is calibrated with a logarithmic scale (in years). For the particular equation, as derived, the one year mark is placed at the mid-point of the scale with infinity at the junction with the fixed resistance R_3. The two year mark is midway between 1 and ∞, the three year mark is midway between 2 and ∞, etc. The output voltage, E_2, is then proportional [redacted]

[redacted]CRET

injury at time t (an interval of time T after the dose), and is equal to $0.1E_1 + 0.9E_1(2)^{-T}$. Since E_1 is made proportional to the dose, the injury equation has been duplicated in an analog circuit. This injury, as expressed by E_2, can be detected in any suitable manner, as with a vacuum tube voltmeter (VTVM).

In practice, radiation injury will stem from several exposures at various times in an individual's history. As pointed out previously, such total injury at a given time is a sum of the individual incremental injuries at that time. Thus, the subject circuit is provided with means for algebraically adding the individual incremental injuries. This is accomplished using a condenser bank, as shown. The output voltage, E_2, is imposed between a pair of sliding contacts, S_1, S_2, that engage an individual condenser, C. A charge is placed on the condenser equal to the voltage E_2. The contacts are then moved to another condenser and the injury-determining circuit is switched to calculate the injury from a different dose. This is repeated for all doses. The total voltage on the condensers is then equal to the sum of all the E_2's and is proportional to the total injury. The value of the injury is continuously determined with a vacuum tube voltmeter, or other suitable means. In this way, the effect of each individual injury upon the total injury can be followed.

It will be apparent to one versed in the art that the choice of circuit component values is not exceedingly critical except that the ratio of R_3 to $R_2 + R_3$ be made to correspond to the constants of the equation. R_1 and R_2 should be relatively large, of the order of 10^4 to 10^6 ohms, respectively, to minimize drain on the DC supply and R_1 should be small compared to R_2. The values of the condensers should be nearly equal and of such size to allow rapid charging but low leakage.

PERTINENT FACTS: Information obtained from: E. P. Blizard (orally) and Memorandum CF-54-9-119.

Earliest date now known: September, 1954.

Persons knowing of development: R. A. Charpie, C. S. Sheppard, E. H. Stern (Convair) and C. L. Storrs (GE). Also, a paper was presented before the ANP-MAC on December 3, 1954.

Contract involved: W-7405-eng-26.

RELATED ART: Published: None known.

Project: Reports UR-206, UR-207, UR-312, CH-3900 and ANL-5288.

PROBABLE VALUE: As pointed out previously, the subject method is not too exact for there are many secondary factors affecting radiation injury that have not been taken into account. However, equations could be derived for such factors and components added to the circuit to include their effect upon the total injury if these factors are found to be of significant importance. The subject method and apparatus, either as discussed and shown or in modified form, will give a quick estimate of injury but will not replace rigorous medical examinations.

At present, one model of the apparatus has been built and tested at the Oak Ridge National Laboratory and another is being built and tested by Convair. The ANP-MAG has commented favorably upon the subject method but as yet the extent of future Project use cannot be determined.

RECOMMENDATIONS AND COMMENTS: The increment of invention may not be sufficient to warrant the filing of a patent application.

Prepared by ______

Date Jan. 13 1955

Approved by ______

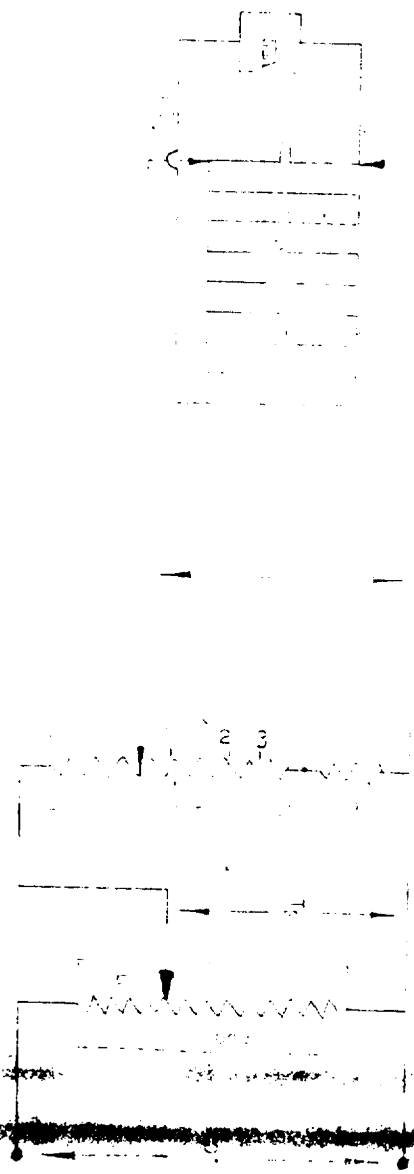

Fig. 1