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Report on the Radiological Instruments  
Used At  
"Crossroads"

By

Henry Faul, Geophysicist

November 7, 1946

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REPORT ON THE RADIOLOGICAL INSTRUMENTS USED AT "CROSSROADS"

To: Donald L. Collins, Chief, Instrument Division  
Radiological Safety Section JTF-1

From: Henry Faul, Geophysicist

The instruments we used in Bikini Lagoon have been variously praised and cussed by all kinds of people for all kinds of reasons. It is the purpose of my report to add a voice to this chorus.

I have tried to give objective criticism of each type of instrument, based on my personal experience - with malice toward none. At this point it must be emphasized that The Victoreen Instrument Company did a remarkable job in getting out a veritable mountain of equipment in a matter of a few weeks. The bare magnitude of this accomplishment deserves notice.

263 G.M. Set

The old 263 G-M set was undoubtedly the most reliable G-M instrument used at Crossroads. Its antiquated components (side-arm G-M tube, large battery, etc.) and a somewhat clumsy mechanical design both contribute to make the weight and bulk of the 263 greater than necessary. In spite of this obvious handicap, it was generally preferred by experienced monitors, wherever accurate and reliable data was required.

This great popularity of the 263 is due to the simple but sound electrical design, embodying a high-voltage battery, a "standard" self-quenching G-M tube, and the Collins-Smith trigger

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pair counting-rate meter. We have found through bitter experience that this orthodox combination is difficult to beat. On the basis of present knowledge it is apparent that any improvement of the 263 will be along mechanical lines - the circuit itself need not and should not be altered.

The following are suggested improvements:

1. The H-V battery should be built up from the smallest available B stacks (Eveready #412) with 3 or 4 extra taps ( $22\frac{1}{2}$  V apart) to give more latitude in the selection of G-M tubes. Together with all other batteries and the major part of the circuit it should be housed in a canvas-covered aluminum box provided with suitable "D" rings and a belt-sleeve to permit carrying on a strap, similar to that used with the army musette bags, or on the operator's belt.

2. The G-M tube and indicating meter can probably be fitted into a single unit to be used as a probe connected to the battery box by a three-wire shielded cable. The cable must be detachable at both ends and should use a dust and spray-proof connector at each end. It would probably be advantageous to have these cables made up by a manufacturer experienced in the business. <sup>1</sup>

A number of small but important details must be considered in the design of the probe suggested above.

a. The G-M tube must be as sturdy as possible, for it is relatively vulnerable when used in a probe. For that reason, the center wire should be of the largest diameter permissible electrically (probably 3 to 5 mils) and provided with a

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1. Amphenol, Cannon, and others offer connecting cables made to the customer's specifications.

fine spring in one end. Such springs are frequently omitted from G-M tubes used in laboratories, primarily because of the greater cost of manufacture, and secondarily because of the widespread belief that spring-mounted center wires may whip and cause spurious counts.

However, it is the writer's experience that when a springless G-M tube is used in a probe, close to 90% of all breakage will be broken center-wires.

b. The G-M tube should be readily detachable from the rest of the probe by means of a watertight connector, to permit quick interchange between gamma and beta-gamma tubes. It is not good practice to use thin-walled tubes for general gamma survey work.

c. It would probably be advantageous to design a new high-intensity G-M tube, to be used along with the standard Korff (gamma) and Eck & Krebs (gamma-beta) tubes. This new tube should have some type of ultra-low efficiency cathode, to give a normal background count of two or three counts per minute.<sup>1</sup>

d. The meter used in the probe must be sturdier than the meters generally used with the Collins-Smith CRM. A 0-50 microamp, 2-inch type is recommended. The trigger pair can drive this meter with no difficulty, and the mechanical-shock resistance of a 0-50 microammeter is considerably greater than that of a 0-20uA meter.

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1. The writer volunteers to work out a detailed design if requested.

## X-265 Survey Meter

The X-265 Survey Meter was apparently designed in great hurry to be a major improvement over the admittedly cumbersome 263 set, but our experience at Bikini has shown that it is anything but that.

Granted that the new instrument is much smaller in bulk and lighter in weight than any previous model of comparable characteristics, we must consider the various sacrifices that were necessary to achieve this end. First, the Simpson low-voltage tube made it possible to operate at 250-300 volts HV, or roughly onethird of the voltage used heretofore. At the same time, however it was necessary to provide a quenching circuit, which in turn required a separate "A" supply, caused appreciable drain on the High Voltage and thus added a number of potential variables that affect the previously simple function of obtaining a Geiger pulse.

The writer has had considerable experience with various types of this quenching circuit using various makes of midget vacuum tubes under various conditions prior to the Bikini tests. The work went on for more than a year in a serious effort to justify the claims of inventors and sub-inventors and the sincere attempt to give a fair chance to a new thing. Now, in retrospect, it can hardly be said that the experience was a happy one. At its present stage of development, the Simpson low-voltage tube is not suitable for other than semi-quantitative (auditory) purposes.

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In adding a one-tube metering circuit to integrate the already questionable pulses of the quenching circuit a combination was obtained that could have been adequate on the desk of a meticulous old lady in an air-conditioned laboratory, but was far from suitable for use at sea, in small boats, and on the precarious decks and ladders of battered warships.

The principal objection in the X-263 circuit is to the use of ultra-small and ultra-high parameters in critical positions. 10-meg resistors and 5 mmf condensers should be avoided in places where they seriously affect the calibration of an instrument. Twisted half-inch bits of Belden wire, or the stray capacity of two terminals on a switch can hardly be considered as condensers of any definite value, especially after the instrument containing them has been carried up and down a few Jacobs ladders. It has been the writer's own experience to see an X-263 change calibration by a factor of three, after just that many days of very considerate use on the bridge of a destroyer.

The mechanical design of the X-263 was sound and the battery racks ingenious. The use of mica board for insulation was not warranted, however. As a result, the only recommendation that can be made regarding the X-263, is to abandon its use in the field until further research has definitely eliminated the numerous "bugs".

The Simpson low-voltage G-M tube is a tempting piece of equipment but up to the present time it has been little more than a blind alley in the development of portable G-M counting rate meters.

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### The Model 247 Survey Meter

The Model 247 survey meter was the only electronic ion-chamber instrument available in any quantity at Bikini, and as such it proved eminently successful. It was by far the most rugged and the only truly spray-proof instrument in the lot. It maintained its calibration very well and thus was the only reliable instrument in its range (.5 to 200 R/day).

The only improvement suggested for the 247 is a simplification of the switching system by eliminating the third (0-200 R/day) range and redesigning the battery supply to make unnecessary the battery adjustment. Flattened shafts should be specified on all switches to prevent the irksome slipping of knobs.

### The X-325 Counting Rate Meter

The X-325 Counting Rate Meter was used for a wide variety of tasks at Bikini, from respectable and pre-designed rigs to haywire affairs contrived on the spur of the moment. It performed remarkably well in spite of the frequently hasty disembowelments it suffered from the hands of rushed improvisers.

From an electronic point of view it might be recommended that a trigger-pair input pulse equalizer be included in the circuit, ahead of the metering trigger pair, to make the instrument more universal and less sensitive to pulse-height and pulse width. The overall range of the X-325 was too small (0-5000 cts/min) and could have easily been made to cover up to 50,000 or 100,000 cts/min.

An additional meter tap to measure plate-voltage together

with a small speaker to permit auditory checking of the input rate would add to the usefulness of the instrument.

Mechanically it is desirable to provide the input bias adjustment with a calibrated dial and place it on the front panel of the instrument. In its present location the potentiometer is inaccessible unless the chassis is removed from its case, and even then adjustment is uncomfortable due to the intimate nearness of the bare 300 volt posts of the meter. The meter itself is frequently difficult to replace because of the simple fact that no play was allowed for the hole in the panel.

#### The Deep-Sea Probe

The deep-sea probe was designed to be used with the X-325 very much after the fashion of the Barnaby drillhole logging instrument. The mechanical design was very similar but some radical changes were made in the electrical circuit for no obvious reason. The result was an instrument that worked but was unreliable at its best.

The following were the most important undesirable features of the deep-sea probe:

1. All the troubles inherent in the Simpson low-voltage tube were also present in the deep-sea probe.

2. The heater current of the two GAK 5 tubes was too great to be conveniently carried over a 1000 foot cable. The resulting loss made it necessary to raise the filament supply voltage.

3. The design of the metal probe-shell violated a rule established in the well-logging industry, namely, smooth

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outline (to prevent the gathering of contaminated material).

4. The oceanographers found the probe too light for rapid lowering into the deep.

There were a few other types of instruments at Bikini and I had an occasional chance to use them or work on them. The experience, however, has been insufficient to form any definite opinion, and I have omitted this equipment from my present report.

Respectfully submitted,

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