Simplified Determination of Radioactive Decay Factors

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A quick and simple method of obtaining radioactive decay factors using a log-log slide rule is described and illustrative examples are presented.

Radioactive decay factors for the radionuclides in nuclear medicine must often be determined as frequently as several times daily, as in the case of ^{99m}Tc ($T_{1/2}$ = 6 hr). The determination of decay factors has generally been accomplished by the use of charts specific for each radionuclide or by calculations using the radioactive decay equation

$$\frac{A_t}{A_0} = e^{-\frac{0.693t}{T_{1/2}}}.$$

A quick and simple method of obtaining these radioactive decay factors to determine activity at any time, using a log-log slide rule, is described and examples are given.

Method

Determination of decay factor for specified decay time.

1. Set the hairline on 0.50 on the LL_{2-} (or equivalent) scale of the log-log slide rule and slide the $T_{1/2}$ on the C scale under the hairline (Fig. 1).
2. Move the hairline over the desired decay time

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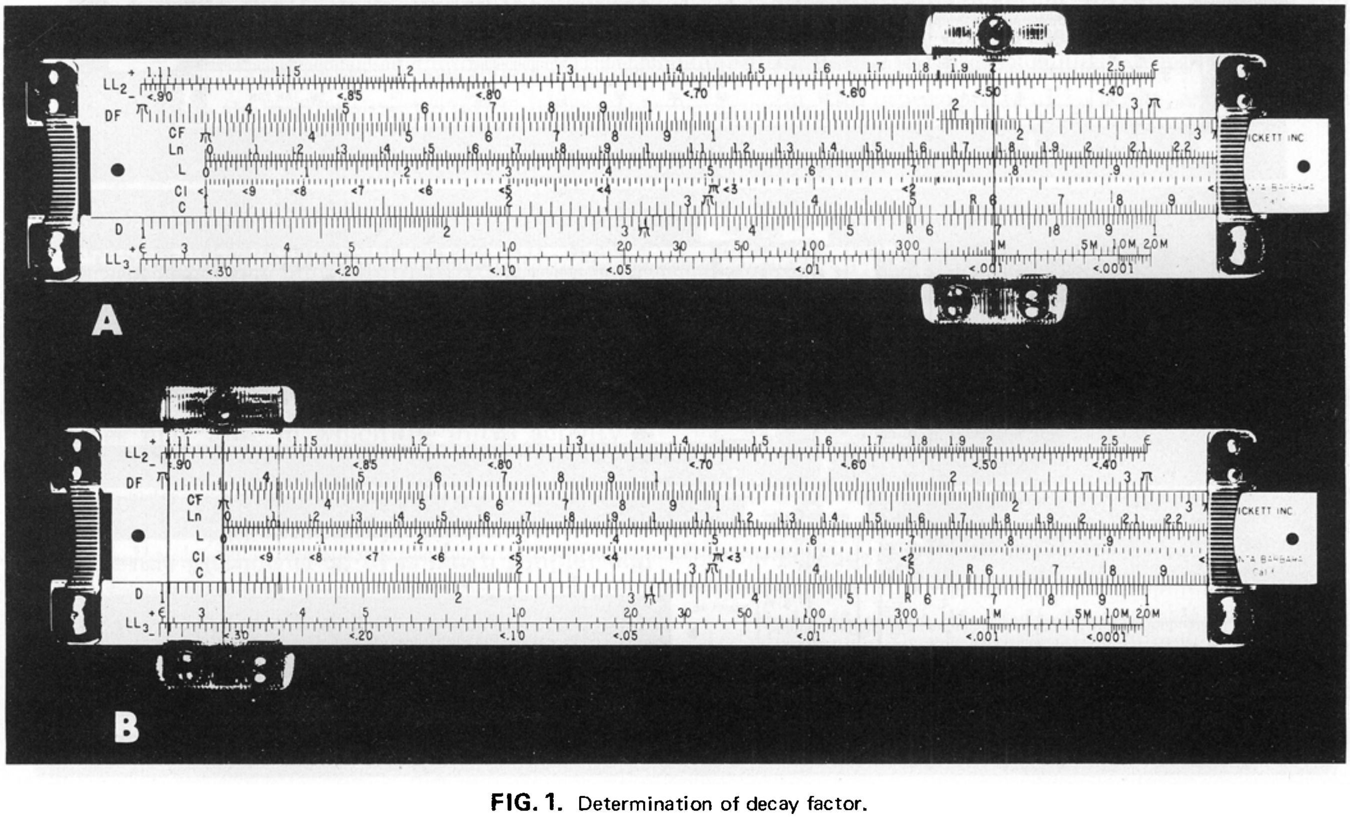

FIG. 1. Determination of decay factor.

on the C scale. Read the fraction remaining on the appropriate LL scale.

3. To determine the appropriate LL scale, estimate the order of magnitude of the result from the approximate number of elapsed half-lives and choose the LL scale corresponding to that order of magnitude.

For cases in which the desired decay period falls on the portion of the slide that is off-scale, use the following procedure (Fig. 2).

1. Set the hairline on 0.50 on the LL_{2-} scale and place $T_{1/2}$ on the C scale under the hairline.
2. Move the hairline to the on-scale C index.
3. Slide the opposite (off-scale) C index under the hairline.
4. Move the hairline to the desired decay time and read the fraction remaining on the appropriate LL scale.

Sample problem

A solution of ^{99m}Tc is assayed at 10mCi/ml at 0730 hr. What is the specific activity at 0830 hr? at 1630 hr? ($T_{1/2}$ = 6 hr).

For 0830 hr, decay time = 1 hr.

1. Set hairline on 0.50 on LL_{2-} scale and place 6 on the C scale under the hairline (Fig. 1A).
2. Move the hairline over 1 on the C scale and read the fraction remaining on the LL_{2-} scale = 0.891 (Fig. 1B).
3. A_t = (10 mCi/ml) X (0.891) = 8.91 mCi/ml.

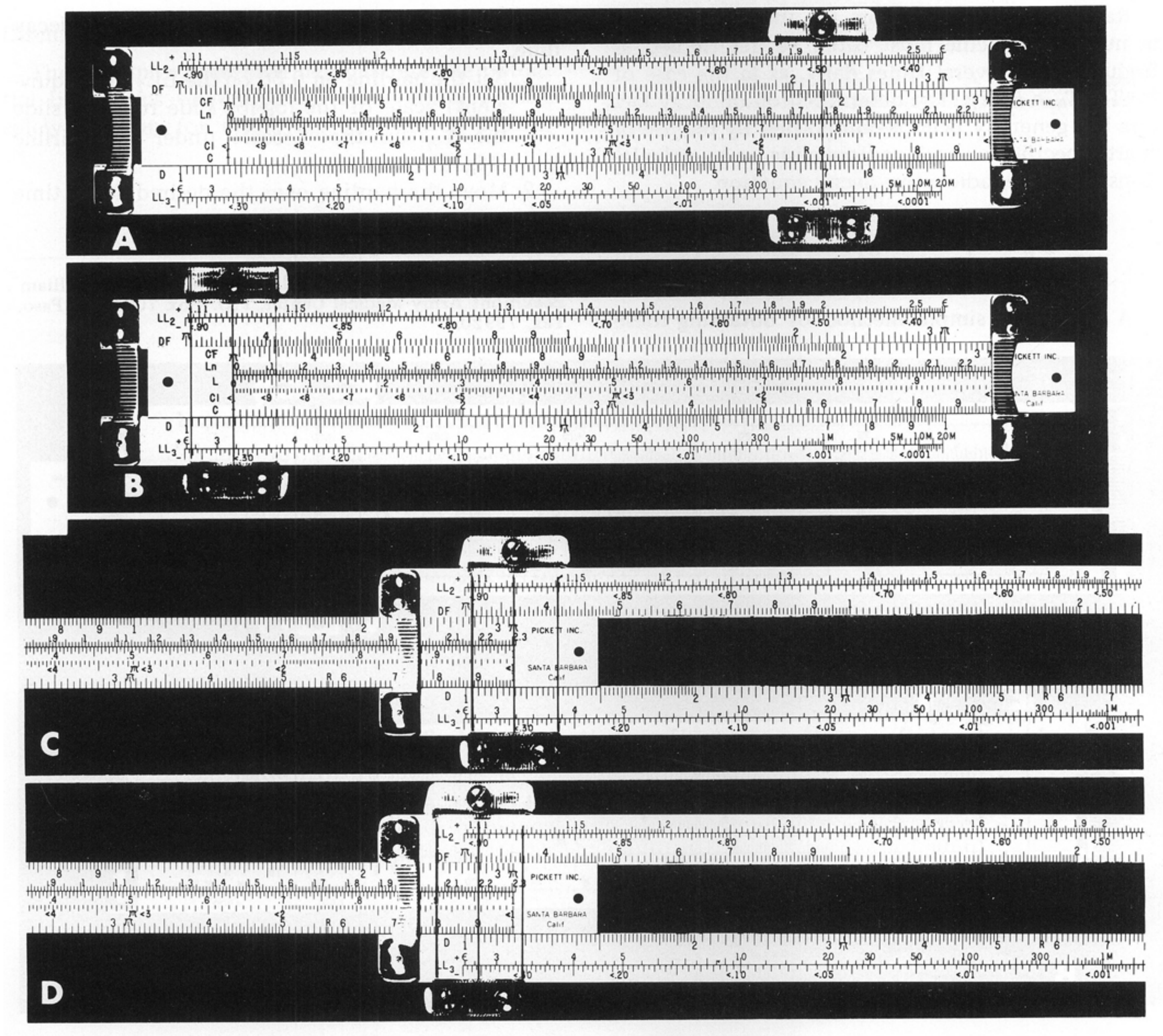

FIG. 2. Determination of decay factor when elapsed time is off-scale.

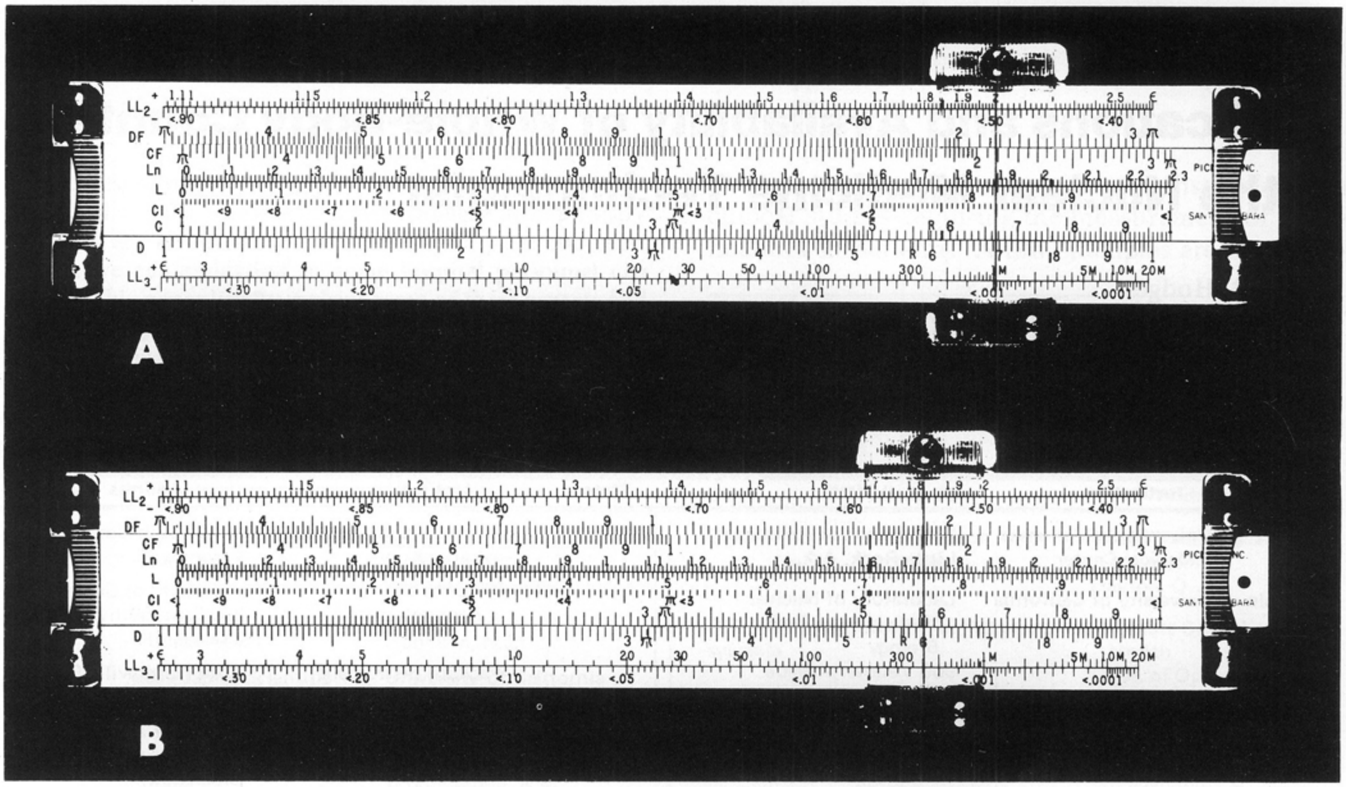

FIG. 3. Determination of time required to achieve given decay factor.

For 1630 hr, decay time = 9 hr.

1. Set the hairline on 0.50 on LL_{2-} scale and place 6 on the C scale under the hairline (Fig. 2A).
2. Because the desired decay time (9 hr) is off-scale, move the hairline to the left C index and slide the right C index under the hairline (Fig. 2B and C).
3. Move the hairline over 9 on the C scale and read the fraction remaining on the LL_{3-} scale = 0.353 (Fig. 2D).
4. A_t = (10 mCi/ml) X (0.353) = 3.53 mCi/ml.

Determination of decay time for specified decay factor.

Instances may arise in which the initial activity is given and it is desired to calculate the elapsed time for the original activity to decay to a specified fraction of the original activity. In this application, the slide-rule method (Fig. 3) is much simpler and quicker than the use of either logarithm tables or electronic calculators.

1. Set the hairline over 0.50 on the LL_{2-} scale and place the $T_{1/2}$ on the scale under the hairline.
2. Slide the hairline to the specified decay factor on the appropriate LL scale and read the desired elapsed time on the C scale.

Sample problem

How long must one wait until a 400 mCi ^{99}Mo generator decays to an activity of 1 mCi ($T_{1/2}$ = 66.6 hr)?

1. $\frac{A_t}{A_0} = \frac{1 \text{ mCi}}{400 \text{ mCi}} = 0.0025$
2. Set the hairline over 0.50 on the LL_{2-} scale and place 66.6 on the C scale under the hairline (Fig. 3A).
3. Slide the hairline to 0.0025 on the LL_{3-} scale and read the time on the C scale = 576 hr or 24 days (Fig. 3B).