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A [illegible] Fall-Out

[illegible]

1. [illegible] method described herein is [illegible] objective that is intermediate [illegible] operational [illegible], and [illegible] of a strictly scientific [illegible]igation. It [illegible] to be the most [illegible]portant factors [illegible], with the idea that we might find out enough about [illegible] a good simplified method for operational use. [illegible] local fall-out [illegible]casting is [illegible] by New Techniques Developed after BRAVO, [illegible] Techniques" of the Task Force Castle Report. [illegible] further investigation of [illegible] which a constant [illegible] could be formed.

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The basic assumptions of the method are as follows:

a. The whole cloud, up to its height of stabilization, is formed instantaneously at the time of detonation. This is what we call the "initial cloud".

b. In any height layer of the initial cloud, the concentration (radioactivity per unit volume) is distributed according to the Gaussian law

$$c(r,h) = c_0(h) \exp(-r^2/a_0^2)$$

where $c_0(h)$ is the central concentration at height h, r is the radial horizontal distance, and a_0 is a "horizontal parameter" (analogous to standard deviation) that is also assumed to be a function of height. From this assumption it follows that the total amount of radioactivity in a slice of unit vertical thickness is $\pi c_0(h)\, a_0^2$.

c. Throughout all of any such layer, the radioactivity is distributed normally with respect to the logarithm of the rate of fall of the particles. Thus at any distance r, the fraction of radioactivity that falls with speeds in the range f to f + df is given by

$$\frac{1}{\sigma(h)\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln \frac{f}{f(h)}}{\sigma(h)}\right)^2\right] \frac{df}{f}$$

where f(h) is the mean rate of fall (geometric) of particle radioactivity, and σ (also assumed to be a function of height) is the standard deviation of the logarithm of fall rates, weighted according to radioactivity. f(h) and σ(h) are constant throughout the layer.

d. The rate of fall of any particle remains constant until it reaches the ground.

e. Any particle that starts from the center of a layer will follow a path solely in accordance with the wind pattern, while all other particles that fall at the same rate from the same level will diffuse laterally from the central particle in such a way that the Gaussian distribution is maintained.

During this process, the increase in the spread parameter is described by

$$\frac{a}{a_0} = \left(1 + \frac{S}{\beta n}\right)^{\frac{n}{\beta}} = p^{\frac{n}{\beta}}$$

where S is the distance traveled by the critical particle until it reaches the ground. (It is to be noted that S is not the straight-line distance from the origin to the landing point unless all winds at all levels are in the same direction). β and n are parameters (quantities that may be used to describe the amount of diffusion. They are not at present regarded as functions of height. (The quantity p is merely an abbreviation for the quantity in brackets).

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a. From these assumptions it follows that the dose rate on the ground is

$$I = \frac{K}{\sqrt{2\pi}} \int [illegible] \frac{[illegible]}{[illegible]} \exp [illegible] + \frac{r^2}{a^2 f^m} \, dh \, \frac{df}{f}$$

where K is dose rate per unit of surface concentration, H is the height of the top of the cloud, and r is to be the distance from the point at which the dose rate is estimated to each of the landing points of central particles. These landing points will depend on the wind pattern below the level from which the central particle originated, so that r is a function of h. The landing points also depend on the rate of fall, so that r is also a function of f. Changing from rate of fall to time of fall, one obtains

$$r^2 = \left([illegible] \, u(h) - X \right)^2 + \left([illegible] \, v(h) - Y \right)^2$$

where (X,Y) are the rectangular coordinates of the point where dose rate is estimated, and u, v are the wind components in the same co-ordinate system, averaged up to the height h.

b. We may also suppose

$$[illegible] \, w(h) \, [illegible] \, \rho(h)$$

noting that w is the average speed regardless of direction. ($\bar{u}$ and $\bar{v}$ are not, in general, the components of $\bar{w}$). This assumption is correct if one is satisfied that the diffusion depends on the total horizontal distance travelled by a central particle. If one wishes to assume that the vertical distance should be included, things become more complicated.

c. The significance of β and m can now be discussed. If m = 2, then

$$\frac{a}{a_0} = [illegible]$$

so that the lateral dimensions of any portion of the cloud will increase

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as if the [illegible] had come from a point source located at a distance β to upwind. The [illegible] increases linearly with distance travelled by the central particle. If m is greater than 1, the boundaries of the cloud will diverge more rapidly, and if m is less than 1, they will diverge less rapidly. One can prevent any increase in [illegible] by making β infinite or by making $\frac{dm}{dt}$ equal to zero. This method of describing the diffusive process is similar to that of Sutton, but not exactly the same.

3. If m = 2, the [illegible] of t, the area covered by a segment of cloud is proportional to the square of the time, as in Felt's method. However, the proportionality factor varies, as $\bar{w}$ varies with height, and further, the [illegible] proportionality factor changes with the overall strength of the wind field, and in these respects it differs from Felt's method.

4. [illegible] the change of variable from ξ to t changes the argument of the exponential to

$$t\ \underset{h}{f}(h)$$

and of ξ [illegible]

[illegible] notes also that concentrations in the initial cloud must be related to those that would have existed at the time for which the dose rate is being calculated.

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The information that is needed for a calculation is then:

a. The winds pattern at heights up to H.

b. H, the height of the top of the cloud.

c. r_0, the initial spatial parameter, or a "Gaussian" radius, as a function of height.

d. C_0, the central concentration as a function of height in the initial cloud, adjusted to the time of [illegible].

e. f, the logarithmic mean radius (adjusted according to radioactivity), as a function of height in the initial cloud.

f. σ', the logarithmic standard deviation of this distribution as a function of height in the initial cloud.

g. μ, diffusion parameter, described above.

h. ν, diffusion parameter, described above.

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5. a. Testing of the method requires the use of high speed computing machinery. With such machinery one can make [illegible] changes in the quantities described above, proceeding on a trial and error [illegible]. In order to achieve some degree of objectivity, the following approach is adopted.

b. The logarithm of the ratio of calculated to observed dose rate is estimated at a number of points for a given shot. This quantity is called γ (gamma). Then the mean gamma, and the statistical variance of the individual gammas about the mean gamma, are calculated. This process is repeated for a number of values of some parametric quantity, [illegible] for example. One then plots the variance against [illegible], and chooses as the best value the one that gives the least variance. One then goes on to other parametric quantities, and treats them in the same way, hoping that there is not too much correlation between the effects of the different types of parameters.

c. It will be noted that this application of the "least squares" method discounts the magnitude of [illegible]. In principle it is possible to get zero variance (a perfect fit) when each calculated value is, for example, exactly ten times the observed value. One would then say that [illegible] of the activity [illegible] on the crater. If, however, one should obtain a perfect fit with only 10% of the observed activity accounted for, one would have to consider other possibilities. One would first look to see whether any large fraction of the activity was excluded from the calculation. In the fallout integration it is not practical to go all the way from zero to infinite time, and part of the activity might have fallen outside of the time range chosen. If this explanation fails, and if the fit is very good, one has to conclude that the least squares criterion, as applied here, is not useful. We have not yet encountered this particular problem.

The method of approach is subject to the [illegible] old criticism running as follows: by subdividing the [illegible] of the cloud at will, you can obtain as many discrete parameter values of a_0, c_0, f, etc. as you wish, so that you should be able to fit any number of observations exactly. This is true in principle, but if you can get a set of values that look reasonable, and can be varied in a sensible way with yield over a wide range, the method can serve a useful operational purpose even though the values might be individually uncertain.

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[illegible]. a. For machine integration, using the IBM Model 701 "Defense Calculator", those parametric quantities (a, c, [illegible] f) and the mean wind components ($\bar{u}$, $\bar{v}$, $\bar{w}$), which are functions of height, may be loaded as tables of data. The total height of the initial cloud [illegible] divided into M equal layers, each identified by an integer i = 0, 1, 2, ... (M-1). The time variable is [illegible] logarithmic units, each time being identified by an integer j = 1, 2, 3, ... N. Storage limits the maximum value of M to 32. N may be any value that doesn't [illegible] machine time, and the minimum and maximum limits of the time integration may be changed at will. The exponential factor in the formula [illegible] as zero if the absolute value of the exponent exceeds a value A which may be as large as 10.

b. The coding is so arranged that the time integration is performed first and the height integration second. At each location, the fraction of the dose rate that comes from each initial layer [illegible] computed and may be printed along with the calculated [illegible] parameters and the coordinates of the location. [illegible] bypass this printing and obtain only the [illegible] for a preselected series of locations.

c. The codes are not yet final, and additional features are being added from time to time. We have two codes: (1) a fast "fixed point" code as outlined above, and (2) a slower "floating-point" code [illegible] which is more flexible in some respects.

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[illegible] starting on this problem [illegible] months ago, a considerable part of the time has been spent on coding and debugging, which we undertook ourselves in order to learn how to use the Model 701. Using Bravo fall-out data, we [illegible] that [illegible] solutions could be obtained for the various [illegible] quantities [illegible]. However, the "best" values, [illegible] selected in this way, gave [illegible] predictions that were only 20 to 50% of the observed values, and the fit was not good. We then turned attention to Nevada data for a while, and became interested in an approximation [illegible] one of the two steps in the double integration. Before this possibility had been fully explored, Mr. [illegible] Shelton, [illegible], joined forces with us, and [illegible]. Mr. Shelton then took [illegible] on the Nevada data, while we [illegible] to the Bravo shot. Mr. Shelton has reported recently that the [illegible] and [illegible]-7, and he is continuing [illegible] on the problem of predicting the [illegible] fall-out on the assumption that practically all of the activity in the [illegible] cloud [illegible] the tropopause. To date, our method of calculation has not [illegible] to give satisfactory results, [illegible] the winds [illegible] to the fall-out occur in more nearly the right places. At this point we feel, therefore, that we do not have any cloud model in which we have confidence. We have merely a [illegible] of calculation, the [illegible] of which has not yet been proven as far as Bravo is concerned.

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. [illegible]ing any sa[illegible] [illegible] [illegible] [illegible], we tackled the "homework"

[illegible] fictions on a [illegible] basis, [illegible] not justify a description.

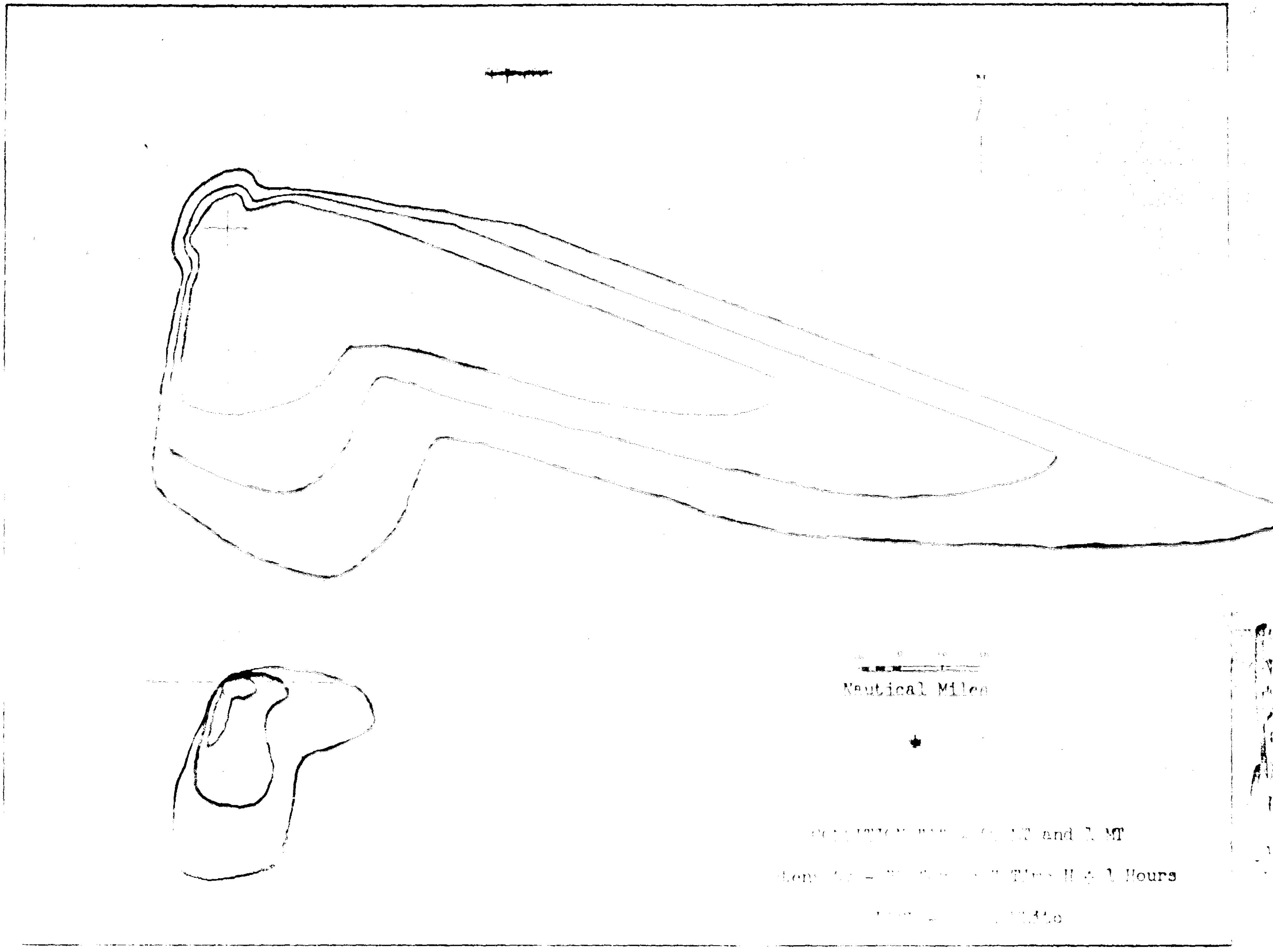
[illegible] values that [illegible] in the [illegible]

	1 MT	50 MT
Height of cloud (km a[illegible])	11.5	19.0
Height of s[illegible] (" ")	7.0	7.0
a for [illegible] (" ")	0.94	4.58
for stem (" ")	0.41	1.49

Data: 9.15 [illegible] 3.0 [illegible] 1.0

The values of [illegible] are taken as constant up to the tropopause, and the re-[illegible] [illegible] requires only the [illegible] of [illegible] values, [illegible] are adjusted to that [illegible] total [illegible] with the yield). [illegible] to the 36 layers of the [illegible] is [illegible], [illegible] ([illegible])

Layers	1 thru 4		[illegible]
"	5 thru 8		[illegible]
"	9 thru 12		[illegible]
"	13 thru 16		[illegible]

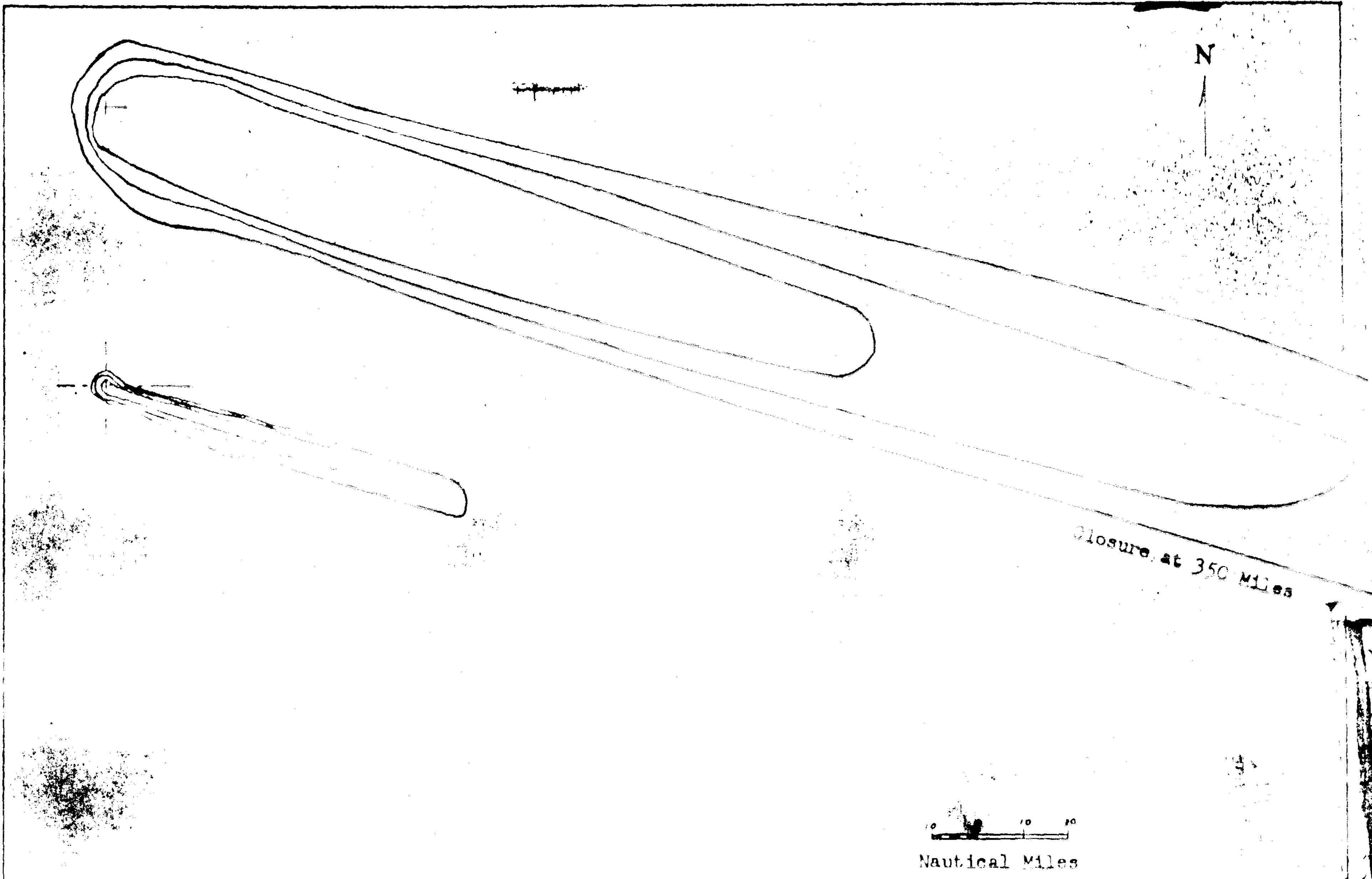

Nautical Miles
[illegible] and 1 MT
[illegible] H + 1 Hours
[illegible]

[illegible] - 50 MT and 1 MT

[illegible] Hours

[illegible] White

~~SECRET~~



CONDITION "[illegible]" - 50 and 1 MT

Intensity - "Reference" Time H & 1 Hours

LASL - T. N. White

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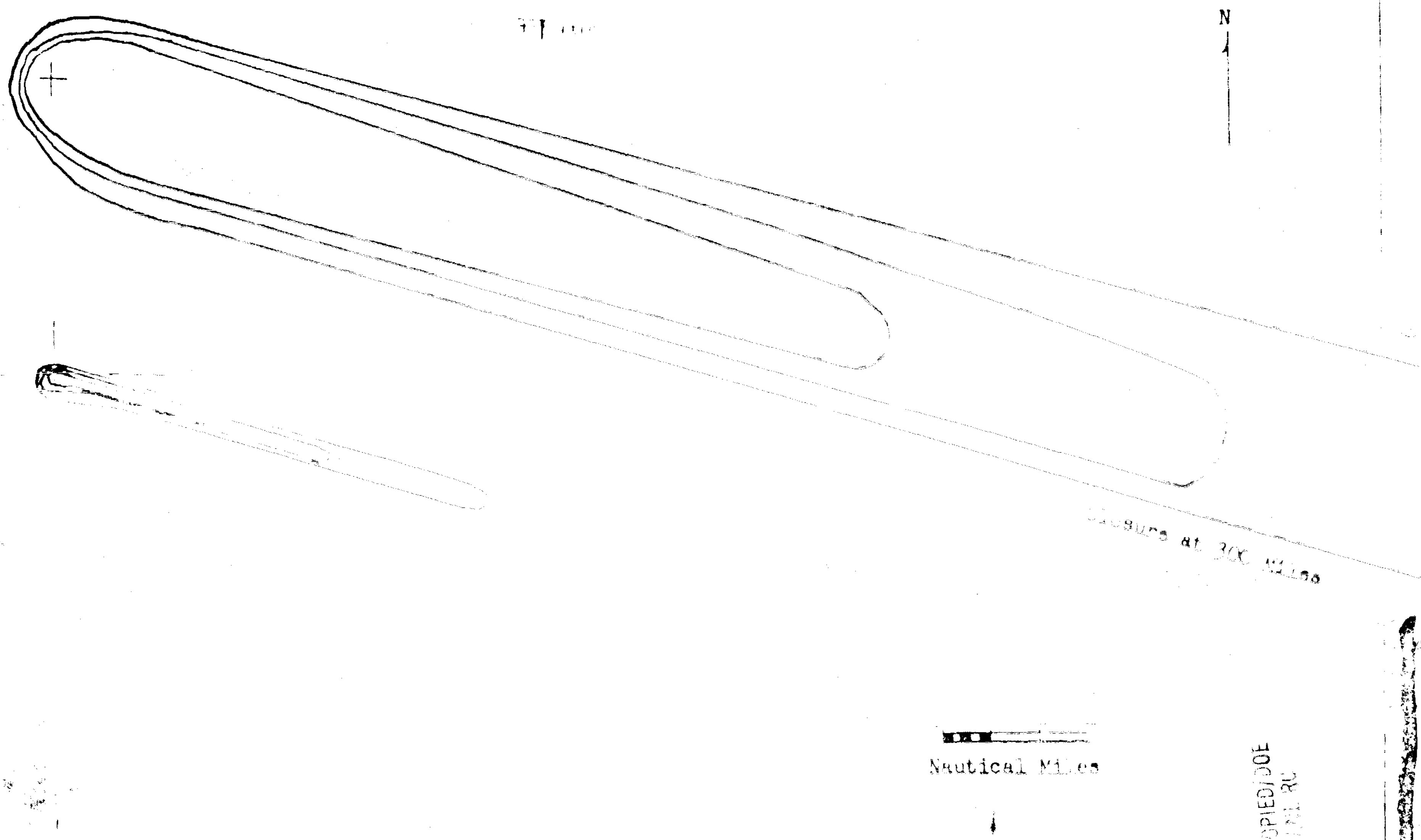

CONDITION "B" - 50 MT and 1 MT

[illegible] - To 48 Hours

[illegible] - T. N. White