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File Name (TITLE): Relationship Between Energy and Rate of Cloud Rise

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1009TH SPECIAL WEAPONS SQUADRON
INTER-OFFICE MEMORANDUM

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AUTH [redacted] RAP 17 Dec 82

Mr. Allen/whk/62189

SUBJECT: The Relationship Between Energy and Rate of Cloud Rise

TO: Dr. W. D. Urry | FROM: P. W. Allen | DATE: 11 Dec 52 | COMMENT NO. 1

1. As you suggested last week, I have gone over all available data on the rates of rise of clouds from U.S. atomic tests and have plotted values for the rates of rise against energy in EKT,* as shown in the accompanying graph, together with the empirical equation of relationship.

2. The rate of rise changes with time, increasing to a maximum during the first minute and decreasing thereafter to essentially zero after about 10 minutes. The data available to us are not good enough to show the maximum rate due to poor timing and infrequent measurements, but may be used to obtain the average rate of rise over a period of minutes. The average over the initial 3 minutes is used on this graph. In all cases except IVY Mike the clouds were still rising rapidly and were still in the troposphere after the third minute. The Mike cloud was treated in a special manner as indicated below.

It is reasonable to believe there to be some dependency of rise rate on the lapse of ambient air temperature with altitude. The effect of inversions and stable layers will, however, be a minimum in the earliest seconds of rise, increasing in importance as the temperature difference decreases between cloud and surrounding atmosphere. When the cloud reaches ambient air temperature, further vertical motion is damped out. It is therefore preferable to measure the rate of rise at the earliest possible time, and the maximum rate of rise should be more indicative of energy than the mean 3-minute rate used here.

Since the mean lapse rate of temperature is markedly different in the stratosphere than in the troposphere, it is preferable to make all measurements in the troposphere until adequate corrections can be made for this.

3. Rate of rise data are available from the following sources:

a. Operation SANDSTONE. Mr. Paul Humphreys, USWB, documented the rise and dispersion of the SANDSTONE clouds in an AFSWP publication, "Classified Scientific Meteorological Information, Operation SANDSTONE". His data were obtained by theodolite and are reasonably accurate over at least the first few minutes of rise.

b. Operation GREENHOUSE. The rise of the GREENHOUSE clouds were obtained from an unpublished report on "Cloud Physics", Project 4.6, by Dr. W. W. Kellogg, Rand Corp. Motion picture photography were analyzed for cloud rise and cloud dimensions, and the rates of rise over the first 4 or 5 minutes are probably good, although weather clouds obscured parts of the atomic clouds. The maximum altitudes of the Dog and George clouds are still in doubt since the tops of these clouds were not visible from the camera positions.

C. Operations BUSTER-JANGLE. Two sources of cloud rise data are available for these operations, one being that taken by myself (with your help in a couple of

(Use reverse side of this form for additional comments)

* EKT = KTE [redacted]

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cases) by hand clinometer, and the other taken by Air Weather Service personnel by theodolite. These two sets checked very well in all cases except Charlie cloud. On the graph, the average of the two is indicated by the circled dot, with the outriggers showing the values themselves.

d. Operation IVY. Three surface vessels and three aircraft were engaged in making cloud rise and height measurements of Mike cloud. Of these, one vessel failed to make any height measurements until H plus 3½ min., and one airplane made only one measurement, at approximately H / 40 sec, before H / 5 min. It is not believed that timing was very accurate on this measurement so it was discarded. The other measurements showed the cloud to have approached maximum altitude at 3 minutes so in addition to the 3 minute average an average was obtained using earlier measurements. Since there is reason to believe the rate to decrease in the stratosphere (above 58000 ft on Mike day) the second average was taken of observations below that height. The two averages are shown as horizontal lines on the graph.

(1) Three minute heights:

U.S.S. Curtiss	100,500 ft.
U.S.S. Rendova	117,000 ft.
Aircraft No. 1 (Dr. Urry)	111,000 ft.
Aircraft No. 2 (Col. Fee)	127,000 ft.
Average	114,000 ft. in 3 min.

(2) Extrapolation of troposphere rates:

U.S.S. Curtiss	46,600 ft. at 1 min.	139,800 ft./3M
U.S.S. Rendova	No early measurements	
Aircraft No. 1	58,200 ft. at 1½ min.	116,400 ft./3M
Aircraft No. 2	No early measurements	
	Average	128,100 ft./3M

Three surface vessels and two aircraft made measurements of the King cloud, and all data are on hand except that from one surface vessel. The three minute heights are as follows:

U.S.S. Oak Hill	58,300
U.S.S. Rendova	56,100
Aircraft No. 1 (Mr. Singlevich)	58,300
Aircraft No. 2 (Col. Moris)	53,000 (Doubtful)
Average	56,400

The average is plotted on the graph.

4. Considerable improvement in this relationship might well result from more accurate determination of the rate of rise and in particular of the maximum rate, and from development of a correction factor for variations in the ambient air lapse rate of temperature.

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P. W. ALLEN

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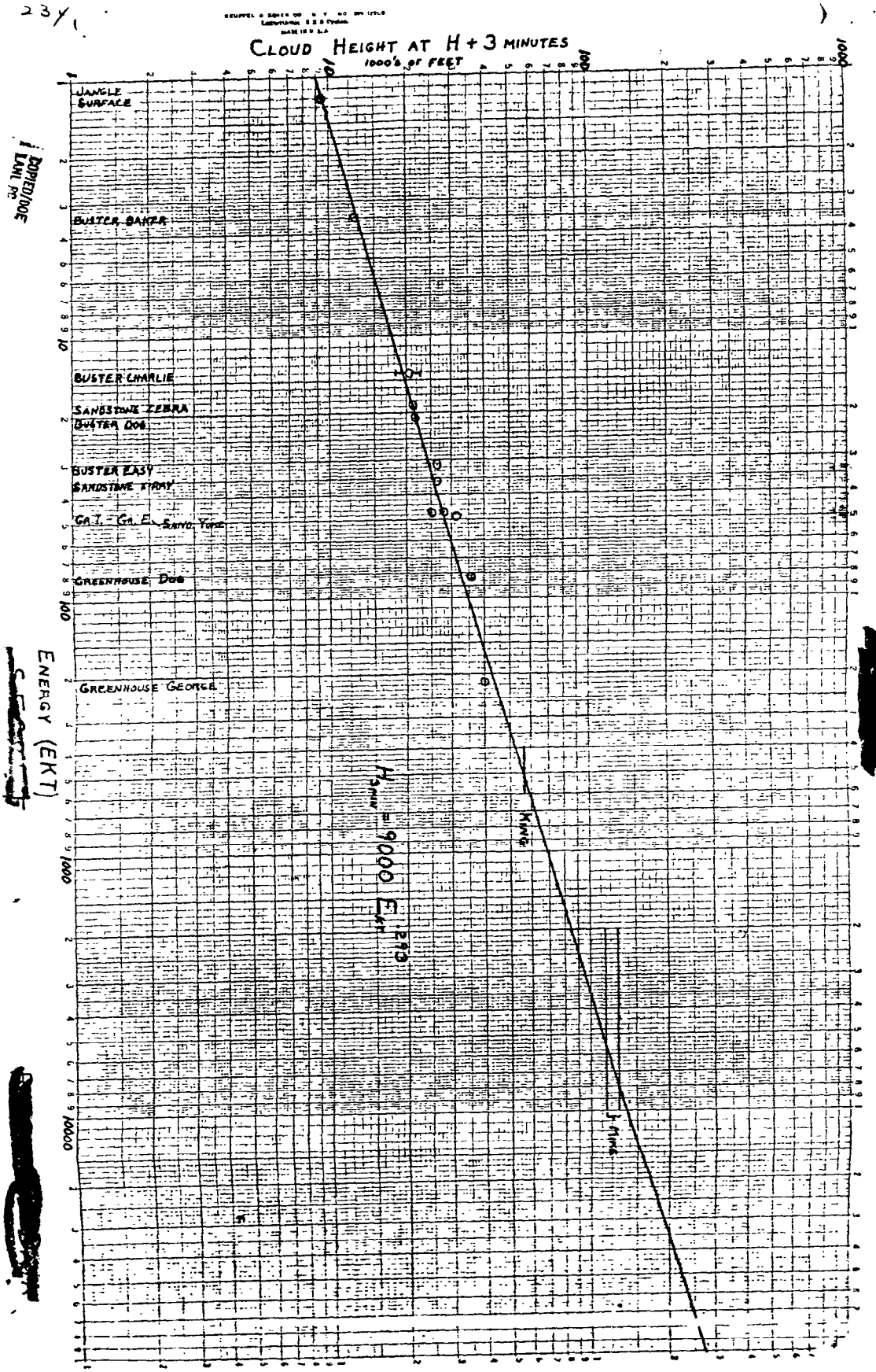
CLOUD HEIGHT AT H + 3 MINUTES
1000's of FEET
JUNGLE SURFACE
BUSTER BAKER
BUSTER CHARLIE
SANDSTONE ZEBRA
BUSTER DOG
BUSTER EASY
SANDSTONE FRAY
GA. I. GA. E. SANTA YNEZ
GREENHOUSE DOG
GREENHOUSE GEORGE
ENERGY (EKT)
$H_{3\,min} = 9000\ E_{kt}^{.290}$
K time
J time